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STATE PARKS

January 6, 2023

Mary Alice Evans, Director
Office of Planning and Sustainable Development
Environmental Review Program
235 S. Beretania Street, Room 702
Honolulu, Hawaiʻi 96813

Subject:	Publication of Draft Kauaʻi Island Utility Cooperative Habitat Conservation Plan
Applicant:	Kauaʻi Island Utility Cooperative
Location:	Island of Kauaiʻi, State of Hawaiʻi

With this letter, the Department of Land and Natural Resources hereby transmits the Draft Kauai Island Utility Cooperative Habitat Conservation Plan for publication in the January 23, 2023, edition of "The Environmental Notice" for a 60-day public comment period.

If there are any questions regarding this letter, please contact Katherine Cullison via email at Katherine.cullison@hawaii.gov.

Sincerely,

DGS

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To: DBEDT OPSD Environmental Review Program
Subject: New online submission for The Environmental Notice

Action Name

Kauai Island Utility Cooperative Habitat Conservation Plan

Type of Document/Determination

Other (contact EPR prior to selecting this choice)

HRS §343-5(a) Trigger(s)

- (1) Propose the use of state or county lands or the use of state or county funds
- (2) Propose any use within any land classified as a conservation district

Judicial district

Kaua'i - multiple districts

Tax Map Key(s) (TMK(s))

Various, island-wide

Action type

Applicant

Other required permits and approvals

State Incidental Take License, CDUA, Federal Incidental Take Permit

Discretionary consent required

?

Approving agency

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Was this submittal prepared by a consultant?

No

Action summary

The Kauai Island Utility Cooperative (KIUC) has drafted a Habitat Conservation Plan (HCP) to support KIUC's application for an incidental take license (ITL) under Hawai‘i Revised Statutes (HRS) Chapter 195D. The covered activities are the operation and maintenance of current and future powerlines and lighting. The draft HCP identifies take of three covered seabirds species associated with powerline collisions and fallout caused by artificial nighttime lighting from streetlights and buildings. Take of 5 covered waterbird species is primarily associated with powerline collisions. Artificial nighttime lighting from streetlights also results in take of green sea turtle nestlings that become disoriented after hatching on natal beaches. The draft HCP includes proposed minimization, monitoring, and adaptive management strategies to accomplish the biological goals and objectives of the conservation plan.

Attached documents (signed agency letter & EA/EIS)

- KIUC_HCP_Appendices_January2023.pdf
- KIUC_HCP_Combined_January2023.pdf
- Publication-of-Draft-Kauai-Island-Utility-Cooperative-Habitat-Conservation-Plan-part-1-signed.pdf

Action location map

- KIUC_HCP_Appendices_January2023.zip

Authorized individual

Katherine Cullison

Authorization

- The above named authorized individual hereby certifies that he/she has the authority to make this submission.

Draft

Kaua‘i Island Utility Cooperative Habitat Conservation Plan

Island of Kaua‘i, Hawai‘i

Prepared for:
Kaua‘i Island Utility Cooperative

Prepared by:
ICF

January 2023

Kaua‘i Island Utility Cooperative
Your Touchstone Energy® Cooperative

ICF

Contents

List of Tables vii

List of Figures viii

Executive Summary ES-1

ES.1 Introduction and Background ES-1
ES.2 Plan Area and Permit Area ES-2
ES.3 Covered Activities ES-4
ES.4 Environmental Setting ES-4
ES.4.1 Covered Seabirds ES-4
ES.4.2 Covered Waterbirds ES-5
ES.4.3 Green Sea Turtle ES-6
ES.5 Conservation Strategy ES-6
ES.5.1 Conservation Framework ES-7
ES.5.2 Conservation Measures ES-9
ES.6 Effects on Covered Species ES-15
ES.6.1 Effects on Covered Seabirds ES-15
ES.6.2 Effects on Covered Waterbirds ES-22
ES.6.3 Effects on Green Sea Turtle ES-23
ES.7 Monitoring and Adaptive Management ES-24
ES.8 Plan Implementation ES-24
ES.8.1 Implementation Responsibilities ES-25
ES.8.2 Regulatory Assurances ES-25
ES.8.3 Costs and Funding ES-26
ES.8.4 Revisions and Amendments ES-26

Chapter 1 **Introduction and Background 1-1**

1.1 Overview and Background 1-1
1.1.1 Applicant: Kauaʻi Island Utility Cooperative 1-1
1.1.2 Need for the KIUC Habitat Conservation Plan 1-1
1.2 Relationship to Other Habitat Conservation Plans on Kauaʻi 1-2
1.2.1 Kauaʻi Seabird Habitat Conservation Plan 1-2
1.2.2 Kauaʻi Lagoons Habitat Conservation Plan 1-3
1.3 Scope of the KIUC HCP 1-3
1.3.1 Plan Area and Permit Area 1-3
1.3.2 Covered Species 1-5
1.3.3 Covered Activities 1-5

1.3.4 Permit Term ... 1-5
1.4 Regulatory Context ... 1-6
1.4.1 Federal Endangered Species Act ... 1-6
1.4.2 Hawaiʻi Revised Statutes, Chapter 195D ... 1-7
1.5 Habitat Conservation Plan Process ... 1-7
1.5.1 HCP Development Phase ... 1-8
1.5.2 Permit Processing Phase ... 1-9
1.5.3 Implementation Phase ... 1-10
1.5.4 National Environmental Policy Act ... 1-10
1.5.5 Migratory Bird Treaty Act ... 1-10
1.5.6 Hawaiʻi State Environmental Review Law ... 1-11
1.5.7 National and State Historic Preservation Acts ... 1-11
1.6 Organization of the KIUC HCP ... 1-12

Chapter 2 **Covered Activities ... 2-1**
2.1 Powerline Operation, Retrofit and Use of Night Lighting for Repairs ... 2-2
2.1.1 Powerline Operation ... 2-2
2.1.2 Powerline Retrofits: Additional Powerlines and Changes in Wire Numbers and Configuration ... 2-6
2.1.3 Operation of New or Extended Powerlines ... 2-7
2.1.4 Night Lighting for Restoration of Power ... 2-7
2.2 Lighting Operation ... 2-8
2.2.1 Facility Lights ... 2-8
2.2.2 Streetlights ... 2-9
2.3 Implementation of the Conservation Strategy ... 2-10
2.4 Activities Not Covered ... 2-10

Chapter 3 **Environmental Setting ... 3-1**
3.1 Affected Physical Environment ... 3-1
3.1.1 Physiography, Geology, and Soils ... 3-1
3.1.2 Hydrology ... 3-4
3.1.3 Climate and Weather ... 3-7
3.2 Land Use ... 3-12
3.3 Existing Biological Environment ... 3-14
3.3.1 Vegetation ... 3-14
3.3.2 Covered Species ... 3-17

Chapter 4 **Conservation Strategy ... 4-1**
4.1 Introduction ... 4-1
4.1.1 Overview ... 4-1

4.2 Methods and Approach 4-2
4.2.1 Regulatory Background on Biological Goals and Objectives and Conservation Measures 4-2
4.2.2 Process of Developing the Biological Goals and Objectives and Conservation Measures 4-3
4.2.3 Information Sources 4-3
4.2.4 Relationship to KIUC Short-Term HCP 4-5
4.3 Biological Goals and Objectives 4-5
4.3.1 Newell's Shearwater (ʻaʻo) 4-9
4.3.2 Hawaiian Petrel (ʻuaʻu) 4-14
4.3.3 Band-Rumped Storm-Petrel (ʻakēʻakē) 4-18
4.3.4 Covered Waterbirds: Hawaiian Coot (ʻalae keʻokeʻo), Hawaiian Gallinule (ʻalae ʻula), Hawaiian Stilt (aeʻo), Hawaiian Goose (nēnē), and Hawaiian Duck (koloa maoli) 4-19
4.3.5 Central North Pacific Distinct Population Segment of the Green Sea Turtle (honu) 4-22
4.4 Conservation Measures 4-23
4.4.1 Conservation Measure 1. Implement Powerline Collision Minimization Projects 4-24
4.4.2 Conservation Measure 2. Implement Measures to Minimize Light Attraction 4-33
4.4.3 Conservation Measure 3. Provide Funding for the Save Our Shearwaters Program 4-36
4.4.4 Conservation Measure 4. Manage and Enhance Seabird Breeding Habitat and Colonies at Conservation Sites 4-38
4.4.5 Conservation Measure 5. Implement a Green Sea Turtle Nest Detection and Temporary Shielding Program 4-54
4.4.6 Conservation Measure 6. Identify and Implement Practicable Streetlight Minimization Techniques for Green Sea Turtle 4-68

Chapter 5 **Effects 5-1**
5.1 Overview 5-1
5.2 Effects Pathways 5-1
5.2.1 Powerlines 5-1
5.2.2 Light Attraction 5-6
5.2.3 Conservation Strategy Implementation 5-9
5.3 Effects on Covered Seabirds 5-9
5.3.1 Methods for Quantifying Take and Assessing Effects on the Covered Seabirds 5-9
5.3.2 Impacts of the Taking—Methods 5-17
5.3.3 Benefits of the Conservation Strategy and Net Effects—Methods 5-20

5.3.4 Effects Common to All Covered Seabirds 5-20
5.3.5 Species-Specific Seabird Effects 5-28
5.4 Effects on Covered Waterbirds 5-49
5.4.1 Methods for Assessing Effects on Waterbirds 5-49
5.4.2 Effects Common to All Covered Waterbirds 5-51
5.4.3 Species-Specific Waterbird Effects 5-54
5.5 Effects on Green Sea Turtle (honu) 5-57
5.5.1 Methods for Assessing Effects 5-57
5.5.2 Effects and Level of Take 5-58
5.5.3 Impacts of the Taking 5-58
5.5.4 Beneficial and Net Effects 5-59
Chapter 6 **Monitoring and Adaptive Management Program 6-1**
6.1 Introduction 6-1
6.1.1 Regulatory Context 6-1
6.2 Overview of Monitoring and Adaptive Management Program 6-2
6.2.1 Types of Monitoring 6-2
6.2.2 Adaptive Management 6-3
6.3 Compliance Monitoring and Adaptive Management Triggers 6-7
6.4 Take and Effectiveness Monitoring and Adaptive Management Triggers 6-20
6.4.1 Powerline Strike Monitoring and Adaptive Management 6-33
6.4.2 Light Attraction Monitoring and Adaptive Management 6-39
6.4.3 SOS Program Monitoring and Adaptive Management 6-41
6.4.4 Conservation Site Monitoring and Adaptive Management 6-43
6.4.5 Green Sea Turtle (honu) Monitoring and Adaptive Management 6-55
6.4.6 Adjusting Monitoring Methods 6-56
Chapter 7 **Plan Implementation 7-1**
7.1 Overview 7-1
7.2 Implementation Responsibilities 7-1
7.2.1 Responsibilities of Kauaʻi Island Utility Cooperative 7-1
7.2.2 Responsibilities of U.S. Fish and Wildlife Service 7-3
7.2.3 Responsibilities of the State of Hawaiʻi Department of Land and Natural Resources 7-4
7.2.4 Responsibilities of the Endangered Species Recovery Committee 7-5
7.3 Regulatory Assurances 7-5
7.3.1 Changed Circumstances 7-6
7.3.2 Unforeseen Circumstances 7-6
7.3.3 Changed Circumstances Addressed by this HCP 7-7

7.4 Costs of KIUC HCP Implementation 7-35
7.4.1 Cost Estimate Methodology 7-38
7.4.2 Plan Administration 7-38
7.4.3 Powerline Collisions Minimization 7-39
7.4.4 Save our Shearwaters Program 7-40
7.4.5 Manage and Enhance Conservation Sites 7-40
7.4.6 Green Sea Turtle (Honu) Nest Detection and Temporary Shielding Program 7-41
7.4.7 Infrastructure Monitoring and Minimization Program 7-42
7.4.8 Seabird Colony Monitoring 7-42
7.4.9 Adaptive Management 7-43
7.4.10 State Compliance Monitoring 7-43
7.4.11 Other Costs 7-44
7.5 Funding Assurances 7-45
7.5.1 Funding Adequacy 7-47
7.6 Revisions and Amendments 7-48
7.6.1 Minor Modifications 7-48
7.6.2 Major Amendments 7-48
7.6.3 Permit Suspension or Revocation 7-49
7.6.4 Permit Renewal 7-49
7.7 Annual Reporting 7-50

Chapter 8 **Alternatives to Take 8-1**
8.1 No Take Alternative 8-1
8.2 Underground Some Transmission Lines 8-2
8.3 Extensive Tree Planting 8-3

Chapter 9 **References 9-1**
9.1 *Executive Summary* 9-1
9.2 Chapter 1, *Introduction and Background* 9-3
9.3 Chapter 2, *Covered Activities* 9-4
9.4 Chapter 3, *Environmental Setting* 9-4
9.5 Chapter 4, *Conservation Program* 9-11
9.6 Chapter 5, *Effects* 9-17
9.7 Chapter 6, *Monitoring and Adaptive Management Program* 9-22
9.8 Chapter 7, *Plan Implementation* 9-23
9.9 Chapter 8, *Alternatives to Take* 9-28
9.10 Chapter 10, *Glossary* 9-29

Chapter 10 **Glossary of Terms 10-1**

Chapter 11 **List of Contributors 11-1**

Appendices

Appendix 1A, Evaluation of Special-Status Species for Coverage in the KIUC HCP

Appendix 3A, Species Accounts

Appendix 4A, Conservation Site Selection Process

Appendix 4B, KIUC Minimization Projects

Appendix 4C, Invasive Plant Species Control Methods

Appendix 5A, Variables Influencing Powerline Strike

Appendix 5B, Rapid Waterbird Powerline Collision Assessment

Appendix 5C, Light Attraction Modeling

Appendix 5D, Bayesian Acoustic Strike Model

Appendix 5E, Population Dynamics Model for Newell's Shearwater ('a'o) on Kaua'i

Appendix 5F, Population Dynamics Model for Hawaiian Petrel (*'ua'u*) on Kaua'i

Appendix 6A, KIUC Monitoring Protocols and Procedures for Protected Seabirds

Appendix 6B, KIUC Site Monitoring Protocols & Procedures for Protected Seabirds

Appendix 7A, Cost Model

List of Tables

Table ES-1 Covered Species ES-1
Table ES-2 Biological Goals and Objectives ES-7
Table ES-3 Covered Seabirds, Requested Take and Estimated Amount by Form of Take ES-17
Table ES-4 Explanation of Population Dynamics Model Scenarios Used for Effects Analysis ES-18
Table ES-5 Summary of Estimated Effects on Covered Waterbirds from Powerline Strikes ES-22
Table ES-6 Summary of Estimated Costs to Implement KIUC HCP ES-26
Table 1-1 Covered Species 1-5
Table 3-1 Major Hurricanes Affecting Kauaʻi: 1950 to 2018 3-10
Table 4-1 Biological Goals and Objectives and Applicable Conservation Measures 4-6
Table 4-2 Amount of Powerline Collision Minimization Activity by Year (2020–2023) 4-26
Table 4-3 Powerline Reconfiguration Projects Implemented in 2020 4-30
Table 4-4 Breeding Pairs of Newell's Shearwater (ʻaʻo) and Hawaiian Petrel (ʻuaʻu) at the HCP Conservation Sites in 2021, Based on Acoustic Monitoring Data 4-41
Table 4-5 Management Actions Implemented in Each Conservation Site 4-43
Table 5-1 Explanation of Population Dynamics Model Scenarios Used for Effects Analysis Purposes 5-19
Table 5-2 Newell's Shearwater (ʻaʻo) Requested Take by Unit of Take, and Estimated Amount by Form of Take 5-21
Table 5-3 Hawaiian Petrel (ʻuaʻu) Requested Take by Unit of Take, and Estimated Amount by Form of Take 5-22
Table 5-4 Band-Rumped Storm-Petrel (ʻakēʻakē) Requested Take and Estimated Amount by Form of Take 5-23
Table 5-5 Estimated Take of Covered Seabirds from Light Attraction After Minimization[a] 5-25
Table 5-6 Covered Seabirds Expected to be Rehabilitated and Released through the SOS Program, by Species 5-27
Table 5-7 Estimated Effects on Covered Waterbirds from Powerline Strikes 5-53
Table 5-8 Covered Waterbird Species Recovered or Rehabilitated and Released by SOS Program 5-54
Table 6-1 Schedule for HCP Compliance 6-8
Table 6-2 Compliance Monitoring Adaptative Management Triggers 6-9
Table 6-3 Adaptive Management Triggers for Take and Effectiveness Monitoring 6-21
Table 6-4 Average Number of Covered Species Rehabilitated by the SOS Program 6-42
Table 7-1 Thresholds of Changed Circumstance for Severe Weather and Natural Hazards (see text for details) 7-13
Table 7-2 Potential Effects and Potential Responses from Severe Weather 7-24
Table 7-3 Summary of Cost to Implement KIUC HCP 7-37
Table 7-4 Plan Administration Costs 7-39
Table 7-5 KIUC Spending on Implementation of Measures Similar to those in this HCP (in 2021 dollars, adjusted for inflation) 7-46

List of Figures

Figure ES-1 KIUC HCP Plan Area ES-3
Figure ES-2 KIUC Bird Flight Diverter Minimization Project Locations ES-10
Figure ES-3 KIUC Wire Minimization Project Locations ES-11
Figure ES-4 Conservation Sites ES-13
Figure ES-5 Newell's Shearwater (ʻaʻo) Population Dynamics Model: Island-wide Outcomes for All Scenarios ES-19
Figure ES-6 Population Dynamics Model Results for Hawaiian Petrel (ʻuaʻu) Island-wide for All Four Scenarios ES-20
Figure 1-1 KIUC HCP Plan Area 1-4
Figure 2-1 Covered Activities: Existing Facilities 2-4
Figure 2-2 Typical Wire Types and Heights of KIUC Powerlines 2-5
Figure 3-1 Topographic Relief of Kauaʻi 3-2
Figure 3-2 Slope Map of Kauaʻi 3-3
Figure 3-3 Perennial Rivers and Streams of Kauaʻi 3-5
Figure 3-4 Wetlands and Open Waters of Kauaʻi 3-6
Figure 3-5 Average Annual Rainfall on Kauaʻi, in Inches 3-8
Figure 3-6 Land Use Designations on Kauaʻi 3-13
Figure 3-7 Land Cover Types of Kauaʻi 3-15
Figure 4-1 High-Risk Powerline Spans for Waterbirds 4-21
Figure 4-2 KIUC Bird Flight Diverter Minimization Project Locations 4-27
Figure 4-3 KIUC Wire Minimization Project Locations 4-28
Figure 4-4 KIUC Powerline Reconfiguration Projects Implemented in 2020 4-31
Figure 4-5 Example of Full-Cutoff Shield Installed by KIUC on a Kauaʻi Streetlight 4-34
Figure 4-6 Conservation Sites 4-40
Figure 4-7 Predator Exclusion Fencing Design 4-48
Figure 4-8a Streetlights Visible from Green Sea Turtle Nesting Habitat at Keālia Beach in 2020 4-59
Figure 4-8b Streetlights Visible from Green Sea Turtle (honu) Nesting Habitat at Kapaʻa Shoreline in 2020 4-60
Figure 4-8c Streetlights Visible from Green Sea Turtle (honu) Nesting Habitat at Wailua Beach in 2020 4-61
Figure 4-8d Streetlights Visible from Green Sea Turtle (honu) Nesting Habitat at Poʻipū Shoreline in 2020 4-62
Figure 4-8e Streetlights Visible from Green Sea Turtle (honu) Nesting Habitat at Kukuiʻula Harbor and Poʻipū Shoreline in 2020 4-63
Figure 4-8f Streetlights Visible from Green Sea Turtle (honu) Nesting Habitat at Waimea Shoreline in 2020 4-64
Figure 4-8g Streetlights Visible from Green Sea Turtle (honu) Nesting Habitat at Kekaha Shoreline in 2020 4-65
Figure 5-1 Estimated Relative Rates of Bird Strikes per Wire Span 5-3

Figure 5-2 Newell's Shearwater (ʻaʻo) Population Dynamics Model: Island-wide Outcomes for All Scenarios 5-30
Figure 5-3 Population Dynamics Model Results for Newell's Shearwater (ʻaʻo) for Each Conservation Site 5-35
Figure 5-4 Population Dynamics Model Results for Newell's Shearwater (ʻaʻo) for Subpopulation Outside Conservation Sites 5-36
Figure 5-5 Population Dynamics Model Results for Newell's Shearwater (ʻaʻo) for all Conservation Sites Combined 5-37
Figure 5-6 Population Dynamics Model Results for Hawaiian Petrel (ʻuaʻu) Island-wide for All Four Scenarios 5-41
Figure 5-7 Population Dynamics Model Results for Hawaiian Petrel (ʻuaʻu) for Each Conservation Site 5-45
Figure 5-8 Population Dynamics Model Results for Hawaiian Petrel (ʻuaʻu) for Unmanaged Sites 5-46
Figure 5-9 Population Dynamics Model Results for Hawaiian Petrel (ʻuaʻu) for all Conservation Sites Combined 5-47
Figure 7-1 A map of the tracks of all hurricanes within 150 miles (241.4 km) of Kauaʻi (as depicted by the dashed circular outline) between 1950 and 2020, generated using NOAA's Historical Hurricane Tracks Mapbox interface 7-16
Figure 7-2 Annual count of the hurricanes formed in the central Pacific Ocean based on the National Hurricane Center's Hurricane Database (National Hurricane Center 2021), which shows no evidence of a directed trend in either increasing or decreasing directions. 7-16
Figure 7-3 Landslide Susceptibility Map for the Conservation Sites 7-22

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Executive Summary

ES.1 Introduction and Background

The Kaua'i Island Utility Cooperative (KIUC) is seeking incidental take authorization from the U.S. Fish and Wildlife Service (USFWS) and the Hawai'i Department of Land and Natural Resources (DNLR), Division of Forestry and Wildlife (DOFAW) for the continued operation and maintenance of existing and new KIUC infrastructure. KIUC's application requests coverage for a period of 50 years. The authorization is needed because some of this infrastructure is known to result in incidental take of the state and federally listed species shown in Table ES-1 and referred to as *covered species*. The KIUC activities potentially resulting in take are referred to as *covered activities* and include the continued operation and maintenance of KIUC's existing and future powerlines and lights, and implementation of the conservation measures.

Table ES-1. Covered Species

English Name	Hawaiian Name	Scientific Name	Status[a] (Federal/State)
Newell's shearwater	'a'o	*Puffinus auricularis newelli*	T/T
Hawaiian petrel	'ua'u	*Pterodroma sandwichensis*	E/E
Band-rumped storm-petrel[b]	'akē'akē	*Oceanodroma castro*	E/E
Hawaiian stilt	ae'o	*Himantopus mexicanus knudseni*	E/E
Hawaiian duck	koloa maoli	*Anas wyvilliana*	E/E
Hawaiian coot	'alae ke'oke'o	*Fulica alai*	E/E
Hawaiian common gallinule	'alae 'ula	*Gallinula galeata sandvicensis*	E/E
Hawaiian goose	nēnē	*Branta sandvicensis*	T/E
Green sea turtle[c]	honu	*Chelonia mydas*	T/T

[a] Status:
E = Listed as endangered under the federal ESA or HRS Chapter 195D.
T = Listed as threatened under the federal ESA or HRS Chapter 195D.
[b] Hawai'i distinct population segment.
[c] Central North Pacific distinct population segment.

KIUC is seeking an incidental take permit (ITP) from USFWS under Section 10(a)(1)(B) of the federal Endangered Species Act (ESA), and an incidental take license (ITL) from DOFAW under Sections 195D-4 and 195D-21 of the Hawai'i Revised Statutes (HRS). This KIUC Habitat Conservation Plan (HCP) supports the issuance of these permits.

KIUC is a public utility cooperative responsible for the production, purchase, transmission, distribution, and sale of electricity on the Island of Kaua'i (Kaua'i). To ensure reliable electrical service to Kaua'i, KIUC owns and operates a variety of electrical utility installations including fossil-fuel-fired, hydroelectric, and solar generating facilities, 17 substations and switchyards, and approximately 1,487 circuit miles (2,393 kilometers [km]) of transmission and distribution lines. KIUC also purchases power from several independent power producers and transmits power that it obtains from these sources through its electrical transmission system.

In May 2011, the USFWS approved KIUC's Short-Term Seabird Habitat Conservation Plan (Short-Term HCP) for a period of 5 years to help develop the knowledge base for a longer permit duration. The KIUC Short-Term HCP covered three seabird species: Newell's shearwater (ʻaʻo), Hawaiian petrel (ʻuaʻu), and band-rumped storm petrel (ʻakēʻakē). After KIUC's Short-Term HCP expired in 2016, KIUC agreed with USFWS and DOFAW to continue implementing the Short-Term HCP conservation measures and reporting until a longer-term HCP could be fully developed. During the Short-Term HCP term, KIUC initiated development of this HCP, adding six species for which the covered activities would potentially result in take, as listed in Table ES-1. This HCP describes potential effects on the nine listed species from KIUC's covered activities over a 50-year permit term. The HCP also describes a conservation strategy to avoid, minimize, and mitigate the effects from those activities during that timeframe and provide a net conservation benefit to each species.

ES.2 Plan Area and Permit Area

The *Plan Area* is the area in which all covered activities and conservation measures will occur. Because KIUC operates an island-wide system exclusively on Kauaʻi and is proposing conservation measures in remote areas of the island, the KIUC HCP Plan Area covers the full geographic extent of Kauaʻi (see Figure ES-1). The *Permit Area* is the specific locations of all covered activities and conservation measures (i.e., the geographic area where the federal ITP and State ITL apply); these locations are described in Chapter 2, *Covered Activities*, and in Chapter 4, *Conservation Strategy*.

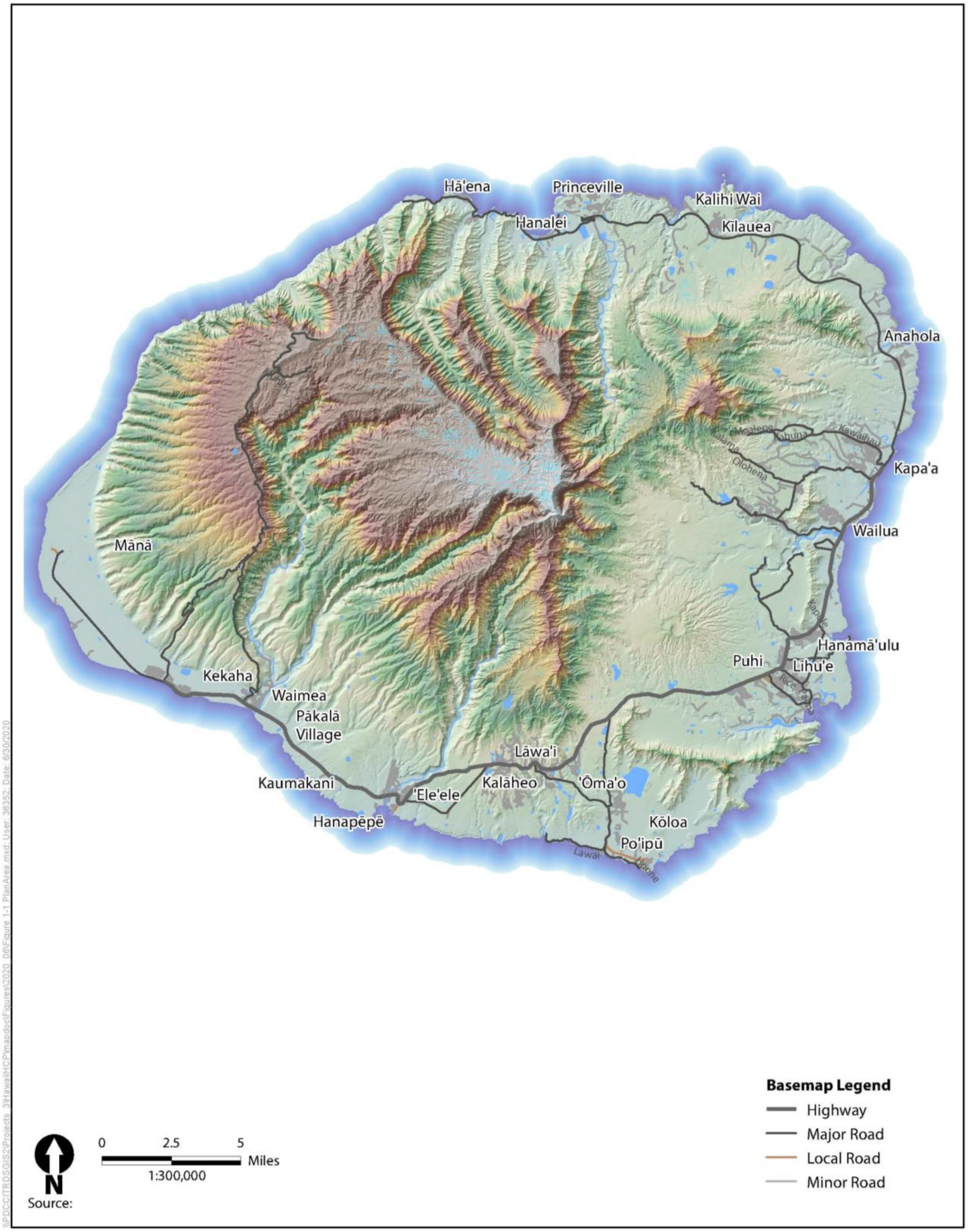

Figure ES-1. KIUC HCP Plan Area

ES.3 Covered Activities

This HCP and its permits are proposed to cover and provide incidental take authorization for KIUC activities that potentially result in take of the covered species. Covered activities must be "under the control" of the permit holder and occur within the permit term to receive coverage. Covered activities in the KIUC HCP are grouped into three broad categories: (1) powerline operations, (2) lighting operations, and (3) implementation of the HCP conservation strategy. The covered activities are listed below; detailed descriptions of the covered activities and their selection process are provided in Chapter 2, *Covered Activities*.

- Powerline operation, retrofit and use of night lighting for repairs. This includes:
    - 171 miles (275 km) of existing transmission wires
    - 816 miles (1,313 km) of existing distribution wires
    - 70 miles (113 km) of existing communication wires
    - Up to 348 miles (560 km) of new powerlines
- Lighting operations: facility, streetlights, and nighttime lighting. This includes:
    - Facility lights at the Port Allen Generating Station and Kapaia Power Generating Station
    - 4,100 existing streetlights
    - Up to 1,754 new streetlights
    - Up to 85 hours of emergency nighttime lighting for restoration of power
- Implementation of the HCP conservation strategy, including construction and maintenance of predator exclusion fences, predator control within and outside the exclusion fences, social attraction to attract covered seabirds to new nesting colony sites, and invasive plant species control.

ES.4 Environmental Setting

Kauaʻi has a land area of approximately 550 square miles (sq mi) (1,425 square kilometers [sq km]). Roughly circular in shape, its most striking physiographic features are a high central plateau of over 5,000 feet (ft) (1,524 meters [m]) at the summits of Mt. Waiʻaleʻale (5,148 ft [1,569 m]) and Mt. Kawaikini (5,243 ft [1,598 m]). The central plateau is characterized by steep cliffs and deeply incised valleys along the northern Nā Pali Coast, the 3,600-ft-deep (1,097 m) Waimea Canyon, the broad Līhuʻe Basin on the southeastern quadrant of the island, and extensive coastal plains. Kauaʻi supports breeding populations of the covered species, as described below.

ES.4.1 Covered Seabirds

The KIUC HCP covered seabirds are Newell's shearwater (ʻaʻo), Hawaiian petrel (ʻuaʻu), and the Hawaiʻi distinct population segment (DPS) of the band-rumped storm-petrel (hereafter band-rumped storm-petrel) (ʻakēʻakē). Kauaʻi supports 90 percent of the total Newell's shearwater (ʻaʻo) population (Pyle and Pyle 2009; Ainley et al. 2020) and 33 percent of the total Hawaiian petrel (ʻuaʻu) population (Raine pers. comm.). No band-rumped storm-petrel (ʻakēʻakē) nests have been located on Kauaʻi; however, based on auditory survey data, breeding likely occurs at several locations on Kauaʻi, primarily in the steep cliff areas of the Nā Pali Coast (Raine et al. 2017a).

The covered seabirds spend most of their time at sea and come to land only to breed (Ainley et al. 2014; Simons 1985; Spear et al. 2007). During the breeding season (generally March through December), they nest in burrows beneath ferns and tree roots in dense forest and on steep slopes and cliffs. Adult Newell's shearwaters (ʻaʻo) and Hawaiian petrels (ʻuaʻu) forage over the sea at night and fly to and from their burrows at night or at sunset or sunrise, to forage and feed their chicks (Raine et al. 2017b). Band-rumped storm-petrels (ʻakēʻakē) have been observed feeding during the day, but likely also feed at night (Harris 1969; Kauaʻi Endangered Seabird Recovery Project 2019).

For species with naturally low reproductive rates that rely on high adult survivorship, introduced threats that increase mortality rates, such as powerline collisions and invasive predators, have resulted in significant population declines. The covered seabirds share these characteristics of low reproductive rates and high adult survivorship, making their populations particularly vulnerable to introduced threats. All three of the covered seabird species have declined over the last few decades (Raine et al. 2017).

Covered seabirds on Kauaʻi are subject to the following threats (Slotterback 2002; State of Hawaiʻi Division of Forestry and Wildlife 2005).

- Depredation at breeding sites by introduced predators such as pigs (*Sus scrofia*), rats (*Rattus rattus*), feral cats (*Felis silvestris*), barn owls (*Tyto alba*), and feral honeybees (Raine et al. 2020).
- Loss and degradation of breeding habitat caused by introduced ungulates such as pigs and goats (*Capra hircus*) and introduced plants.
- Collisions with powerlines, buildings, and towers.
- Artificial lighting from various sources (e.g., streetlights, resorts), which attracts and causes "fallout" of seabirds and increases their chance of colliding with artificial structures.
- Pollution (e.g., mercury, plastic ingestion, oil spills).
- Factors affecting seabird prey availability in the ocean such as ocean acidification, overharvesting by the fishing industry as well as bycatch, and changing ocean conditions due to climate change.
- Extreme weather events such as storms and flooding (exacerbated with climate change).

The daily movement patterns of the covered seabirds between breeding and foraging habitats and their relatively low maneuverability make them particularly susceptible to colliding with artificial structures, predominantly utility lines (Travers et al. 2019, 2020a). Their nocturnal movements, in addition to the phototropic tendencies of fledglings (i.e., tendency to be attracted to light), make them susceptible to fallout from artificial lighting (Telfer et al. 1987).

ES.4.2 Covered Waterbirds

The KIUC HCP covered waterbirds are the Hawaiian stilt (aeʻo), Hawaiian duck (koloa maoli), Hawaiian coot (ʻalae keʻokeʻo), Hawaiian common gallinule (ʻalae ʻula), and the Hawaiian goose (nēnē). The covered waterbirds are endemic to Hawaiʻi.

Except for the Hawaiian goose (nēnē), the covered waterbird species are associated only with wetlands and open water habitat in Kauaʻi. Hawaiian geese (nēnē) use a wide variety of habitats, including highly altered landscapes such as pastures, agricultural fields, and golf courses (U.S. Fish and Wildlife Service 2004).

Long-term census data indicate that the statewide population of the covered waterbirds is stable or increasing (Paxton et al. 2022). The most consequential threat to the covered waterbird species has been the loss of wetland habitat. Environmental contaminants such as fuel spills, water pollution, and pesticides continue to degrade habitats that support covered waterbirds, and these species are also threatened by diseases such as avian botulism. Collisions with vehicles and structures (e.g., powerlines) are also a threat to the covered waterbirds. For example, when taking off and landing, the long, low flight path of the Hawaiian goose (nēnē) makes it vulnerable to collisions with stationary structures and moving objects such as vehicles and aircraft (Banko et al. 2020; State of Hawai'i Division of Forestry and Wildlife 2015). The most significant threat facing the Hawaiian duck's (koloa maoli) continued existence is hybridization with feral mallards; as a result, it is now among the rarest of the world's birds (Engilis et al. 2020).

ES.4.3 Green Sea Turtle

The Hawaiian population of the green sea turtle (honu) is a threatened population segment of this species identified as the Central North Pacific Distinct Population Segment (CNPDPS) (81 *Federal Register* 20057). The CNPDPS of the green sea turtle (honu) (hereafter green sea turtle) is also protected by Chapter 195D of the HRS and Section 13-124 of Hawai'i Administrative Rules. The range of the green sea turtle (honu) includes the Hawaiian Archipelago and Johnston Atoll.

Green sea turtles (honu) spend most of their lives in open coastline and protected bays and lagoons (Seminoff et al. 2015). On shore, green sea turtles (honu) rely on beaches characterized by intact dune structures, native vegetation, lack of artificial lighting, and normal beach temperatures for nesting (Limpus 1971; Salmon et al. 1992; Ackerman 1997; Witherington 1997; Lorne and Salmon 2007). In 2015, Parker and Balazs documented 20 nesting sites[1] around Kaua'i. Although nesting density is low (generally zero to two nests per year), observations of nesting have increased over the past 5 years (State of Hawai'i Division of Aquatic Resources 2020).

The decline of green sea turtle (honu) is primarily attributed to development and public use of beaches, vessel strikes, attraction to artificial lights, bycatch in fishing gear, pollution, interactions with recreational and commercial vessels, beach driving, and major storm events. The species is also threated by the effects of climate change, including habitat loss and warming sea and air temperatures, including increased sand temperatures (Schroeder and Mosier 2000).

ES.5 Conservation Strategy

The KIUC HCP conservation strategy includes measures to avoid, minimize, and mitigate the impact of the taking on covered species from covered activities and to provide a net benefit to each species. The conservation strategy relies on (1) implementing tools and techniques to minimize effects on covered species from the covered activities, and (2) managing designated areas on the landscape for the benefit of covered species.

[1] Nesting data reported from Kaua'i are speculative due to the lack of systematic surveys. Estimates may also be skewed toward high-use beaches and beaches that regularly have resting seals (as this is how green sea turtle [honu] nests have been opportunistically found).

ES.5.1 Conservation Framework

The conservation strategy is based on a set of biological goals and objectives for each covered species, shown in Table ES-2. Biological goals and objectives state the intentions of the HCP. The measurable biological objectives also become the threshold by which the success of the HCP will be judged. The conservation strategy consists of six conservation measures for meeting the biological goals and objectives, described in Section 1.4.2, *Conservation Measures.*

Table ES-2. Biological Goals and Objectives

Newell's Shearwater (ʻaʻo) (*Puffinus auricularis newelli*)
Goal 1. Provide for the survival of the Kauaʻi metapopulation of Newell's shearwater (ʻaʻo) and contribute to the species' recovery by minimizing and fully offsetting the impacts of KIUC's taking of this species over the term of the HCP to an extent that is likely to result in numbers of breeding pairs, demography and age structure, population growth rate, and spatial distribution that is representative of a viable metapopulation on Kauaʻi.
Objective 1.1. Substantially reduce the extent and effect of collisions of adult/subadult Newell's shearwaters (ʻaʻo) with KIUC powerlines island-wide, as measured against the pre-HCP strike estimate (Travers et al. 2020b), in accordance with the location, extent, and schedule outlined in the HCP.
Objective 1.2. Minimize the adverse effects of artificial light attraction on Newell's shearwater (ʻaʻo) fledglings from all existing and future KIUC streetlights and existing covered facilities by continuing to implement practicable conservation measures throughout the permit term.
Objective 1.3. Increase the number of Newell's shearwater (ʻaʻo) breeding pairs and new chicks produced annually throughout the duration of the permit by managing and enhancing suitable Newell's shearwater (ʻaʻo) breeding habitat and breeding colonies across 10 conservation sites and reducing the abundance and distribution of key seabird predators in northwestern Kauaʻi. The success of this objective will be measured by the following metrics within all of the 10 conservation sites combined: • Metric 1. Maintain an annual minimum of 1,264 breeding pairs as determined by call rates and burrow monitoring. • Metric 2. Reach a target of 2,371 breeding pairs by year 25 of the permit term and 4,313 breeding pairs by the end of the permit term. • Metric 3. Growth rate for breeding pairs annually of at least 1.0% as measured by a 5-year rolling average. • Metric 4. Maintain a 5-year rolling average 87.2% reproductive success rate. • Metric 5. Eradicate terrestrial predators within predator exclusion fencing. • Metric 6. Produce at least one breeding pair within each of the four social attraction sites by year 10 of the permit term • Metric 7. Ensure that invasive plant and animal species do not preclude meeting the objective metrics above.
Hawaiian Petrel (ʻuaʻu) (*Pterodroma sandwichensis*)
Goal 2. Provide for the survival of the Kauaʻi metapopulation of Hawaiian petrel (ʻuaʻu) and contribute to the species' recovery by minimizing and fully offsetting the impacts of KIUC's taking on this species over the term of the HCP to an extent that is likely to result in numbers of breeding pairs, demography and age structure, population growth rate, demography, and spatial distribution that is representative of a viable metapopulation on Kauaʻi.
Objective 2.1. Substantially reduce the extent and effect of collisions of adult/subadult Hawaiian petrels (ʻuaʻu) with KIUC powerlines island-wide, as measured against the pre-HCP estimate (Travers et al. 2020b) in accordance with the location, extent, and schedule outlined in the HCP.

Objective 2.2. Minimize the adverse effects of artificial light attraction on Hawaiian petrel (ʻuaʻu) fledglings from all existing and future KIUC streetlights and existing covered facilities by continuing to implement practicable conservation measures throughout the permit term.

Objective 2.3. Increase the number of Hawaiian petrel (ʻuaʻu) breeding pairs and new chicks produced annually throughout the duration of the permit by managing and enhancing suitable Hawaiian petrel (ʻuaʻu) breeding habitat and breeding colonies across 10 conservation sites and reducing the abundance and distribution of key seabird predators in northwestern Kauaʻi. The success of this objective will be measured by the following metrics within all of the 10 conservation sites combined:

- Metric 1. Maintain an annual minimum of 2,257 breeding pairs as determined by call rates and burrow monitoring.
- Metric 2. Reach a target of 2,926 breeding pairs by year 25 of the permit term and 3,751 breeding pairs by the end of the permit term.
- Metric 3. Growth rate for breeding pairs annually of at least 1.0% as measured by a 5-year rolling average.
- Metric 4. Maintain a 5-year rolling average 78.7% reproductive success rate.
- Metric 5. Ensure that invasive plant and animal species do not preclude meeting the objective metrics above.

Band-Rumped Storm-Petrel (ʻakēʻakē) (*Oceanodroma castro*)

Goal 3. Contribute to the recovery of the band-rumped storm-petrel (ʻakēʻakē) by reducing threats associated with existing and future KIUC streetlights, existing covered facility lights, and introduced predators on Kauaʻi.

Objective 3.1. Minimize artificial light attraction on band-rumped storm-petrel (ʻakēʻakē) fledglings from all existing and future KIUC streetlights and existing covered facilities by continuing to implement practicable conservation measures throughout the permit term.

Objective 3.2. Facilitate the rescue, rehabilitation, and release of band-rumped storm-petrel (ʻakēʻakē) fledglings through funding of the Save Our Shearwaters Program or other certified rehabilitation facility to offset light attraction by KIUC streetlights.

Objective 3.3. Implement predator control, including barn owl control, within the conservation sites to reduce threats to band-rumped storm-petrel (ʻakēʻakē) in areas near the conservation sites (e.g., Nā Pali Coast).

Covered Waterbirds: Hawaiian Coot (ʻalae keʻokeʻo) (*Fulica alai*), Hawaiian Gallinule (ʻalae ʻula) (*Gallinula galeata sandvicensis*), Hawaiian Stilt (aeʻo) (*Himantopus mexicanus knudseni*), Hawaiian Goose (nēnē) (*Branta sandvicensis*), and Hawaiian Duck (koloa maoli) (*Anas wyvilliana*)

Goal 4. Contribute to the recovery of covered waterbird species by reducing threats associated with KIUC powerlines on Kauaʻi.

Objective 4.1. Reduce covered waterbird collisions with KIUC powerlines in Hanalei and Mānā (Kawaiʻele Waterbird Sanctuary), in accordance with the location, extent, and schedule outlined in the HCP, and relative to measured collisions in 2021.

Objective 4.2. Facilitate the rescue, rehabilitation, and release of grounded covered waterbirds through funding of the Save Our Shearwaters Program or other certified rehabilitation facility to offset collisions with KIUC powerlines.

Green Sea Turtle (honu) (*Chelonia mydas*) (Central North Pacific Distinct Population Segment)

Goal 5. Contribute to the recovery of the species by increasing the ability for green sea turtles (honu) to successfully transit Kauaʻi beaches.

Objective 5.1. Locate and temporarily shield green sea turtle (honu) nests at all locations that are visually affected by KIUC streetlights on an annual basis.

Objective 5.2. For the duration of the permit permanently minimize light effects to the extent practicable from existing and future KIUC streetlights onto beaches with suitable green sea turtle (honu) nesting habitat by implementing practicable minimization techniques that will further reduce or eliminate these light effects.

ES.5.2 Conservation Measures

KIUC will implement or fund six conservation measures that, collectively, are expected to meet the biological goals and objectives summarized above. Below is a short summary of each conservation measure. Further details of each measure can be found in Chapter 4, Section 4.4, *Conservation Measures*.

ES.5.2.1 Conservation Measure 1. Implement Powerline Collision Minimization Projects

Minimization actions under this conservation measure include reconfiguration of powerlines (i.e., changing the profile from vertical to horizontal and reducing the number of layers), static wire removal, and installation of bird flight diverters to substantially reduce powerline collisions. Bird flight diverters are regularly spaced reflective or light-emitting diode (LED) devices that make powerlines more visible to birds, reducing the number of collisions.

KIUC began early implementation of powerline collision minimization projects in 2020, and by the end of 2023 (year 1 of HCP implementation) all practicable minimization projects will be complete on existing powerlines. Minimization will be implemented along a total of 188.1 miles (302.7 km) of existing powerlines by the end of 2023, with many of those miles having both static wire removal and bird flight diverter installation. This will result in static wire removal and bird flight diverters being installed throughout most of KIUC's powerline system, with an expected 65 percent reduction in powerline strikes for covered seabirds and 90 percent reduction in powerline strikes for covered waterbirds compared with 2018 conditions. Figures ES-2 and ES-3 show the location of each bird flight diverter and static wire minimization project identified in Appendix 4B, *KIUC Minimization Projects*. When constructing new transmission and distribution lines during the permit term, KIUC will avoid high-collision zones in the Plan Area to the maximum extent practicable and will design powerlines to minimize strike risk in addition to installing bird flight diverters.

This conservation measure applies to covered seabirds and covered waterbirds. This conservation measure is intended to support Objectives 1.1, 2.1, and 4.1 shown in Table ES-2.

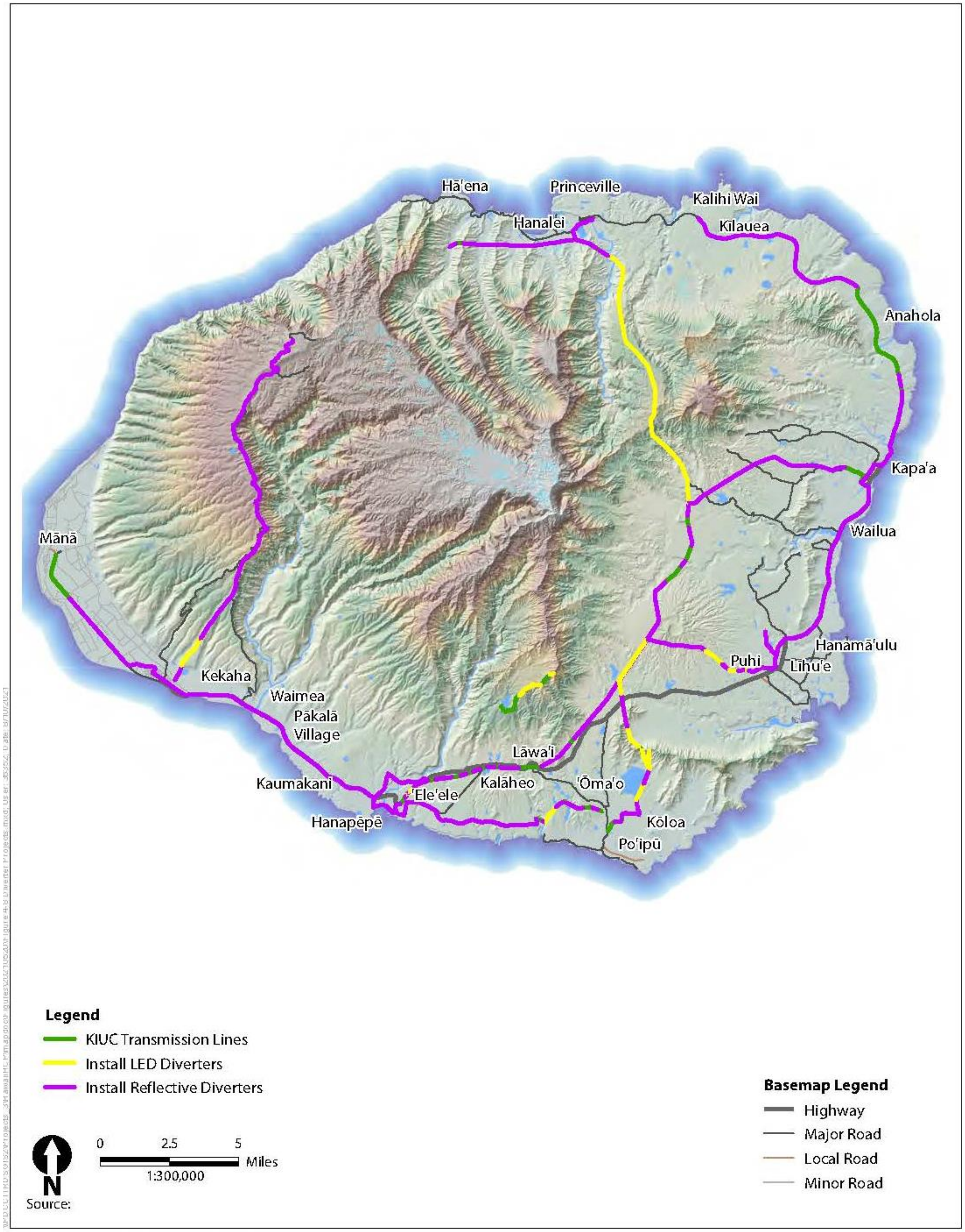

Figure ES-2. KIUC Bird Flight Diverter Minimization Project Locations

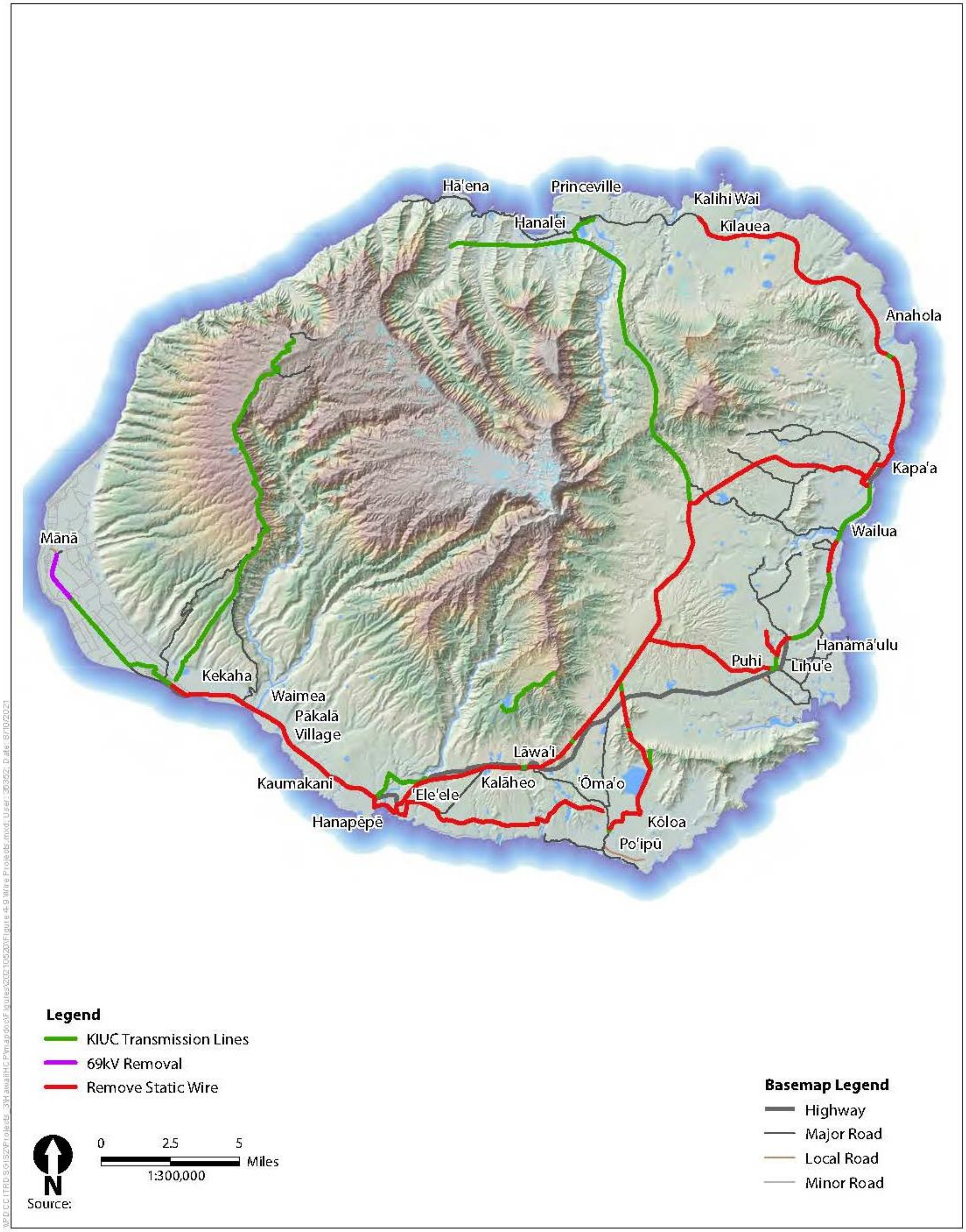

Figure ES-3. KIUC Wire Minimization Project Locations

ES.5.2.2 Conservation Measure 2. Implement Measures to Minimize Light Attraction

Minimization actions under this conservation measure include light attraction through the installation of full-cutoff shield fixtures and use of white bulbs, and dimming exterior night lighting during the fledgling fallout season. In 2017, all existing KIUC streetlights were retrofitted with full-cutoff shields to minimize light attraction, and all KIUC streetlights were converted from high-pressure sodium bulbs to more energy-efficient 3000-kilowatt LED bulbs. In 2019, KIUC replaced all green light bulbs in streetlights with white light bulbs to further reduce light attraction. Light from all new streetlights during the permit term will be similarly minimized. In addition, a predator removal program will be implemented to minimize depredation of light-attracted grounded seabirds.

This conservation measure only applies to the covered seabird species because they are the only covered species group affected by light attraction away from coastal locations. This conservation measure is intended to support Objective 1.2 shown in Table ES-2.

ES.5.2.3 Conservation Measure 3. Provide Funding for the Save our Shearwaters Program

KIUC began funding and largely implementing the Save our Shearwaters (SOS) Program with DOFAW in 2003. Under the HCP, KIUC will fund the SOS Program to a consistent level of $300,000 dollars per year (in 2021 dollars)[2] to rescue, rehabilitate, and release all covered seabirds and waterbirds found within the SOS Program's operational area on Kaua'i, regardless of the source of injury. KIUC will also employ a public outreach and education program, in coordination with the SOS Program, to inform and educate the public about the risks of powerline strikes and light attraction to the covered species on Kaua'i.

This conservation measure applies to covered seabirds (particularly band-rumped storm-petrel ['akē'akē]) and covered waterbirds. This conservation measure is intended to support Objectives 3.2 and 4.2 shown in Table ES-2.

ES.5.2.4 Conservation Measure 4. Manage and Enhance Seabird Breeding Habitat and Colonies at Conservation Sites

This conservation measure is intended to support Objectives 1.3, 2.3, and 3.3 shown in Table ES-2. KIUC will manage and enhance 10 conservation sites for the KIUC HCP (Figure ES-4). Nine of these sites have been selected, and the final location of the tenth site is still under evaluation. The final site is identified temporarily as "Conservation Site 10" and will occur in the area shown as a dashed purple line on Figure ES-4 in the northwest corner of Kaua'i. KIUC will select and commit to a specific location for Conservation Site 10 no later than the end of 2023 and before permit issuance. Details regarding the site selection process are provided in Appendix 4A, *Conservation Site Selection.*

[2] KIUC funding will increase annually to keep pace with inflation.

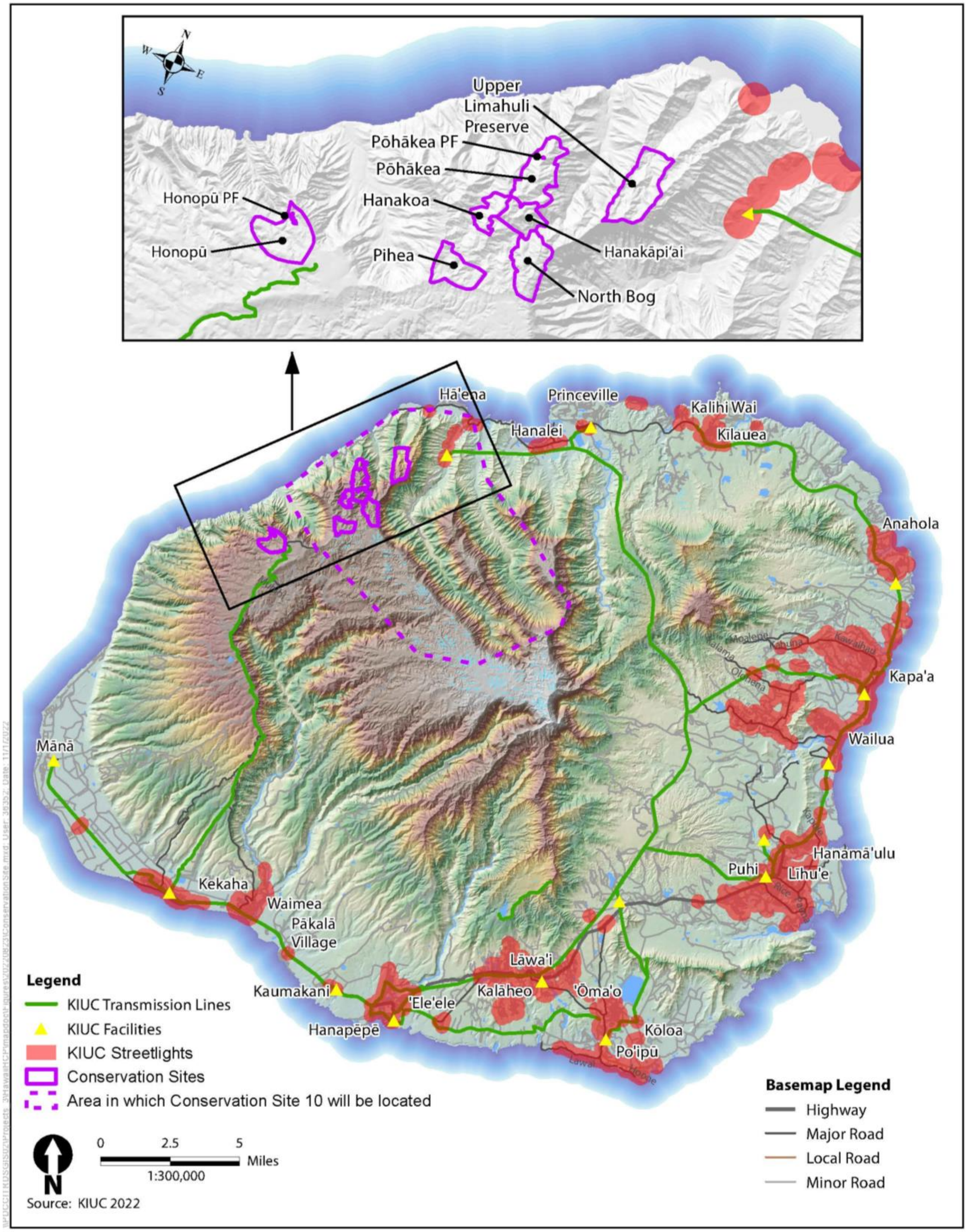

Figure ES-4. Conservation Sites

Designated conservation sites for the Newell’s shearwater (‘a‘o) and Hawaiian petrel (‘ua‘u) will continue to be managed as follows.

- Predator control measures will be implemented at all conservation sites and will be used to establish predator-free breeding habitat or substantially reduce predation, which is critical to successfully restore productive seabird colonies (Buxton et al. 2014; Jones and Kress 2012; Young et al. 2018; Raine et al. 2020). Barn owl and feral bee control will also be implemented where signs of these species are identified. Terrestrial predator control methods may include traps, bait stations, snares, hunting, and other control methods.
- Predator exclusion fencing will be maintained that are impenetrable to most introduced terrestrial predators including feral cats, rats, pigs, and goats. KIUC will establish these fences at four locations: Pōhākea PF and Honopū PF[3], Upper Limahuli Preserve, and Conservation Site 10. The remaining conservation sites occur within existing ungulate exclusion fence that was constructed and is maintained by other entities, and additional fencing will not be required at these locations.
- Social attraction techniques will be used to expand existing colonies and establish new colonies at conservation sites within otherwise suitable breeding habitat. Social attraction methods will include removal of unsuitable vegetation and replanting with native species, installation of artificial burrows, and broadcasting calls in the restored habitat during peak breeding season (April through mid-September). Social attraction will be implemented at Upper Limahuli Preserve, Pōhākea PF, Honopū PF, and Conservation Site 10.
- Invasive plant control will be implemented within the Upper Limahuli Preserve and Upper Mānoa Valley conservation sites. Invasive plant species control at the other conservation sites will occur on an as-needed basis, when species are documented during monitoring and determined to be spreading or otherwise problematic.

ES.5.2.5 Conservation Measure 5. Implement a Green Sea Turtle Nest Detection and Temporary Shielding Program

This conservation measure is intended to support Objective 5.1 shown in Table ES-2. A nest detection and shielding program will be implemented to minimize and offset the effects of light attraction on green sea turtles (honu) from KIUC streetlights. Nest shielding will initially be installed on seven beaches identified by KIUC and USFWS as having suitable green sea turtle (honu) nesting habitat and KIUC streetlights that have been documented as being visible from that habitat. The nest shielding will be installed when active green sea turtle (honu) nests are detected via drone surveys or volunteer monitors. Light-proof fencing will be erected around the nest after approximately 45 days of incubation to minimize the potential for vandalism. After the green sea turtle (honu) hatchlings have emerged and entered the ocean, the fence will be removed and evidence of hatching will be reported to USFWS, DOFAW, and the State of Hawai‘i Division of Aquatic Resources (DAR) within 24 hours. Unhatched eggs, deceased hatchlings, or samples of either will be sent to the National Oceanic and Atmospheric Administration by a permitted biologist for DNA analysis. Annual monitoring will occur on all beaches on Kaua‘i to allow for continual updates to the nest shielding program by identifying additional beaches that may require shielding as well as removing locations where environmental conditions change and light attractant risks are removed. All staff and

[3] DOFAW are currently constructing these fences, KIUC will be responsible for management and maintenance during the permit term.

volunteers will be required to complete an annual training provided by USFWS, DOFAW, DAR or trainers approved by USFWS, DOFAW, and DAR, that will allow them to recognize green sea turtle (honu) tracks, signs of nesting, and hatchling activity, as well as the proper techniques for installing a temporary light shield. These measures will be implemented over the 50-year permit term unless KIUC is able to demonstrate to USFWS, DOFAW, and DAR that permanent modification of existing and future streetlights fully avoids take of green sea turtles (honu) (see Conservation Measure 6).

ES.5.2.6 Conservation Measure 6. Identify and Implement Practicable Streetlight Minimization Techniques for Green Sea Turtle

This conservation measure is intended to support Objective 5.2 shown in Table ES-2. Measures implemented to minimize the impact of streetlights on the covered seabirds (Conservation Measure 2) do not reduce streetlight visibility to green sea turtle (honu) hatchlings. As of 2020, KIUC and USFWS identified 29 streetlights that are visible from suitable green sea turtle (honu) nesting habitat within the Plan Area. Additional modifications are needed to reduce light attraction of green sea turtle (honu) hatchlings at these locations without compromising public health or safety. KIUC will work with the County and State to determine the range of available practicable minimization measures and their timeline for implementation. Light minimization techniques may include additional shielding or change in wattage. If no practicable minimization measures can be agreed upon, KIUC would not be required to implement this conservation measure further, and instead would continue to implement the temporary shielding required under Conservation Measure 5 throughout the life of the permit term. If new locations are identified as beaches and the surrounding vicinity changes over time or new streetlights are installed that could cast light onto suitable green sea turtle (honu) habitat, the same light minimization techniques agreed upon for the existing 29 streetlights will be implemented for any additional streetlights identified throughout the permit term.

ES.6 Effects on Covered Species

Effects on the covered species have been evaluated using a systematic, scientific analysis of the estimated adverse, beneficial, and net effects as a result of the HCP covered activities and their effects pathways. Effects are summarized below by species group: covered seabirds, covered waterbirds, and green sea turtle (honu).

ES.6.1 Effects on Covered Seabirds

KIUC activities result in four sources of take of covered seabirds: collisions with powerlines, light attraction from streetlights, facility lights and nighttime lighting, and predator trapping at the conservation sites. The covered seabirds collide with powerlines, static wires, and fiber optic cables owned and operated by KIUC along their flight paths between the ocean feeding areas and montane breeding habitats (Travers et al. 2020a). KIUC operates streetlights, external lights at its covered facilities, and night lighting for emergency restoration of power; artificial lighting often attracts the covered seabirds (primarily fledglings), and after flying around the lights, the seabirds can tire or inadvertently hit a structure and may become grounded, an event referred to as fallout (Imber 1975; Telfer et al. 1985). The conservation strategy may also result in a minimal amount of take of covered seabirds as individual birds may be inadvertently caught in leg hold or other traps placed for invasive predator control. The following sections summarize methods and results for estimating the level of take from each covered activity, the effects of take on the covered seabirds, the beneficial effects of the conservation strategy, and the net effects considering both the adverse effects of take and the beneficial effects of the conservation strategy.

ES.6.1.1 Take Analysis: Methods

To quantify take of Newell’s shearwater (‘a‘o) and Hawaiian petrel (‘ua‘u) from powerlines, KIUC used acoustic monitors that recorded bird collisions at key locations and applied a Bayesian model as described in Appendix 5D, *Bayesian Acoustic Strike Model*. While acoustic monitoring provides data on the number of birds colliding with lines, these data cannot provide information on the species colliding with the powerlines or the proportion of those collisions that result in injuries or mortality (Travers et al. 2021). Travers et al. (2021) therefore used observations of seabird powerline collisions to estimate the proportion of collisions by species and the post-collision outcomes. KIUC reduced annual take estimates based on projected results of powerline minimization measures, and estimated take from planned new powerlines by extrapolating from calculations for existing powerlines. KIUC also calculated changing annual collisions over time as a function of changing abundance and powerline strike minimization (see Appendix 5E, *Population Dynamics Model for Newell’s shearwater (‘a‘o) on Kaua‘i*, and Appendix 5F, *Population Dynamics Model for Hawaiian petrel (‘ua‘u) on Kaua‘i*, for a detailed description of this step). There have been no direct observations of band-rumped storm-petrel (‘akē‘akē) colliding with powerlines (Travers et al. 2021), and a reliable collision estimate could not be determined, although if they were hitting the lines in large numbers they would have probably been observed because other small species that are somewhat difficult to detect such as bats that have struck powerlines have been documented (Raine pers. comm). Instead, a small amount of take was estimated for this species independent of the calculations described herein.

To calculate take of Newell’s shearwater (‘a‘o) and Hawaiian petrel (‘ua‘u) from streetlights, KIUC assigned fallout documented by the SOS Program to streetlights based on the proportional contribution of those lights to the lightscape of Kaua‘i. The proportional assessment was developed using remotely sensed radiance (brightness) data collected by a sensor on the Suomi National Polar-Orbiting Partnership Satellite (Cao et al. 2020). The process used to estimate fledgling fallout due to streetlights is described in Appendix 5C, *Light Attraction Modeling*. For the covered facilities, take was estimated using the average number of downed birds located at each facility as documented in KIUC monitoring logs (Kaua‘i Island Utility Cooperative 2019) and the SOS database. KIUC assumes that all fallout from covered activities results in mortality of each covered species, except when SOS rescues are successful. The population dynamics model assumes 100 percent of fallout results in mortality.

Impacts on band-rumped storm-petrel (‘akē‘akē) from light attraction are difficult to estimate because it is a very small and cryptic seabird that is difficult to find once grounded. KIUC set a total take limit 40 of band-rumped storm-petrel (‘akē‘akē) over the 50-year permit term.

To estimate the number of covered seabirds anticipated to be taken as a result of trapping predators at conservation sites, KIUC estimated annual rates of injuries and mortalities based on trapping data from 2015 through 2022 for six of KIUC’s longest running conservation sites and extrapolated based on assumed trapping efforts during the 50-year permit term.

To estimate indirect take of eggs and chicks as a result of powerline collisions, KIUC assumed every breeding adult injury or mortality resulted in the loss of an egg or chick that breeding season. KIUC assumed 20 percent of powerline collisions consisted of breeding adults, and 100 percent of mortality or injury from predator trapping consisted of breeding adults.

ES.6.1.2 Take Analysis: Results

Table ES-3 provides the requested take amount by unit of take for Newell's shearwater ('a'o), Hawaiian petrel ('ua'u), and band-rumped storm-petrel ('akē'akē), respectively. KIUC requests all forms of take (injury, mortality, indirect take of eggs and chicks) associated with the requested take by unit of take. That is, the requested take is quantified by unit of take, and take will be measured during implementation by unit of take, but the estimated resulting breakdown of injuries, mortalities, and indirect take cannot be measured during implementation. Chapter 5, *Effects*, provides the estimated breakdown for each species in terms of injury, mortality, and indirect take of eggs and chicks that was incorporated into the population dynamics model. The following sections summarize effects on each of the covered seabirds.

Table ES-3. Covered Seabirds, Requested Take and Estimated Amount by Form of Take

	Type of Take	Unit of Take	Requested Take by Unit of Take (50 years)	Percent of Total Take for the Species
Newell's shearwater ('a'o)	Existing and new powerlines	Powerline strikes	35,236	88%
	Existing streetlights	Fallout	3,345	8%
	New streetlights	Fallout	1,025	3%
	Facilities	Fallout	260	1%
	Conservation program	Individuals caught in traps	177	<1%
	Total		**40,043**	**100%**
Hawaiian petrel ('ua'u)	Existing and new powerlines	Powerline strikes[f]	21,196	97%
	Existing streetlights	Fallout	200	1%
	New streetlights	Fallout	60	<1%
	Facilities	Fallout	5	<1%
	Conservation Program	Individuals caught in traps	315	1%
	Total		**21,776**	**100%**
Band-rumped storm-petrel ('akē'akē),	Existing and new powerlines	Powerline strikes	22	21%
	Existing streetlights	Fallout	35	34%
	New streetlights	Fallout	46	45%
	Facilities	Fallout	0	0%
	Conservation Program	Individuals caught in traps	0	0%
	Total		**103**	**100%**

ES.6.1.3 Effects Assessment

To assess effects on Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu), KIUC used a custom population dynamics model for the Kauaʻi metapopulation.[4] Appendix 5E, *Population Dynamics Model for Newell's Shearwater (ʻaʻo) on Kauaʻi* describes the model and results for Newell's shearwater (ʻaʻo). Appendix 5F, *Population Dynamics Model for Hawaiian Petrel (ʻuaʻu) on Kauaʻi* describes the model and results for Hawaiian petrel (ʻuaʻu). The modeling framework allows each subpopulation to have its own set of vital rate values and therefore different trends in abundance through time. The vital rates for each subpopulation were also modeled to change through time as management efforts continue to be implemented and increase their benefits to the species, corresponding to the timeline of these measures described in Chapter 4, *Conservation Strategy*. Island-based estimates of abundance for each subpopulation were used to initialize population trajectories, which were then projected forward in time through the 50-year permit term. The model compared four scenarios outlined in Table ES-4.

Table ES-4. Explanation of Population Dynamics Model Scenarios Used for Effects Analysis

Scenario	Take from KIUC Activities	KIUC HCP Powerline Minimization	KIUC HCP Conservation Strategy	Purpose
No-Take	No	Yes (100% strike reduction)	No	A hypothetical scenario in which the take proposed for authorization under the HCP does *not* occur. This scenario isolates factors that are *not* related to the proposed take, so that impacts of the proposed take during the permit term can be clearly evaluated.
Unminimized Take	Yes	No	No	A scenario in which powerline minimization measures attributed to this HCP do not occur. This scenario isolates the beneficial effects of KIUC's minimization measures by comparing outcomes with unminimized take versus the proposed take.
Proposed Take	Yes	Yes	No	A scenario in which the proposed, minimized take occurs, but with no additional measures to offset impacts. The purposes of this scenario are to compare against the no take, unminimized take, and HCP scenarios for analyzing effects of the proposed take, the minimization, and the compensatory mitigation, respectively.
HCP	Yes	Yes	Yes	This is the scenario proposed in the HCP, including the minimized take and the compensatory mitigation of the conservation strategy. The HCP scenario is compared against the other scenarios to evaluate the adverse, beneficial, and net effects of implementing the HCP.

[4] A metapopulation is a group of populations that periodically interbreed. Newell's shearwater (ʻaʻo) populations on Kauaʻi are recognized as a distinct metapopulation (Vorsino 2016).

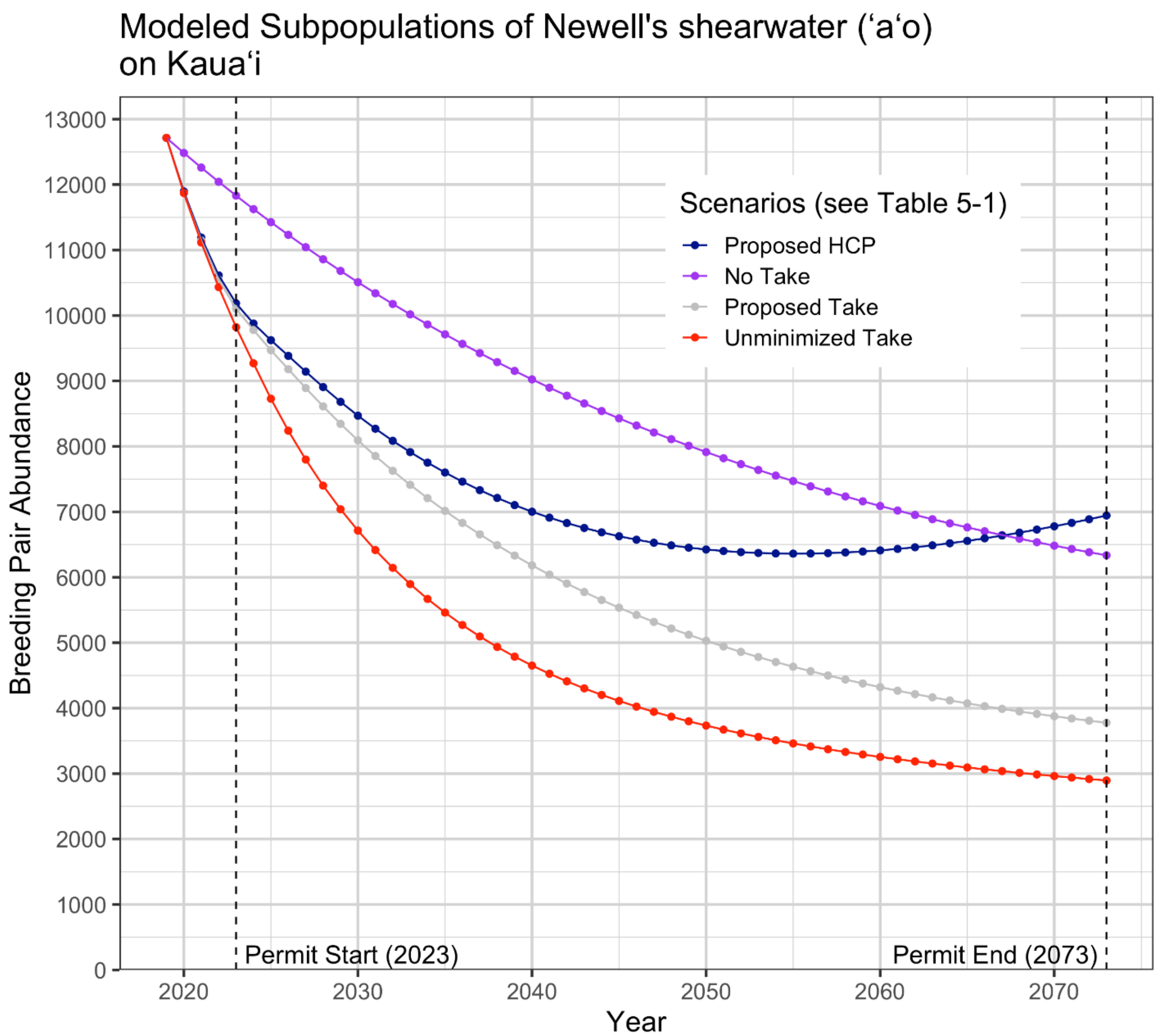

Figure ES-5. Newell's Shearwater (ʻaʻo) Population Dynamics Model: Island-wide Outcomes for All Scenarios[5]

[5] See Table ES-4 for a description of each scenario evaluated to assess effects of the take and the conservation strategy. See Appendix 5E, *Population Dynamics Model for Newell's Shearwater (ʻaʻo) on Kauaʻi* for details on the model structure and assumptions.

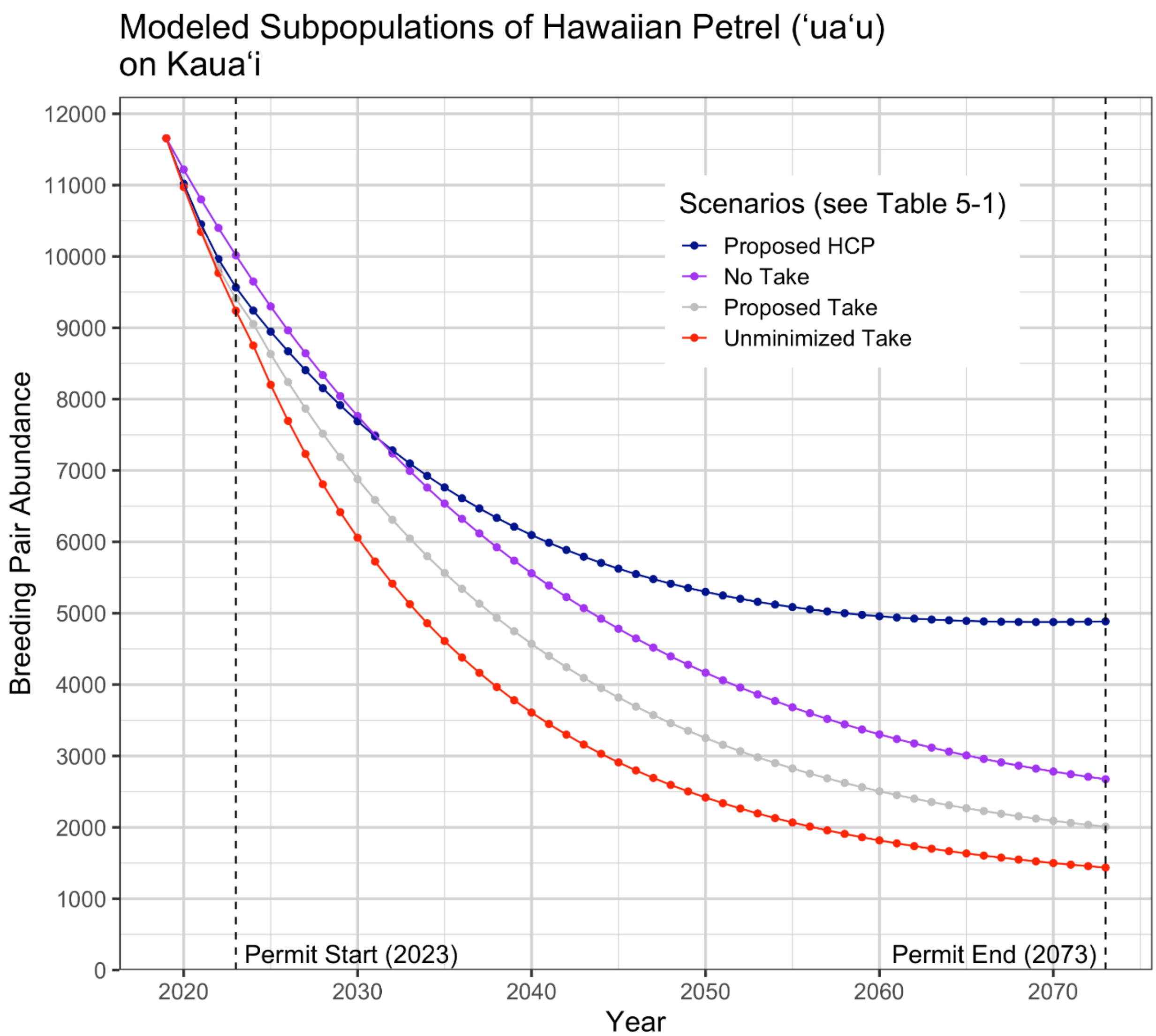

Figure ES-6. Population Dynamics Model Results for Hawaiian Petrel (ʻuaʻu) Island-wide for All Four Scenarios

Impact of the Taking

To evaluate the impacts of the taking on Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu), the hypothetical no-take scenario was compared with the proposed take scenario. The results are shown by comparing the purple line with the grey line in Figures ES-5 and ES-6.

As shown with the purple line on both figures, in the hypothetical absence of take related to KIUC operations during the permit term and without the proposed conservation measures,[6] the Kauaʻi metapopulation would continue to decline. This assessment shows that the effects of predation and

[6] Since KIUC powerlines are already in operation and their removal would be infeasible, this no-take scenario is hypothetical and used only as a basis for evaluating the impact of the proposed taking that would occur under this HCP on the species.

other threats to the species are substantial even without the adverse effects of KIUC's covered activities.

As shown by the grey line on both figures, even with minimization, the continued loss of Newell's shearwaters ('a'o) and Hawaiian petrel ('ua'u) as a result of KIUC covered activities could have an appreciable negative effect on the Kaua'i metapopulations of these species in the absence of mitigation measures to offset these effects.

The worldwide population size of the band-rumped storm-petrel ('akē'akē) is uncertain, but is most likely around 150,000 birds (Appendix 3A, *Species Accounts*). The Hawai'i DPS of the band-rumped storm-petrel ('akē'akē) represents a small, remnant population of possibly 400–500 birds or an estimated 221 breeding pairs (U.S. Fish and Wildlife Service 2020). The loss of 108 band-rumped storm-petrels ('akē'akē) over the 50-year permit term (an average of approximately 2 birds per year), is not likely to have an appreciable effect on the survival and recovery of the Hawai'i DPS of band-rumped storm-petrel ('akē'akē).

Beneficial and Net Effects

To evaluate the beneficial effects of powerline minimization on Newell's shearwater ('a'o) and Hawaiian petrel ('ua'u), KIUC compared the unminimized take scenarios with the minimized take scenarios. As shown by comparing the red and grey lines on Figures ES-5 and ES-6, the proposed minimization measures result in substantially reduced levels of metapopulation decline for both species. In the absence of these conservation measures to offset impacts, however, the metapopulations continue to decline for both species.

To evaluate the beneficial effects of the conservation strategy (minimization and mitigation) on Newell's shearwater ('a'o) and Hawaiian petrel ('ua'u), KIUC compared the unminimized take scenarios with the HCP scenario. As shown by comparing the red and dark blue lines on Figures ES-5 and ES-6, the metapopulation sizes at the end of the 50-year permit term are substantially greater for both species under the HCP scenario than under the unminimized take scenario, demonstrating the beneficial effects of the conservation strategy.

To evaluate net effects of the HCP on Newell's shearwater ('a'o) and Hawaiian petrel ('ua'u), considering both adverse effects of the take and beneficial effects of the conservation strategy, KIUC compared the HCP scenario with the hypothetical no-take scenario. For both species, the HCP results in net beneficial effects on the species in that metapopulation numbers are greater and population trends are more positive under the HCP scenario than under the hypothetical no-take scenario. For Newell's shearwater ('a'o), the net benefit in metapopulation numbers is not realized until approximately 2067, but a shift toward positive population growth begins at approximately 2055 and there is a strong upward trend by the end of the permit term. For Hawaiian petrel ('ua'u), the net benefit in metapopulation numbers occurs as early as year 15 of the permit term, and the population trends stabilize by the end of the permit term.

The SOS Program (funded mostly by KIUC) is expected to minimize and partially offset effects of powerline strikes for band-rumped storm-petrel ('akē'akē). Based on SOS data from 2009 through 2019, an estimated 20 band-rumped storm-petrels ('akē'akē) will be rescued and released over the 50-year permit term, minimizing, and partially offsetting the 44 mortalities from KIUC covered activities conservatively estimated for this species over the permit term. Although no band-rumped storm-petrels ('akē'akē) have been observed at the conservation sites to date, the species is likely to benefit from predator control at the Honopū conservation site because of its proximity to the Nā Pali

Coast where most band-rumped storm-petrel (ʻakēʻakē) are thought to occur on Kauaʻi. Barn owl control at all conservation sites is likely to benefit band-rumped storm-petrel (ʻakēʻakē) by reducing predation at their breeding sites from these wide-ranging predators. KIUC expects funding of the SOS Program, in addition to the conservation measures for the other two covered seabird species, are sufficient to offset the impact of the taking on band-rumped storm-petrel (ʻakēʻakē). Considering both the take associated with KIUC activities and the effects of SOS recoveries and regional predator control, the KIUC HCP will have a net benefit to band-rumped storm-petrels (ʻakēʻakē) on Kauaʻi.

ES.6.2 Effects on Covered Waterbirds

The covered waterbirds are susceptible to powerline strikes but not susceptible to light attraction, so the analysis focuses only on estimating the effects of powerline strikes. The effects analysis for covered waterbirds is based on an assessment provided as Appendix 5B, *Rapid Waterbird Powerline Collision Assessment*. A combination of acoustic data of recorded strikes and observations of waterbird behavior around powerlines were used to estimate powerline collisions for three of the covered waterbirds: Hawaiian stilt (aeʻo), Hawaiian duck (koloa maoli), and Hawaiian goose (nēnē). Observational and acoustic data were not available for Hawaiian common gallinule (ʻalae ʻula) or Hawaiian coot (ʻalae keʻokeʻo), so strike estimates were not developed for these species. Rather, analysis of grounded bird detections was used to estimate the number of powerline mortalities (not strikes) for these two species. The resulting take estimates for the 50-year permit term are provided in Table ES-5. KIUC requests take of the covered waterbirds associated with 74 percent of all KIUC powerline collisions along powerline spans in Mānā (spans 1–113) and Hanalei (spans 462–478 and 1297–1328) during the permit term.

Rescue and recovery efforts through the SOS Program will minimize and offset the number of covered waterbird mortalities from powerline strikes. In addition, the SOS Program is expected to fully offset mortalities through the rescue, recovery, and release of waterbirds back into the wild that are affected by factors unrelated to KIUC's covered activities (e.g., botulism). Rescuing, treating, and releasing covered waterbirds in this situation contributes to the species recovery by increasing their survival and reproduction. The final column in Table ES-5 provides the projected 50-year total of recoveries based on the annual average number of individuals of each covered waterbird species recovered or released from the SOS Program from 2012 through 2019, which is when SOS consistently collected data on waterbirds. As shown in Table ES-5, the number of recoveries exceeds the number of mortalities for all the covered waterbird species. As these species are stable or increasing on Kauaʻi despite ongoing loss resulting from powerline collisions, the proposed take is not expected to adversely affect the survival or recovery of the species on Kauaʻi and the SOS recoveries are expected to provide a net benefit for the covered waterbird species.

Table ES-5. Summary of Estimated Effects on Covered Waterbirds from Powerline Strikes

Covered Species	50-Year Injury[a]	50-Year Powerline Mortality[a]	50-Year Projected SOS Rehabilitation[a]
Hawaiian stilt (aeʻo)	28	65	69
Hawaiian duck (koloa maoli)	94	219	763
Hawaiian coot (ʻalae keʻokeʻo)	17	42	219
Hawaiian common gallinule (ʻalae ʻula)	67	167	175
Hawaiian goose (nēnē)[f]	215	502	1,106

[a] See footnotes in Table 5-7 for explanations as to how these numbers were calculated.

ES.6.3 Effects on Green Sea Turtle

Adverse effects of lights on green sea turtle (honu) hatchlings are well documented throughout the species' range, where hatchlings become disoriented by lights when heading back to sea from nests on the beach and die from dehydration, predation, or vehicle collisions. Green sea turtles (honu) have been documented to be vulnerable to these effects from KIUC streetlights in close proximity to suitable green sea turtle (honu) nesting habitat.

KIUC conducted a field evaluation in 2020 to assess the extent to which KIUC streetlights might affect green sea turtles (honu), and to evaluate where additional minimization measures are needed. Seven beaches were determined to have streetlights that were visible from potentially suitable green sea turtle (honu) nesting habitat at the time of the evaluation.

Based on a low average annual nesting density of green sea turtles (honu) at all Kaua'i beaches and presumed efficacy of the minimization measures described in Section 1.4.2, *Conservation Measures*, KIUC assumes that with the monitoring and minimization measures, most or all take resulting from KIUC streetlights will be avoided. Despite this, KIUC requests take authorization of 50 green sea turtle (honu) nests over the 50-year permit term, which is equivalent to an average of one nest every year. Take of any hatchlings in a nest of any type (disorientation, injury, or mortality) will count as take of that nest. This requested take accounts for the possibility of green sea turtle (honu) nests going undetected by monitors and not being temporarily shielded from a KIUC streetlight. Alternatively, temporary shielding may be ineffective at some nest sites due to incorrect placement or vandalism, in which case hatchlings may be affected by KIUC streetlights.

The estimated number of female green sea turtles (honu) that nest in the Plan Area is only 0.39 percent of the total breeding females estimated for the entire CNPDPS of green sea turtle (honu) (Seminoff et al. 2015). Of 20 nesting sites documented on Kaua'i, all but two were described as having intermittent or indeterminate use (Parker and Balazs 2015). The loss of up to 50 nests over a 50-year period resulting from KIUC streetlights, where most or all of the take is expected to consist of small fraction of the hatchlings in each nest, is not expected to adversely affect the population or appreciably reduce the likelihood of the species' survival and recovery in the wild.

The green sea turtle (honu) monitoring and minimization measures will not only minimize take resulting from KIUC streetlights (possibly to zero) but is also expected to minimize take resulting from other proximate light sources. On six of the seven beaches identified[7] in KIUC's 2020 streetlight assessment, most of the light is from sources other than KIUC streetlights, including residential buildings, commercial buildings (e.g., restaurants, resorts, shopping centers), and beach infrastructure (e.g., restrooms, parking lot lighting, walking path lighting). As described in Chapter 4, *Conservation Strategy*, KIUC's nest shielding program will shield any nests that have even the smallest potential to be affected by KIUC streetlights. This will result in the shielding of green sea turtle (honu) nests affected by non-KIUC light sources. As such, the take of hatchlings in up to 50 nests over 50 years is expected to be fully offset through the reduction of take from non-KIUC light sources. The nest shielding program is also expected to provide a net conservation benefit to green sea turtle (honu) because over the 50-year permit term KIUC will be shielding more nests than would be affected by their own streetlights.

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[7] At the Kekaha Shoreline, the primary light source is KIUC streetlights. Surrounding lights in the vicinity are sparse and therefore contribute little to the beach lightscape.

ES.7 Monitoring and Adaptive Management

Chapter 6, *Monitoring and Adaptive Management Program*, of the KIUC HCP describes the monitoring and adaptive management program. The purposes of this program are to do the following.

- Ensure that KIUC remains in compliance with the HCP, the federal ITP, and the State ITL.
- Ensure take of the covered species does not exceed the maximum limits set by the federal ITP and State ITL.
- Evaluate the effectiveness of the conservation measures (Chapter 4, *Conservation Strategy*) on an ongoing basis and identify when adaptive management must be applied to improve their effectiveness.

For compliance monitoring KIUC has included in Chapter 6, *Monitoring and Adaptive Management Program*, a compliance schedule and adaptive management triggers and responses for all relevant compliance monitoring actions (see Table 6-2 in Chapter 6). Compliance monitoring and adaptive management will allow KIUC to document that all the requirements of the HCP are being met and will allow USFWS and DOFAW[8] to determine, using the success metrics in Table 6-2, whether the HCP is on track both in terms of scope and schedule.

The take monitoring under the KIUC HCP compares the actual take that occurs during implementation to ensure KIUC does not exceed the 50-year take limit authorized by the federal ITP and State ITL. Table 6-2 describes triggers for adaptive management responses if take levels are higher than expected based on 5-year rolling averages of take during HCP implementation.

Chapter 6, *Monitoring and Adaptive Management Program*, of the KIUC HCP also includes monitoring and adaptive management triggers and responses to ensure the effectiveness of the HCP's conservation measures. DOFAW and USFWS will be participate in adaptive management decisions, although KIUC will have discretion over day-to-day adjustments to the conservation strategy that do not rise to the level of adaptive management as detailed in Chapter 6. Table 6-3 of the HCP includes the monitoring strategies, metrics of success, adaptive management triggers, and adaptive management responses for all the HCP's conservation measures.

ES.8 Plan Implementation

Chapter 7, *Plan Implementation*, of the KIUC HCP describes how KIUC will implement the HCP. The chapter describes the following topics.

- Implementation responsibilities of KIUC, USFWS, and DOFAW (Section 7.2, *Implementation Responsibilities*).
- Regulatory assurances requested for this HCP under the federal ESA and HRS (Section 7.3, *Regulatory Assurances*);
- Estimated costs of HCP implementation (Section 7.4, *Costs of KIUC HCP Implementation*) and funding assurances (Section 7.5, *Funding Assurances*).

[8] And DAR, when green sea turtle (honu) is involved.

- The process to revise or amend the HCP during implementation (Section 7.6, *Revisions and Amendments*).
- Requirements for annual reporting to USFWS and DOFAW (Section 7.7, *Annual Reporting*).

ES.8.1 Implementation Responsibilities

KIUC is responsible for implementing the conservation and other implementation actions described in the HCP. USFWS and DOFAW will have the responsibility during HCP implementation for reviewing and verifying reports submitted by KIUC for completeness and compliance; determining whether KIUC is making progress towards achieving the biological goals and objectives and implementing all applicable requirements of the HCP; making recommendations to KIUC regarding adaptive management changes according to the adaptive management process described in Chapter 6, *Monitoring and Adaptive Management Program*; coordinating with KIUC as necessary to stay informed about HCP implementation; and providing technical advice to KIUC, as necessary or requested. Additionally, DOFAW will be responsible for providing HCP Annual Reports to the Endangered Species Recovery Committee (ESRC) for their review and recommendations for adaptive management, considering recommendations from the ESRC regarding adaptive management or other changes to the HCP to improve its effectiveness, and coordinating with USFWS and KIUC regarding these recommendations.

ES.8.2 Regulatory Assurances

No Surprises assurances are provided by the federal ESA through the "No Surprises" rule (50 Code of Federal Regulations [CFR] Section 17.22.32). This rule provides assurances to ITP holders that USFWS will not require the commitment of additional land, water, or financial compensation; or additional restrictions on the use of land, water, or other natural resources beyond the level otherwise agreed to in the HCP without the consent of the permittee. The HRS provides for regulatory "incentives" in Section 195D-23 that are similar to the regulatory assurances provided by the federal ESA. The State cannot, in order to protect a threatened or endangered species, "impose additional requirements or conditions, or modify any existing requirements or conditions to mitigate or compensate for changes in the conditions or circumstances of any species or ecosystem, natural community, or habitat covered by the [HCP]." Allowable exceptions are described in Chapter 7, Section 7.3, *Regulatory Assurances.*

Consistent with the No Surprises regulations, the KIUC HCP identifies and analyzes reasonably foreseeable changed circumstances that could affect a species or geographic area during its term (50 CFR Section 17.3). Changed circumstances addressed in the HCP include effects of severe weather, natural hazards, and climate change, new invasive species, disease outbreaks in the covered species, vandalism, and population declines due to issues at sea. Should one or more of the changed circumstances described in the HCP occur, KIUC is required to implement the measures specified in Section 7.3.3, *Changed Circumstances Addressed by this HCP*, to respond to the changes. KIUC is not required to implement remedial actions for any unforeseen circumstances, which are also defined in the same section.

ES.8.3 Costs and Funding

The cost to implement the KIUC HCP is summarized in Table ES-6.

Table ES-6. Summary of Estimated Costs to Implement KIUC HCP

Cost categories	50-year total HCP cost (2023–2073)[a]	Percentage of 50-year total HCP cost
Plan Administration	$20,665,000	7.8%
Powerline Collision Minimization	$23,006,640	8.7%
Save Our Shearwaters Program	$15,000,000	5.7%
Manage and Enhance Conservation Sites	$80,607,204	30.4%
Green Sea Turtle Nest Detection and Temporary Shielding Program	$5,205,000	2.0%
Infrastructure Monitoring and Minimization Program	$26,995,544	10.2%
Seabird Colony Monitoring Program	$47,649,648	18.0%
State Compliance Monitoring	$2,500,000	0.9%
Changed Circumstances	$28,646,679	10.8%
Adaptive Management	$12,868,745	4.9%
Contingency	$1,749,762	0.6%
Total	**$264,894,222**	**100.0%**

[a] Costs are expressed in 2021 dollars.

KIUC has the financial capacity and commits to fully fund all costs of the KIUC HCP summarized in Table ES-6. To ensure funding for adaptive management and for remedial measures should they be needed to address changed circumstances, KIUC will secure a letter of credit in an amount sufficient to fund a reasonable proportion of expected adaptive management or remedial actions in any one year, as described in Section 7.5, *Funding Assurances*. Costs for implementation of the KIUC HCP are part of KIUC's operational costs, which will be passed on to all KIUC ratepayers. KIUC's costs for implementation of the KIUC HCP are anticipated to be fully covered by its revenues received, electricity rates charged, and debt financing.

KIUC has demonstrated its ability to fund HCP implementation since 2011. Since 2016, KIUC has continued to implement many of the same conservation measures in the Short-Term HCP that are now part of this HCP. In addition, KIUC has implemented many powerline collision minimization projects during both the Short-Term HCP and afterwards, as early implementation actions for this HCP. This track record of funding many of the same conservation actions since 2016 provides assurances to USFWS and DOFAW that KIUC will be able to fully fund HCP implementation.

ES.8.4 Revisions and Amendments

There are two types of changes that may be made to the HCP: minor modifications or major amendments. Minor modifications are changes to the HCP provided for under the operating conservation program, including adaptive management changes and responses to changed circumstances. Minor modifications also include revisions that do not increase the levels of authorized incidental take or do not materially modify the scope or nature of effects on the covered species from activities or actions covered by the ITP and State ITL. USFWS and DOFAW will confirm receipt of any modification request and will notify KIUC acknowledging the minor modification or determining if such modification request constitutes a major amendment.

Major amendments are changes in the HCP that may affect the impact analysis or conservation strategy. Amendments to the HCP and either the ITP or State ITL follow the same formal application and review process as the original HCP and permits, including National Environmental Policy Act/ Hawaiʻi Environmental Protection Act[9] review, *Federal Register* notices, an internal Section 7 consultation by USFWS, and approval by the ESRC and the Board of Land and Natural Resources.

[9] HRS Chapter 343.

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Chapter 1
Introduction and Background

1.1 Overview and Background

1.1.1 Applicant: Kauaʻi Island Utility Cooperative

The Kauaʻi Island Utility Cooperative (KIUC) is a not-for-profit, tax-exempt cooperative association governed by a publicly-elected nine-member Board of Directors.[1] As a public utility responsible for the production, purchase, transmission, distribution, and sale of electricity on the Island of Kauaʻi (Kauaʻi), KIUC is regulated by the State of Hawaiʻi (state) Public Utility Commission, and is required by law to provide and ensure the availability of electrical service on the island of Kauaʻi. KIUC is entirely owned by its members, which total approximately 34,000 ratepayers.

To ensure reliable electrical service to Kauaʻi, KIUC owns and operates a variety of electrical utility installations. These installations include fossil-fuel-fired, hydroelectric, and solar generating facilities, 17 substations and switchyards, and approximately 1,487 circuit miles of transmission and distribution lines. KIUC also purchases power from several independent power producers and transmits power that it obtains from these sources through its electrical transmission system.

1.1.2 Need for the KIUC Habitat Conservation Plan

KIUC's electrical transmission and distribution system is largely above ground and consists of wires supported by poles or towers that extend from 25 to more than 100 feet above ground. Three species of seabirds listed under the federal Endangered Species Act (federal ESA) are known to collide with these powerlines. Such collisions often result in injury or mortality of the affected birds. In addition to powerline collisions, lights at KIUC facilities and KIUC streetlights[2] are known to attract and/or disorient listed seabirds, particularly fledglings making their first flights to sea. Birds that become disoriented by these lights can exhaust themselves by flying around the lighted areas before eventually landing on the ground (commonly referred to as *fallout*). Due to their physiology, these birds have difficulty regaining flight, so without intervention, they either succumb to starvation or dehydration, or are killed by invasive predators or vehicles.

The take of species (See Chapter 10, *Glossary of Terms*) protected by the federal ESA and its state law equivalent, the Hawaiʻi Revised Statutes (HRS) Chapter 195D, incidental to otherwise lawful activities, is prohibited unless authorized via an incidental take permit (federal ITP) issued by the U.S. Fish and Wildlife Service (USFWS) and an incidental take license (state ITL) issued by the State of Hawaiʻi Department of Land and Natural Resources (DLNR), Division of Forestry and Wildlife (DOFAW) (hereafter DOFAW), respectively. These permits are referred to collectively as the *take authorizations*. Applications for a federal ITP and state ITL are supported by a habitat conservation plan (HCP) that describes, among other things, the anticipated effects of the proposed taking on listed species; how those effects on the affected species will be avoided, minimized, and mitigated; and how the HCP will be funded.

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[1] KIUC was formed as a cooperative pursuant to the provisions of Chapter 421C of the Hawaiʻi Revised Statutes.

In May 2011, USFWS approved KIUC's *Short-Term Seabird Habitat Conservation Plan* (Short-Term HCP) for a period of 5 years. The Short-Term HCP addresses the following federal and state-listed seabirds which are known to be adversely affected by KIUC facilities.

- Newell's shearwater (‘a‘o) (*Puffinus auricularis newelli*)
- Hawaiian petrel (‘ua‘u) (*Pterodroma sandwichensis*)
- Hawai‘i distinct population segment of the band-rumped storm-petrel (hereafter band-rumped storm-petrel) (‘akē‘akē) (*Oceanodroma castro*)

Before the Short-Term HCP was prepared, relatively little was known about the distribution, population, and behaviors of the three listed seabirds on Kaua‘i, or the extent of the effects of KIUC's facilities and operations on these species. Thus, a central purpose of the Short-Term HCP was to have KIUC, in concert with multiple conservation partners, implement a suite of specific monitoring and research projects, and use the resulting new information to inform the development and implementation of a subsequent HCP that would have a longer permit duration.

At the time the take authorization for the Short-Term HCP was issued to KIUC in 2011, USFWS expected that KIUC would receive longer-term take coverage under the *Kaua‘i Seabird Habitat Conservation Plan* (KSHCP; Section 1.2.1, *Kaua‘i Seabird Habitat Conservation Plan*). However, by 2015, monitoring data suggested that KIUC's annual take would exceed the capacity of the KSHCP, prompting a decision by DOFAW that KIUC needed to prepare a separate long-term HCP covering only KIUC's facilities and operations that result in take of the three listed seabirds.

1.2 Relationship to Other Habitat Conservation Plans on Kaua‘i

1.2.1 Kaua‘i Seabird Habitat Conservation Plan

DOFAW and USFWS approved the KSHCP in 2020 and issued federal ITPs and state ITLs to the qualifying applicant. The KSHCP covers the effects of artificial nighttime lighting on the Newell's shearwater (‘a‘o), Hawaiian petrel (‘ua‘u), band-rumped storm-petrel (‘akē‘akē), and the Central North Pacific distinct population segment of the green sea turtle (hereafter green sea turtle) (honu) (*Chelonia mydas*). Take of listed species due to light attraction on Kaua‘i is an island-wide issue that adversely affects the above covered species and is collectively caused by many different entities (hotels and resorts, businesses, and government agencies). The duration of the KSHCP permits is 30 years and the geographic scope of the HCP is the entire island of Kaua‘i.

The structure of the KSHCP enables multiple parties on Kaua‘i to each hold their own federal ITP and state ITL for light attraction effects on the covered species at their particular facility under the coordinated framework of the KSHCP. This framework takes advantage of economies of scale and enables a pooling of funding resources to collectively implement mitigation activities to achieve the conservation goals of the KSHCP. The inclusion of eight entities[3] in the KSHCP involved the development of Participant Inclusion Plans that were approved by DOFAW and USFWS.

The KSHCP overlaps with the KIUC HCP in geographic scope and in coverage of the same three seabird species. Each of these plans addresses anticipated take of seabirds and sea turtles resulting from light attraction and includes conservation/mitigation measures to offset those impacts. The plans will be implemented separately.

1.2.2 Kauaʻi Lagoons Habitat Conservation Plan

Kauaʻi Lagoons LLC received approval from USFWS and DOFAW for the Kauaʻi Lagoons HCP in 2012. This HCP covers short-term construction and long-term resort and golf course operations at the approximately 600-acre Kauaʻi Lagoons Resort[4] in Līhuʻe. The Kauaʻi Lagoons HCP covers activities including new facility construction, general property operation and maintenance (including facility lighting), and public access and usage (e.g., driving, biking). The associated state ITL and federal ITP provide take authorization for Newell's shearwater (ʻaʻo), Hawaiian petrel (ʻuaʻu), band-rumped storm-petrel (ʻakēʻakē), Hawaiian stilt (aeʻo) (*Himantopus mexicanus knudseni*), Hawaiian coot (ʻalae keʻokeʻo) (*Fulica alai*), Hawaiian common gallinule (ʻalae ʻula) (*Gallinula galeata sandvicensis*), Hawaiian duck (koloa maoli) (*Anas wyvilliana*), and Hawaiian goose (nēnē) (*Branta sandvicensis*). The duration of the Kauaʻi Lagoons HCP is 30 years and the geographic scope is restricted to the resort property.

Although the Kauaʻi Lagoons HCP and the KIUC HCP provide take coverage for the same seabird and waterbird species and include light attraction of listed seabirds as a covered activity, there is no overlap in the location of KIUC streetlights and Kauaʻi Lagoon lights.

1.3 Scope of the KIUC HCP

1.3.1 Plan Area and Permit Area

The *Plan Area* is the area in which all covered activities and conservation measures will occur. Because KIUC operates an island-wide system exclusively on Kauaʻi and is proposing conservation measures in remote areas of the island, the KIUC HCP Plan Area covers the full geographic extent of Kauaʻi (see Figure 1-1). The *Permit Area* is the specific locations of all covered activities and conservation measures (i.e., the geographic area where the ITP applies); these locations are described in Chapter 2, *Covered Activities*, and in Chapter 4, *Conservation Strategy*.

[3] These entities include NCL (Bahamas Ltd.), The Princeville Resort Kauaʻi, Kauaʻi Marriott Resort, Kauaʻi Coffee Company, LLC, Sheraton Kauaʻi Resort (Starwood Resorts), County of Kauaʻi, Hawaiʻi Department of Transportation, and Alexander & Baldwin, Inc. The permit issued to Alexander and Baldwin, Inc. also covers their 11 subsidiaries and affiliates including A & B Properties Hawaii, LLC, Alexander & Baldwin, LLC, McBryde Sugar Company, LLC, McBryde Resources, Inc., Kukuiʻula Village, LLC, Kukuiʻula Development Company (Hawaii), LLC, KDC, LLC, ABP Waipouli, LLC, ABP LR1 LLC, ABP LR2 LLC, and ABP LR3 LLC.

[4] In 2015, the name of Kauaʻi Lagoons Resort was changed to Hōkūala Resort. In 2019–2020, the Hōkūala Community Association requested a minor amendment to change the name of the Kauaʻi Lagoons Habitat Conservation Plan to Hōkūala Habitat Conservation Plan. The minor amendment is pending further consideration by USFWS.

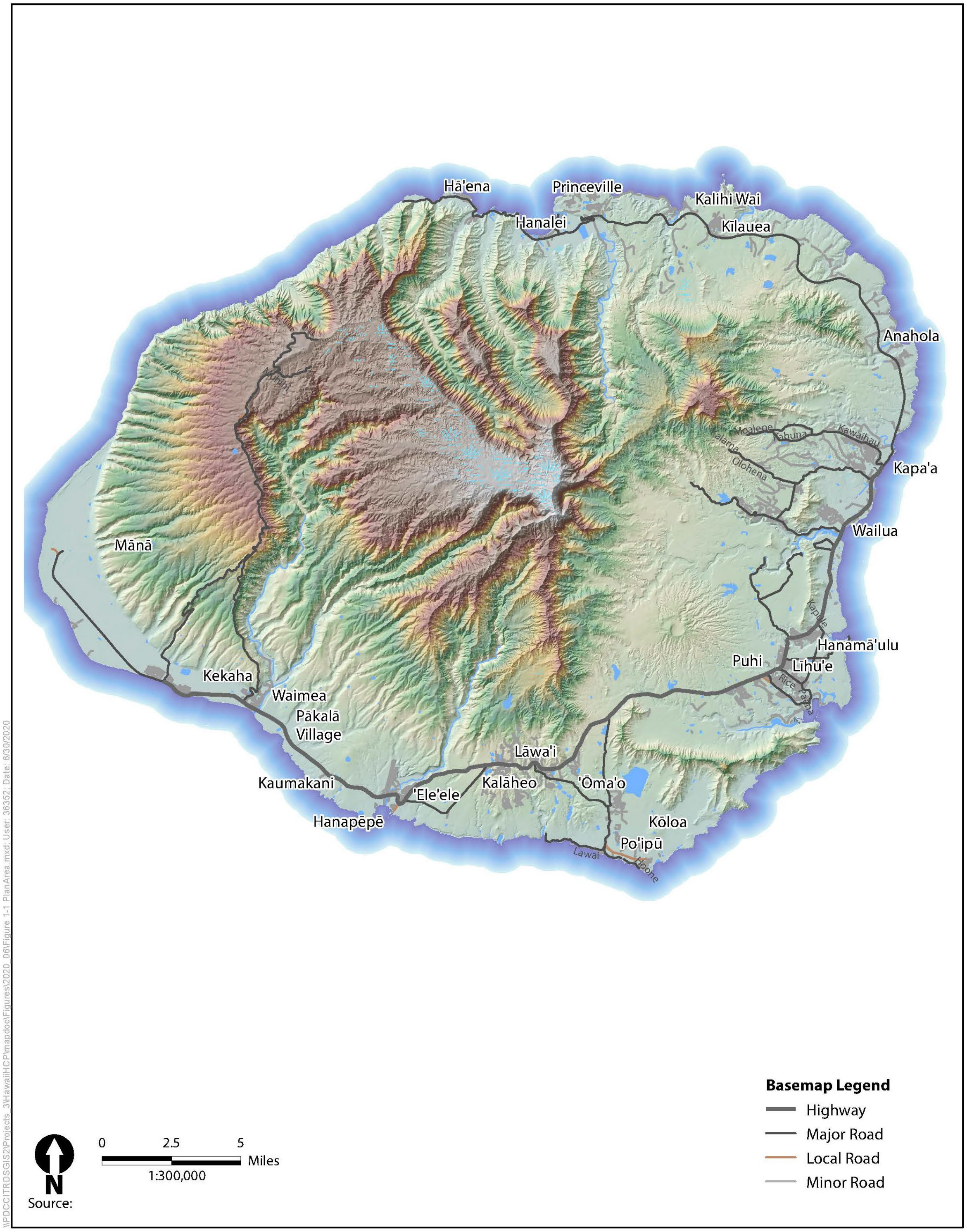

Figure 1-1. KIUC HCP Plan Area

1.3.2 Covered Species

Nine species are covered in this HCP and are referred to as *covered species* (Table 1-1). The covered species were selected based on their listing status and potential for the covered activities to result in take as defined by the federal ESA and state HRS Chapter 195D. Appendix 1A, *Evaluation of Special-Status Species Considered for Coverage*, describes the evaluation process and rationale by which KIUC selected the covered species.

Table 1-1. Covered Species

English Name	Hawaiian Name	Scientific Name	Status[a] (Federal/State)
Newell's shearwater	ʻaʻo	*Puffinus auricularis newelli*	T/T
Hawaiian petrel	ʻuaʻu	*Pterodroma sandwichensis*	E/E
Band-rumped storm-petrel[b]	ʻakēʻakē	*Oceanodroma castro*	E/E
Hawaiian stilt	aeʻo	*Himantopus mexicanus knudseni*	E/E
Hawaiian duck	koloa maoli	*Anas wyvilliana*	E/E
Hawaiian coot	ʻalae keʻokeʻo	*Fulica alai*	E/E
Hawaiian common gallinule	ʻalae ʻula	*Gallinula galeata sandvicensis*	E/E
Hawaiian goose	nēnē	*Branta sandvicensis*	T/E
Green sea turtle[c]	honu	*Chelonia mydas*	T/T

[a] Status:
E = Listed as endangered under the federal ESA or HRS Chapter 195D.
T = Listed as threatened under the federal ESA or HRS Chapter 195D.
[b] Hawaiʻi distinct population segment.
[c] Central North Pacific Region distinct population segment.

1.3.3 Covered Activities

Covered activities are those projects or ongoing activities that have the potential to take the covered species and for which KIUC is requesting take authorization. Covered activities include the continued operation and maintenance of many of KIUC's facilities; the construction, operation, and maintenance of certain future KIUC facilities; and implementation of the conservation measures described in this HCP. Covered activities are described in detail in Chapter 2, *Covered Activities*.

1.3.4 Permit Term

The *permit term* represents the period over which KIUC is authorized to incidentally take the covered species in conjunction with implementing the HCP. All conservation actions outlined in the HCP must also be completed within the permit term to offset the impacts of the covered activities on the covered species. KIUC is requesting take authorization from USFWS and DOFAW for 50 years. Accordingly, all assessments made in this HCP are based on a 50-year permit term.

This permit term was determined by KIUC as a reasonable timeframe to justify the significant investment in preparing and implementing this HCP. This period provides sufficient regulatory assurances to justify this investment and provides KIUC with the certainty it needs to continue to provide cost-effective electricity to its members on Kauaʻi. This permit term also provides enough time in which to implement the conservation strategy and conduct long-term biological monitoring to determine its effectiveness in offsetting the impacts of the taking of the covered species caused by covered activities. As discussed in Chapter 7, *Plan Implementation*, prior to the expiration of the KIUC HCP and the take authorizations, KIUC may apply to renew or extend the federal ITP, and the state ITL in accordance with applicable laws existing at that time.

1.4 Regulatory Context

1.4.1 Federal Endangered Species Act

The federal ESA provides for the conservation of endangered or threatened species and the ecosystems on which they depend. Section 9 of the federal ESA prohibits the take of endangered or threatened wildlife species without a special exemption. Under the federal ESA, the term *take* means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect listed species or to attempt to engage in any such conduct (16 United States Code [U.S.C.] 1532; 50 Code of Federal Regulations [CFR] 17.3). *Harm* includes significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns including, but not limited to, breeding, feeding, or sheltering (50 CFR 17.3). *Harass* is defined as intentional or negligent acts or omissions that create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt essential behavioral patterns including, but not limited to, breeding, feeding, or sheltering (50 CFR 17.3).

1.4.1.1 Federal Section 7 Process

Section 7 of the federal ESA requires all federal agencies to ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of critical habitat. To that end, proposed federal actions that may affect listed species or critical habitat trigger formal consultation with USFWS, unless a may affect, not likely to adversely affect determination is warranted. The proposed issuance of a federal ITP for this HCP is a federal action that triggers a formal ESA Section 7 consultation. Consultation begins when the federal agency submits a written request for initiation to USFWS, along with a biological assessment (BA) of its proposed action and when USFWS accepts that BA as complete. If USFWS concurs with the finding in the BA that the action is not likely to adversely affect a listed species or critical habitat, the action may be conducted without further review under the federal ESA. If not, formal consultation is conducted. The outcome of formal consultation is USFWS issuance of a biological opinion (BiOp) describing how the proposed federal agency action is likely to affect the listed species and its critical habitat, and whether the action complies with the federal ESA Section 7 mandate to avoid jeopardy and destruction/adverse modification of critical habitat. For this HCP, USFWS will consult internally (with itself) to comply with Section 7 of the federal ESA.

If the BiOp concludes the proposed federal action is likely to jeopardize the continued existence of a listed species or adversely modify its critical habitat, the BiOp will include “reasonable and prudent alternatives” to avoid those outcomes. If the BiOp concludes that the proposed federal action would take a listed species but would not jeopardize its continued existence or destroy or adversely modify critical habitat, the BiOp will include an incidental take statement exempting anticipated take. *Incidental take* “refers to takings that result from, but are not the purpose of, carrying out an otherwise lawful activity” (50 CFR 402.02). The incidental take statement accompanying the BiOp specifies the form, the amount or extent of anticipated take and reasonable and prudent measures and terms and conditions to minimize the impacts of the taking on the listed species and to specify monitoring and reporting requirements.

1.4.1.2 Federal Section 10 Process

Section 10(a) of the federal ESA establishes a process for non-federal entities to obtain authorization to incidentally take ESA-listed species. Private landowners, corporations, state agencies, local agencies, and other non-federal entities must obtain a Section 10(a)(1)(B) federal ITP for take of federally listed fish and wildlife species "that is incidental to, but not the purpose of, otherwise lawful activities." Submission of a conservation plan, generally referred to as an HCP, is required for all ESA Section 10 federal ITP applications. A detailed description of the HCP process is presented in the *Habitat Conservation Planning and Incidental Take Permit Processing Handbook* (HCP Handbook) (U.S. Fish and Wildlife Service and National Marine Fisheries Service 2016).

1.4.2 Hawai'i Revised Statutes, Chapter 195D

HRS Chapter 195D is the state's legislation corresponding to the federal ESA. Chapter 195D formally declares the state's policy to proactively ensure that the survival of indigenous aquatic life, wildlife, and plants and their habitat are perpetuated, and provides that any species listed as endangered or threatened pursuant to the federal ESA is automatically deemed to be an endangered or threatened species by the state. Section 195D-3 expressly prohibits, except as permitted by rules adopted by DOFAW, any person to take, possess, transport, transplant, export, process, sell, offer for sale, or ship any species that DOFAW has determined to need conservation (see also HRS Section 195D-4(e)). Under the HRS, *take* is defined similarly to the federal ESA as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect endangered or threatened species of aquatic life or wildlife, or to cut, collect, uproot, destroy, injure, or possess endangered or threatened species of aquatic life or land plants, or to attempt to engage in any such conduct.

HRS Section 195D-4(g) establishes a process for permitting incidental take. After consultation with the Endangered Species Recovery Committee (ESRC), the Board of Land and Natural Resources (BLNR) may issue a take authorization in the form of a temporary license as part of an HCP to allow take otherwise prohibited if the take is incidental to, and not the purpose of, carrying out an otherwise lawful activity. The role of the ESRC (Section 195D-25) is to provide guidance to DOFAW and BLNR on matters relating to endangered, threatened, proposed, and candidate species. The ESRC is comprised of biological experts, representatives of relevant federal and state agencies (e.g., USFWS, U.S. Geological Survey, DOFAW), and other appropriate governmental and non-governmental members. The ESRC reviews all HCP permit applications and makes recommendations to BLNR on whether they should be approved, amended, or rejected. The ESRC also reviews all existing HCPs and state ITLs annually to ensure compliance and makes recommendations for any necessary changes to existing HCPs.

1.5 Habitat Conservation Plan Process

The process for obtaining federal and state incidental take authorization has three phases: (1) the HCP development phase; (2) the permit application processing phase; and (3) if a permit is issued, the post-issuance/implementation phase.

1.5.1 HCP Development Phase

During the HCP development phase, the applicant prepares an HCP that includes a description of covered activities, covered species, the conservation program that will be implemented to avoid, minimize, and mitigate the impacts of anticipated taking of listed species, and funding assurances for implementation of the HCP. Based on the USFWS and National Marine Fisheries Service (2016) HCP Handbook, an HCP submitted in support of a federal ITP application must include the following information.

- A complete description of the activity(ies) for which take will be authorized.
- A determination of the type and potential amount of take of the covered species caused by covered activities, and specification of the impacts on the covered species likely to result from such taking.
- Steps and measures that the applicant will implement to avoid, minimize, and mitigate such impacts, to the maximum extent possible.
- Assurances that adequate funding will be made available to implement the avoidance, minimization, and mitigation measures proposed under the HCP.
- Procedures and funding to deal with changed circumstances.
- Alternative actions to such taking that were considered, and the reasons why such alternatives are not being utilized.
- A discussion of the biological goals and objectives of the HCP.
- A monitoring plan.
- An adaptive management plan.

Pursuant to HRS Section 195D-21(a), HCPs submitted in support of a state ITL must provide the following information.

- The geographic area encompassed by the HCP.
- The ecosystems, natural communities, or habitat types within the Plan Area that are the focus of the HCP.
- The endangered, threatened, proposed, and candidate species known or reasonably expected to occur in the ecosystems, natural communities, or habitat types in the Plan Area.
- The activities contemplated to be undertaken with sufficient detail to allow DOFAW to evaluate the impact of the activities on the ecosystems, natural communities, or habitat types within the Plan Area.
- The measures to be undertaken to protect, maintain, restore, or enhance those ecosystems, natural communities, or habitat types within the Plan Area.
- A schedule for implementation of the proposed measures and actions contained in the HCP.
- An adequate funding source to ensure that the proposed measures and actions contained in the HCP are undertaken in accordance with the schedule.

The HCP development phase concludes, and USFWS's permit processing phase begins when the applicant submits a complete permit application package to USFWS. HRS Section 195D-4(i) directs

DOFAW to work cooperatively with federal agencies to concurrently process federal ITP and state ITL permit applications pursuant to the federal ESA on a consolidated basis to the extent feasible to minimize procedural burdens upon the applicant.

1.5.2 Permit Processing Phase

Once an applicant submits a draft HCP and a complete federal ITP application, USFWS publishes a Notice of Availability of the draft HCP document (and the draft National Environmental Policy Act [NEPA] document that accompanies the draft HCP) in the *Federal Register* for a 30-day minimum public comment period on the potential issuance of a federal ITP based on the HCP. After a complete application has been received, USFWS initiates the internal ESA Section 7 consultation process addressing the effects of the HCP and the federal ITP action on listed species and critical habitat (Section 1.4.1.1, *Federal Section 7 Process*). The culmination of the consultation process is USFWS's issuance of a BiOp. The public comment period and consultation process are important feedback mechanisms during HCP development and can inform other measures the Secretary of the Interior may require as being necessary or appropriate for purposes of the plan pursuant to the authority for such measures under ESA Section 10(a)(2)(A)(iv).

When the BiOp is completed, USFWS prepares the required federal ESA findings under Section 10 and decides whether it will issue the federal ITP. These findings analyze whether the HCP meets each component of the Section 10 permit issuance criteria. The statutory and regulatory federal ITP issuance criteria for each covered species are listed below.

- The taking will be incidental to an otherwise lawful activity.
- The applicant will to the maximum extent practicable, minimize and mitigate the impacts of such taking.
- The applicant will ensure that adequate funding for the HCP will be provided.
- The HCP includes provisions to address any changed or unforeseen circumstances.
- The taking will not appreciably reduce the likelihood of survival and recovery of the listed species in the wild.
- The applicant will ensure that other measures required by USFWS as being necessary or appropriate will be met.
- USFWS has received assurances that the applicant will implement the HCP.

The State of Hawai'i's BLNR approval process for an HCP and issuance of the state ITL occurs in parallel with the federal process. DLNR reviews the HCP for consistency with state regulations on the take of listed species and the Office of Environmental Quality Control publishes a Notice of Availability of the draft HCP in its bulletin *The Environmental Notice* for a 60-day minimum public comment period.[5] During this time, the ESRC meets to review and provide comments on the draft HCP, conducts a site visit, reviews any revisions to the draft HCP resulting from public comment and USFWS consultation (DOFAW would also hold a public meeting on Kaua'i), and provides a recommendation to approve or deny the HCP/ITL application to BLNR. BLNR then decides to approve or deny the HCP/ITL application; if the HCP is approved, DOFAW issues the state ITL.

[5] At DLNR's discretion, the state public comment period can be initiated as soon as the public draft HCP is complete, prior to the federal comment period.

1.5.3 Implementation Phase

If the federal ITP and state ITL are issued, the applicant (now a permittee) will implement the HCP as described in the final HCP, the federal ITP, and state ITL. The applicant will prepare regular monitoring reports and will coordinate with USFWS as specified in the HCP and federal ITP. USFWS will monitor and review the permittee's compliance with the HCP and federal ITP, including the progress towards achieving the HCP's biological goals and objectives, over the entire permit term. In addition, the ESRC will review the HCP and state ITL on an annual basis to ensure compliance with all agreed upon activities and make recommendations for any necessary changes on the basis of available monitoring reports and scientific and other reliable data.

1.5.4 National Environmental Policy Act

NEPA requires federal agencies to analyze the environmental impacts of their discretionary decisions and ensure that environmental information is available to agency officials before decisions are made and before actions are taken. NEPA also ensures public scrutiny during project planning and decision-making. Depending on the scope and potential effects of the HCP, the federal agency usually prepares one of three environmental documents: (1) a categorical exclusion; (2) an environmental assessment; or (3) an environmental impact statement (EIS). The NEPA process helps federal agencies make informed decisions with respect to the environmental consequences of their actions and ensures that measures to protect, restore, and enhance the environment are included, as necessary, as a component of their actions.

Although the federal ESA and NEPA requirements overlap considerably, the scope of NEPA goes beyond that of the federal ESA by considering impacts of a federal action not only on fish and wildlife resources but also on other resources such as water quality, air quality, and cultural resources.

1.5.5 Migratory Bird Treaty Act

The Migratory Bird Treaty Act of 1918, as amended (MBTA), implements various treaties and conventions between the United States and Canada, Japan, Mexico, and the former Soviet Union for the protection of migratory birds. Under the MBTA, taking, killing, or possessing migratory birds is unlawful, as is taking of any parts, nests, or eggs of such birds (16 U.S.C. 703). Take is defined more narrowly under the MBTA than under the federal ESA and includes only the death or injury of individuals of a migratory bird species or their eggs. The MBTA defines migratory birds broadly; all covered birds in this HCP are considered migratory birds under the MBTA.

USFWS provides guidance regarding take of federally listed migratory birds (U.S. Fish and Wildlife Service and National Marine Fisheries Service 2016:Appendix 5). According to these guidelines, an incidental take permit can function as a Special Purpose Permit under the MBTA (50 CFR 21.27) for the take of all ESA-listed migratory birds that are covered by the HCP in the amount and/or number and subject to the terms and conditions specified in the HCP. Any such take would not be in violation of the MBTA (16 U.S.C. 703-12).

All the covered bird species identified in Table 1-1 are protected by the MBTA and listed under the federal ESA. Accordingly, once issued, the federal ITP will automatically function as a Special

Purpose Permit under the MBTA, as specified under 50 CFR 21.27, for these species for a 3-year term subject to renewal by KIUC.

Other migratory birds not covered by the HCP and that may be affected by the covered activities are discussed in the NEPA document for this HCP.

1.5.6 Hawaiʻi State Environmental Review Law

The State of Hawaiʻi Office of Environmental Quality Control facilitates the state's environmental review process pursuant to HRS Chapter 343 and its implementing regulations (Hawaiʻi Administrative Rules 11-200), also commonly known as the Hawaiʻi Environmental Protection Act. The office announces the availability of environmental assessments and EISs for public review and comment, as well as summaries of proposed actions and details of upcoming EIS public scoping meetings in its semi-monthly publication, *The Environmental Notice*. The office is responsible for environmental oversight and review and assists throughout the environmental review process.

1.5.7 National and State Historic Preservation Acts

The National Historic Preservation Act (NHPA) of 1966 (16 U.S.C. 470) established a comprehensive program to preserve the historical and cultural foundations of the nation as a living part of community life. Prior to implementing an *undertaking* (e.g., issuing a federal permit), Section 106 of the NHPA requires federal agencies to assess and determine whether the undertaking has the potential to affect historic properties that are on the National Register of Historic Places (National Register) or that are eligible for listing on the National Register, and to afford the Advisory Council on Historic Preservation and the State Historic Preservation Officer (SHPO) a reasonable opportunity to comment on any undertaking that may adversely affect such properties. NHPA Section 101(d)(6)(A) allows properties of traditional religious and cultural importance to a tribe or Native Hawaiian organization to be determined eligible for inclusion on the National Register if they meet the listing criteria. The Section 106 process normally involves step-by-step procedures that are described in detail in the implementing regulations (36 CFR 800) and summarized below.

- Establish if the proposed federal action constitutes an undertaking as defined in the NHPA.
- Delineate the Area of Potential Effect.
- Identify and evaluate historic properties in consultation with the SHPO and interested parties.
- Assess the effects of the undertaking on properties that are eligible for inclusion on the National Register.
- Where effects are present, consult with the SHPO, other agencies, and interested parties to develop an agreement that addresses the treatment of historic properties and notify the Advisory Council on Historic Preservation accordingly.
- Finally, proceed with the project according to the conditions of the agreement.

HRS Chapter 6E establishes a comprehensive program of historic preservation to promote the use and conservation of historic properties for the education, inspiration, pleasure, and enrichment of state citizens. HRS Section 6E-8 requires that before any agency or officer of the state or its political subdivisions commences any project that may affect an historic property, aviation artifact, or a burial site, the agency or officer must advise DOFAW and allow the department an opportunity for review of the effect of the proposed project and obtain its written concurrence before commencing. KIUC must comply with the requirements of this law and its regulations as it implements the avoidance, minimization, and mitigation measures that are part of the KIUC HCP.

1.6 Organization of the KIUC HCP

The KIUC HCP consists of the following sections.

- Chapter 1, *Introduction and Background*, provides an overview of KIUC as the applicant, the purpose and need for the KIUC HCP, and the regulatory framework within which the KIUC HCP is being prepared.
- Chapter 2, *Covered Activities*, describes KIUC’s existing and future activities that are covered by the KIUC HCP.
- Chapter 3, *Environmental Setting*, describes the existing conditions of the Plan Area relevant to the HCP.
- Chapter 4, *Conservation Strategy*, summarizes the conservation strategy and describes the specific conservation actions to be implemented to fully offset the impacts of the taking of covered species by covered activities, and to contribute to the recovery of the covered species.
- Chapter 5, *Effects*, presents the impacts of the covered activities on each of the covered species.
- Chapter 6, *Monitoring and Adaptive Management*, discusses the monitoring requirements and adaptive management procedures associated with implementation of conservation actions and reserve management.
- Chapter 7, *Plan Implementation*, discusses how the HCP is to be implemented and funded over time, including timeframes and success criteria.
- Chapter 8, *Alternatives to Take*, presents the required analysis of alternatives considered that would reduce take of the covered species but were rejected by KIUC and why they were rejected.
- Chapter 9, *References*, lists the documents and sources cited and relied upon in preparing this HCP.
- Chapter 10, *Glossary of Terms*, provides definitions for technical terms used in the HCP.
- Chapter 11, *List of Contributors*, provides a list of individuals that contributed to the HCP.
- Appendix 1A, *Evaluation of Special-Status Species for Coverage in the KIUC HCP*, lists the special-status species that were considered for coverage under this HCP, their legal status, their coverage under the HCP (covered or noncovered status), and the rationale for coverage. Attachments to this appendix provide additional detail on Hawaiian hoary bat (‘ōpe‘ape‘a) (*Lasiurus cinereus semotus*) and listed plant species, including avoidance and minimization measures that must be implemented during the 50-year HCP permit term.
- Appendix 3A, *Species Accounts*, presents detailed ecological accounts of all covered species, including modeling results of habitat distribution, that were developed for selected species.

- Appendix 4A, *Conservation Site Selection Process*, presents the methods and results for habitat suitability analyses and population distribution modeling that were conducted to inform the conservation site selection process.
- Appendix 4B, *KIUC Minimization Projects*, presents a spreadsheet of all KIUC's completed and planned powerline flight diverters and static wire removal projects.
- Appendix 4C, *Invasive Plant Species Control Methods*, present the invasive plant species control methods that are currently employed (and will continue to be employed during HCP implementation) within the conservation sites
- Appendix 5A, *Variables Influencing Powerline Strike*, presents the methods and results for estimating take of the covered seabird species caused by light attraction due to KIUC streetlights and lights at KIUC facilities on Kaua‘i.
- Appendix 5B, *Rapid Waterbird Powerline Collision Assessment*, describes each of the variable influencing powerline strikes, with an emphasis on the covered seabirds.
- Appendix 5C, *Light Attraction Modeling*, presents the methods and results for estimating take of the covered seabird species caused by light attraction due to KIUC streetlights and lights at KIUC facilities on Kaua‘i.
- Appendix 5D, *Bayesian Acoustic Strike Model*, outlines the methods and results for estimating pre-HCP annual collisions with existing powerlines
- Appendix 5E, *Population Dynamics Model for Newell's Shearwater (‘a‘o) on Kaua‘i*, presents the methods and results for the effect of KIUC's minimization and conservation actions on the Kaua‘i metapopulations of Newell's shearwater (‘a‘o).
- Appendix 5F, *Population Dynamics Model for Hawaiian Petrel (‘ua‘u) on Kaua‘i*, presents the methods and results for the effect of KIUC's minimization and conservation actions on the Kaua‘i metapopulations of Hawaiian petrel (‘ua‘u).
- Appendix 6A, *KIUC Monitoring Protocols and Procedures for Protected Seabirds*, described the monitoring protocols and procedures that will be employed to locate and rescue grounded seabirds at KIUC covered facilities and at construction sites with night lighting.
- Appendix 7A, *Cost Model,* describes the cost model used to estimate HCP costs described in Chapter 7.

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Chapter 2
Covered Activities

This chapter describes existing and future activities for which KIUC is seeking take coverage under the HCP; these activities are collectively referred to as *covered activities*. The scope of covered activities was determined using a systematic process involving the application of screening criteria. Under the HCP, a covered activity must meet all of the following criteria. These criteria are based on the requirements in the Habitat Conservation Planning and Incidental Take Permit Processing Handbook (U.S. Fish and Wildlife Service and National Marine Fisheries Service 2016).

- **Control or Authority:** The covered activity must be under the direct control of KIUC as a project or activity it implements directly, implements through contracts or leases, or controls through a regulatory framework (e.g., under a federal or state permit or other authorization).
- **Location:** The covered activity must occur within the geographic area of the KIUC HCP Plan Area (see Section 1.3.1, *Plan Area and Permit Area*).
- **Timing:** The covered activity must occur during the proposed permit term (50 years; see Section 1.3.4, *Permit Term*).
- **Impact:** The covered activity must have a reasonable likelihood of causing incidental take of one or more covered species (see Section 1.3.2, *Covered Species*).
- **Project Definition:** The location, footprint, frequency, and types of impacts resulting from the activity can be defined well enough such that direct and indirect impacts to covered species can be evaluated and conservation measures can be developed.

The covered activities that meet all these criteria are described in three broad categories: (1) powerline operations and retrofit, (2) lighting operations, and (3) implementation of the HCP conservation strategy. These categories are described in the following subsections as they relate to operation and retrofit of existing and future KIUC infrastructure. KIUC is seeking take coverage under federal and state permits for all covered activities described in this chapter.

The final section of this chapter lists KIUC infrastructure operations and retrofit activities not covered by the HCP because it was determined they do not meet one or more of the criteria listed above.

The covered activities described in this chapter are intended to be as inclusive as possible of KIUC activities currently occurring or expected to occur in the Permit Area and that have a reasonable likelihood of causing incidental take of the covered species. Any activities identified in the future that, in either or both U.S. Fish and Wildlife Service's (USFWS) or State of Hawai'i Department of Land and Natural Resources, Division of Forestry and Wildlife's (DOFAW) view may not clearly fall within the scope of covered activities described in this chapter will be evaluated on a case-by-case basis, by USFWS and DOFAW to determine whether take is covered under their respective permits, or whether a new permit or permit amendment is required. Factors the agencies will consider in this assessment include, but are not limited to, the following.

- The activity is under the direct control or authority of KIUC.
- The activity does not increase the probability that the biological goals and objectives of the HCP (Chapter 4, *Conservation Strategy*) cannot be met.

- The activity does not change the types of impacts evaluated in Chapter 5, *Effects Analysis*, including, without limitation, the take estimate of any covered species.
- Adequate take coverage under the federal and state permits remains available for the covered activities originally described in the KIUC HCP.
- The activity is otherwise legal, does not require an HCP amendment under then applicable law, and does not require additional regulatory compliance including, without limitation, supplemental National Environmental Policy Act/Hawaiʻi Environmental Policy Act analysis.

If USFWS or DOFAW determines that a specific project or activity is reasonably certain to cause take of the of the covered species and is under KIUC's control but it is not included within the descriptions in this chapter, then KIUC will not receive coverage under their respective permits, and KIUC may, at its discretion, apply for an amendment to either the federal incidental take permit or state incidental take license, or both, in accordance with processes set out in then-applicable law.

2.1 Powerline Operation, Retrofit and Use of Night Lighting for Repairs

2.1.1 Powerline Operation

KIUC owns and operates overhead electric powerlines on Kauaʻi (Figure 2-1). The wire sizes and pole heights vary widely for each type of line depending on site-specific physical circumstances present along the powerline corridor (e.g., topography). Moreover, line configuration may switch from one type to another (and often back again) within distances of as little as a few hundred feet (ft) depending on site-specific conditions. This changeability makes it impossible to map the differences on a system-wide scale. All KIUC wires on Kauaʻi are considered operational when the wires are in place (i.e., when they are in the bird's flight path) but they do not need to be electrified. The types of KIUC wires with the potential to cause take of the covered species fall into one of the following three categories: (1) transmission, (2) distribution, and (3) communication (Figure 2-2a). KIUC is seeking permit coverage for all existing and future KIUC wires falling into one of these three categories and all existing and future KIUC supporting structures holding these wires. Supporting structures for the purposes of this HCP include only poles, towers, lattice structures, and H-frames[1] (hereafter referred to as support structures).

- **Transmission Wires**. KIUC owns and operates 171 circuit-miles[2] (mi) (275 kilometers [km]) of transmission lines. Transmission wires are typically raised between 59 ft (18 meters [m]) and 79 feet (24 m) above the ground, with the tallest lines more than 100 ft (34 m) above the ground (Figures 2-2a and 2-2b). There are roughly 1,330 KIUC-owned support structures that support the transmission wires. The transmission circuits are protected from lightning strikes by a wire mounted above the conductor wire, known as an overhead shield wire (OHSW), static wire, or earth wire. The OHSW, if present, is typically the highest wire and, because it is a smaller and

[1] Poles and towers are columns or posts that are differentiated based on the type of material: poles are wood, and towers are steel. Lattice structures and H-frame structures are also currently part of the grid system and can both be made of either wood or steel (Kauaʻi Island Utility Cooperative 2020).

[2] A circuit-mile is defined as 1 mile of either a set of alternating current three-phase conductors in an overhead or underground alternating current circuit, or one pole of a direct current circuit.

lighter wire, it sags less than the conductor wires. A fiber-optic communication cable may be present in place of the OHSW. There are approximately 16.4 mi (141 km) of static wires and 15 mi (24 km) of fiber-optic communication wires.

A single transmission circuit is comprised of three conductor wires (three phases) that can be on one or both sides of the pole and can switch back and forth. These wires are nearly always bare aluminum; often two circuits are mounted on a single pole. This configuration is common on the west side of Kauaʻi. However, on the east and north sides of Kauaʻi, transmission lines often include double circuits with six wires on alternate sides of the pole (Travers et al. 2019). Transmission wires can be arranged in three different types of arrays.

- ○ Vertical arrays, where the conductor wires are immediately above one another on the pole (Figure 2-2a).
- ○ Triangular arrays, where conductor cables are mounted on either side of the pole.
- ○ Horizontal arrays, where the lines are mounted on horizontal crossarms or post-type insulators, which is rare for transmission wires but more common for distribution wires.

- **Distribution Wires**. KIUC owns and operates 816 circuit-mi (1,408 km) of distribution lines. Distribution wires built on the same pole as transmission wires are always mounted underneath the transmission wires (termed an *under-build*; Figure 2-2a). Where transmission wires are not present, distribution wires are mounted on support structures that are 40 to 50 ft (12 to 15 m) tall (Figure 2-2a), often with under-build service circuits mounted below the distribution wires. There are roughly 25,000 KIUC-owned support structures that support distribution, and some of these support structures also support transmission wires above the distribution wires. Distribution circuits can range from two to four wires (i.e., one to three conductors and a neutral wire), depending on the requirements in the area. Distribution wires can be placed closer together than transmission wires because they carry a lower voltage. As with transmission lines, the distribution wires are arranged in a variety of ways and a variety of heights depending upon each pole's site-specific circumstances; it is common for distribution wires to be vertically spaced on alternating sides of the pole (Travers et al. 2019). Moreover, distribution circuits frequently change from one configuration to another over a short distance. In some instances, distribution wires owned by other public agencies or private entities are located on the same pole with KIUC distribution wires. Distribution wires less than 35 feet in height are not covered by this HCP because they are below the height where collisions with covered seabirds are likely to occur (see Section 2.4, *Activities Not Covered*).
- **Communication Wires**. KIUC owns and operates approximately 70 circuit-mi (112 km) of communication lines. KIUC's communication wires are typically only present where transmission lines are also present but are not present in all transmission line locations. The communication wire, if present, is typically mounted below the transmission and distribution wires and is therefore typically the nearest wire to the ground (Figures 2-2a and 2-2b). Because the communication wire consists of fragile fiber-optic cable, it is protected by a black plastic buffer tube. The buffer tubes may be different diameters depending on the length of the wire. In some cases, the communication wire serves as the static wire at the top of the line, as described above under *Transmission Wires*.

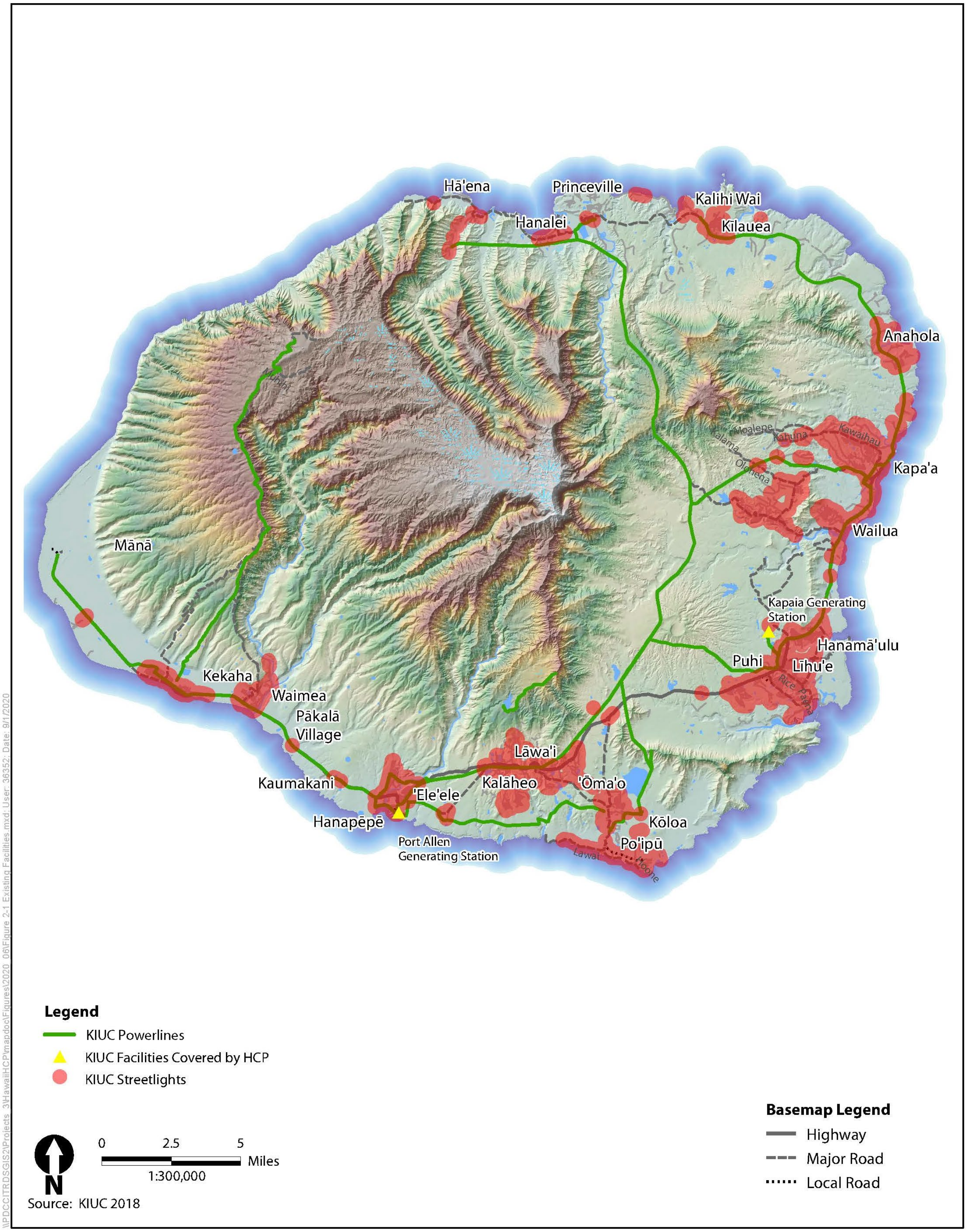

Figure 2-1. Covered Activities: Existing Facilities

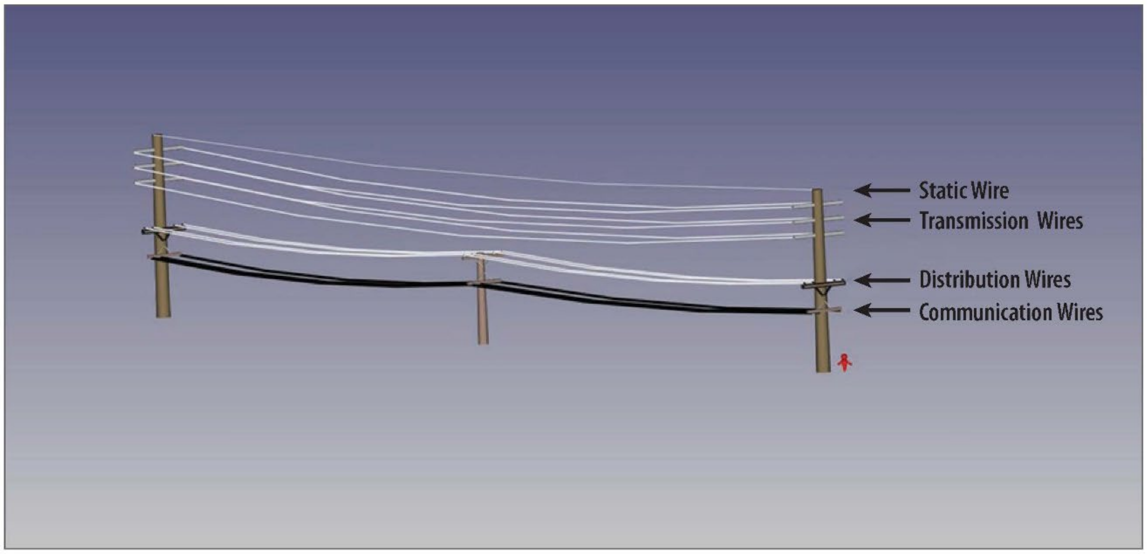

FIGURE 2-2a. Types of wires covered in the KIUC HCP, shown in a vertical array.

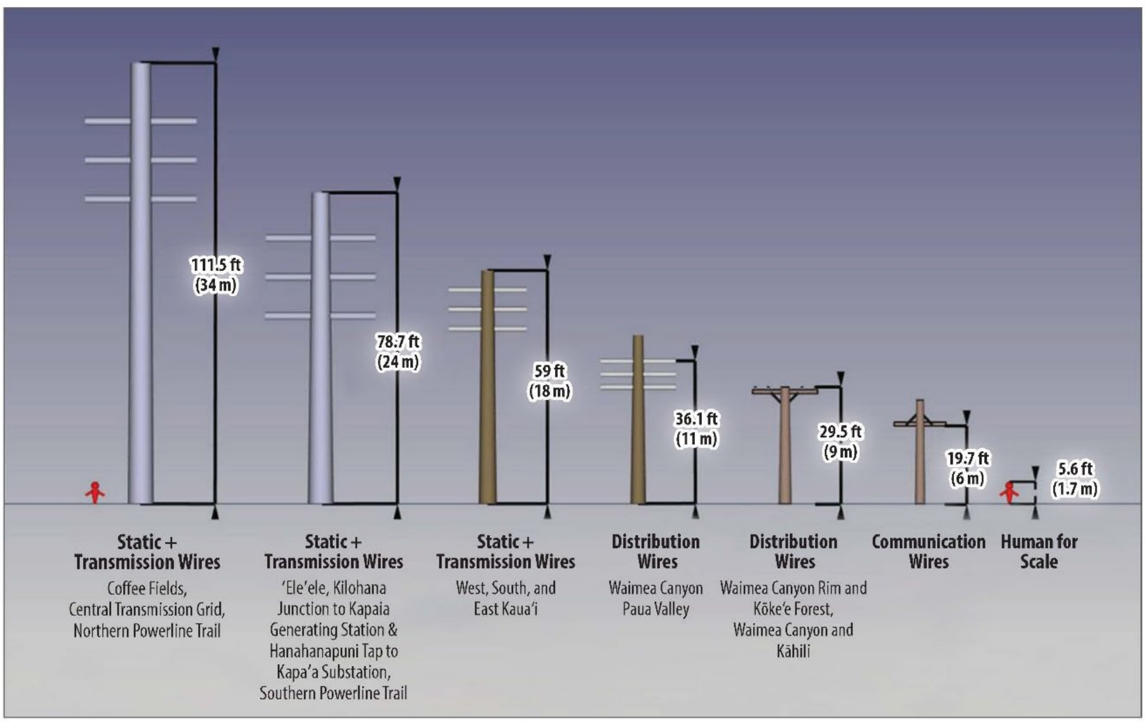

FIGURE 2-2b. Typical wire heights of KIUC transmission, distribution, and communication lines based on general location.

Source: Travers et al. 2019

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Figure 2-2. Typical Wire Types and Heights of KIUC Powerlines

2.1.2 Powerline Retrofits: Additional Powerlines and Changes in Wire Numbers and Configuration

KIUC periodically modifies transmission lines or distribution lines in response to changes in electricity demand. In other cases, KIUC may modify powerline systems in response to changing land uses that might interfere with safe and reliable power delivery. In either instance, powerline retrofits are covered activities if these modifications change wire height, add new powerlines, or expose wires, as described below.

2.1.2.1 Increasing Wire Height

KIUC increases wire height primarily to meet minimum clearance standards. For example, reconductoring, which replaces a smaller conductor with a heavier-duty one, is occasionally necessary to accommodate increasing electrical loads on the lines. To maintain a proper offset distance between the wires, the height of a heavier-duty line must sometimes be increased.

Retrofit of wires with increased heights is a covered activity in this HCP. KIUC estimates that over the 50-year permit term, 16 percent of their total transmission wire length (i.e., 27.2 mi [43.8 km]) will require wire height increases (an average of 0.54 mile [0.9 km] per year for 50 years).

2.1.2.2 Adding New Powerlines

KIUC adds new powerlines into its electric system to increase capacity, especially to carry additional electrical load during times of peak usage. New powerlines can provide redundancy in the system that reduce or prevent power outages for customers. New powerlines are expected in response to growing demand for power due to population growth. In addition, KIUC expects to install new powerlines to connect new power sources (e.g., new renewable generation stations) to the electric grid. KIUC expects to install new powerlines in three circumstances, each of which is summarized below.

1. Adding wires to existing circuits (i.e., on existing poles or towers and on existing support structures).
2. Adding new powerlines to new poles or towers in existing rights-of-way (i.e., adjacent to existing powerline circuits).
3. Adding new powerlines to new poles or towers in new rights-of-way (i.e., where powerlines did not exist before).

KIUC frequently adds new wires to their existing circuits to accommodate growth in demand and to increase redundancy in the system. In some cases, KIUC can offset the effects of the additional wires by changing the vertical arrangement to a horizontal (i.e., one-level) arrangement.

When there is no additional capacity or space available on existing poles or towers, KIUC must construct new powerline corridors with new poles or towers. To save costs, improve efficiency of operations, and minimize visual impacts KIUC strives to place these new powerlines in an existing right-of-way adjacent to existing power poles or towers. However, there are many cases where this is not feasible owing to narrow rights-of-way or land use constraints that do not allow a wider corridor. In these instances, KIUC would build a new powerline (with new poles or towers) in a new right-of-way.

In all these cases, KIUC does not control where new demands for electrical service will arise. KIUC is a secondary developer of new powerlines that is asked to provide electricity based on the request of a primary developer of the new power demand (e.g., a new residential development, a new commercial development, or a new power generation source). In all cases the primary developer will address cultural resource issues associated with project construction, including the location of new powerline poles or towers, through the Hawai'i Revised Statutes 6E regarding historic preservation, where appropriate. Construction of new powerlines is not a covered activity under this HCP until the wires are in place (they do not need to be electrified), because construction activities are not expected to result in take of covered species (Section 2.4, *Activities Not Covered*). KIUC is requesting take coverage for the operation of new wires and support structures in locations that are currently unknown. KIUC estimates that over the 50-year permit term, a maximum of 34 percent of its powerlines (348 mi [560 km]) will require new wires (an average of 7 mi [11.3 km] per year for 50 years). Of these 348 mi (560 km) of new wires, a maximum of 17 percent will be in high-collision-risk zones (in comparison to 48 percent in low-collision-risk zones) and most of the new powerlines will be distribution lines.

2.1.2.3 Exposing Wires

Vegetation management is performed near powerlines to maintain adequate clearance. Vegetation management is a covered activity only when and where it exposes wires that were previously shielded by vegetation.

2.1.3 Operation of New or Extended Powerlines

As described above, KIUC expects to add new or extend existing powerlines to accommodate growth and to integrate renewable resources across Kaua'i. KIUC will also need to expand the system of distribution lines to service new homes and businesses that are developed outside of the existing network of distribution lines. These expansions are expected to require extending existing distribution lines or building new transmission lines.

Operation of new or extended powerlines (for transmission and distribution) is a covered activity in this HCP. Because new or extended powerlines will require new wires and support structures, the 20 percent limit for the addition of new wires and support structures across KIUC's electric system included under Section 2.1.2.2, *Adding New Powerlines*, also encompasses the operation of new wires associated with new powerlines. Construction of new powerlines is not a covered activity until the wires are in place (they do not need to be electrified) because construction activities are not expected to result in take of covered species (Section 2.4, *Activities Not Covered*).

2.1.4 Night Lighting for Restoration of Power

When equipment failure or powerline damage occurs, KIUC must restore power to its customers as quickly as possible.[3] In this context, KIUC may need to repair existing powerlines or construct new powerlines and support structures (in cases where the damage is too extensive to utilize the existing infrastructure). If the power outage occurs at night, lighting may be necessary to illuminate the work area. While repair work at night due to outages is rare, KIUC is requesting take coverage for all

[3] This does not include catastrophic events like Hurricane 'Iniki that threaten human life and property.

repairs that may require night lighting during the seabird fallout season (September 15 to December 15) over the 50-year permit term.

Restoration of power takes on average 1 hour to complete and night lighting is operated for half of that time. The first half-hour is typically used to troubleshoot and setup, and the last half-hour is used to perform the repair using lights. Based on records of past outages, KIUC estimated an average of 170 hours of nighttime outages occur on an annual basis during the covered seabird fallout season (September 15 to December 15). Therefore, KIUC assumes half of those hours (i.e., 85 hours) require night lighting on an annual basis.

2.2 Lighting Operation

2.2.1 Facility Lights

2.2.1.1 Existing Facilities

Operation of facility lights at the Port Allen Generating Station and the Kapaia Power Generating Station (Figure 2-1) is a covered activity in the KIUC HCP. Both facilities maintain night lighting for operations, visibility of personnel, and safety.

The Port Allen Generating Station is located at Port Allen east of Hanapēpē. Facility lighting at the Port Allen Generating Station includes 29 KIUC-owned lights mounted on poles and placed throughout the facility and eight lights mounted on building walls. In September 2019, the existing 150-watt high pressure sodium (HPS) streetlights were retrofitted with 41- and 90-watt white light-emitting diode (LED) bulbs, allowing output to be dimmed while still maintaining visibility for staff. In addition, the eight wall-mounted lights were retrofitted with shielded wall-mounted white LED box lighting.

The Kapaia Power Generating Station is located approximately 1 mile northwest of the town of Līhu'e. Lighting consists of KIUC-owned streetlights and building lights placed throughout the facility in the parking lot and outdoor work areas. The streetlights consist of 150-watt HPS bulbs placed close to one another and relatively close to the ground. Each bulb is housed in a shield that completely covers the bulb except for the downward-facing glass. The design reflects all the light downward so that there is no upward lateral light transmission. The building lights use the same design concept but use a lower-wattage bulb.

Despite the light attraction minimization efforts at the Port Allen Generating Station and the Kapaia Power Generating Station, any KIUC infrastructure that produces light at night when the covered seabirds are fledging has the potential to cause fallout, resulting in incidental take. As such, the entire surface of the Port Allen Generating Station and Kapaia Power Generating Station, or approximately 9 acres and 14 acres, respectively, are covered under the HCP because seabird fallout may occur anywhere within the stations.

2.2.1.2 Night Lighting for Repair of Facilities

As described in Section 2.1.4, *Night Lighting for Restoration of Power*, night lighting may be necessary to facilitate repair of KIUC infrastructure. Night lighting for repair at all[4] KIUC facilities is a covered activity in the KIUC HCP. KIUC is requesting take coverage for all events that would require night lighting during the seabird fallout season (September 15 to December 15). The 50 hours of annual night lighting described under Section 2.1.4, *Night Lighting for Restoration of Powers*, also includes night lighting that would be required for repairs at covered facilities.

2.2.2 Streetlights

2.2.2.1 Existing Streetlights

KIUC owns and operates approximately 4,100 streetlights under agreements with the state, County of Kaua'i, and private entities, which includes those located at KIUC facilities as identified in Section 2.2.1.1, *Existing Facilities* (Figure 2-1). Most of these lights are on poles and towers that also carry electric lines, but some of the lights are stand-alone fixtures on their own stanchions. All lights are switched on and off at sunset and sunrise automatically by photosensitive switches installed in individual lights. As of 2017, all KIUC streetlights were converted from HPS to more energy-efficient 3000-kilowatt LED bulbs (Kaua'i Island Utility Cooperative 2017), and of these approximately 75 percent are 41-watt bulbs and approximately 25 percent are 90-watt bulbs. All KIUC-operated streetlights have full cutoff shielded fixtures.[5]

Operation of existing KIUC streetlights is a covered activity in the KIUC HCP because they contribute to the lightscape on Kaua'i. For a streetlight to be considered operational under this HCP, the light must be on. Despite efforts to minimize the reflectance of KIUC streetlights, they may still result in covered seabird fledgling fallout and green sea turtle (honu) (*Chelonia mydas*) disorientation, resulting in incidental take (although in the case of green sea turtle [honu] only coastal streetlights visible from suitable beach habitat would have the potential to affect this species).

2.2.2.2 New Streetlights

KIUC expects to operate up to 1,754 new shielded streetlights along Kaua'i's roadways over the 50-year permit term (an average of 35 new streetlights per year). Based on growth projections on Kaua'i, the number of new streetlights is not expected to exceed 50 per year. As with all the existing streetlights on Kaua'i, any new streetlights will also be equipped with full-cutoff shields.

Operation of future streetlights is a covered activity under the HCP for the same reason as described for existing streetlights (Section 2.2.2.1, *Existing Streetlights*). Construction of new streetlights is not a covered activity because installation of the streetlights is not expected to result in take of any covered species given that the light is not operational during construction. KIUC has no authority over the siting of new streetlights because they are the secondary developer asked to provide electricity and install streetlights based upon the request of a primary developer. The primary

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[4] This includes all existing and new KIUC facilities, even those that apart from nighttime lighting events are not covered by this HCP (i.e., solar and hydroelectric facilities).

[5] *Full cutoff shielded fixtures* are designed to direct the light downward and outward, rather than upward toward the sky.

developer will address cultural resource issues for the covered activities through the Hawai'i Revised Statutes 6E (historic preservation) process, where appropriate.

2.3 Implementation of the Conservation Strategy

Activities related to implementation of the HCP conservation strategy at the conservation sites may result in short-term impacts on the covered species. The conservation measures implemented at the conservation sites include construction and maintenance of predator exclusion fences, predator control within and outside of the predator exclusion fences, social attraction to attract covered seabirds to new nesting colony sites within the fenced areas, and selective invasive plant species control. These activities are further described in Chapter 4, Section 4.5, *Conservation Measures*, and are expected to have a net benefit to the covered seabird species (see Chapter 5, *Effects Analysis*).

2.4 Activities Not Covered

The KIUC HCP is designed to cover all activities for which KIUC envisions the need for incidental take coverage over the permit term. The following activities were determined by KIUC to not require coverage in this HCP. If coverage of any of these activities becomes necessary in the future, KIUC may apply for an amendment to this HCP, as described in Chapter 7, *Plan Implementation*.

- **Construction of KIUC Infrastructure.** Construction of all KIUC infrastructure is not a covered activity in the KIUC HCP, including but not limited to construction of buildings, streetlights, facilities, powerlines, and LED diverters. Construction of KIUC infrastructure is not a covered activity because ground-disturbing activities would not result in take of the covered species. The only exception is that powerlines are covered once the wires are strung between the supporting structures, even if construction is not complete and the wires are not electrified.
- **Routine Wire Retrofit and Repair.** KIUC must regularly service and repair all wires, either for preventative retrofit or in response to equipment failure. Routine retrofit of wires and supporting structures is not a covered activity unless the retrofit will increase wire height, add new wires, or expose wires to increased collision risk (i.e., through vegetation maintenance) (see Section 2.1.2, *Powerline Retrofit*, for details). These routine retrofit activities are not covered activities because they are not reasonably certain to result in take of the covered species.
- **Routine Support Structure Retrofit and Replacement**. KIUC must regularly service and repair all supporting structures, either for preventative retrofit or in response to damage. Preventative retrofit does not include any conservation measures included in Chapter 4, *Conservation Strategy*, of this HCP. Routine retrofit of support structures (e.g., power poles) is not a covered activity under this HCP. Replacement of support structures is also not covered in this HCP if the replacement support structure is located along an existing powerline. In addition, increasing pole height is not a covered activity under this HCP. These routine retrofit activities are not covered activities because they are not reasonably certain to result in take of the covered species.
- **Operation and Retrofit of Other Infrastructure within the Port Allen Generating Station and the Kapaia Power Generating Station.** Operation and retrofit of all KIUC infrastructure within the Port Allen Generating Station or Kapaia Power Generating Station, other than

powerlines and facility lights, are not covered activities in the KIUC HCP because they are not reasonably certain to result in take of the covered species. This includes operation and retrofit of KIUC infrastructure such as buildings, parking lots, fuel storage tanks, water treatment facilities, and gas turbines.

- **Operation and Retrofit of Service Wires.** Service wires are always mounted below distribution wires, where both are present. In cases where service wires are the only electric wires on a pole, they are typically mounted on poles and towers that are less than 35 ft (10.7 m) tall. In both cases, due to their lower height, they are not reasonably certain to result in take of the covered species. As such, operation and retrofit of service wires is not a covered activity in the KIUC HCP.
- **Distribution Wires at Low Heights or Owned by Others**. Distribution wires can be installed at a variety of heights depending upon each pole's site-specific circumstances. Distribution wires less than 35 feet (10.7 m) above ground are not covered under this HCP because they are not likely to result in take of the covered species. In addition, KIUC does not own all distribution wires in the Plan Area. Distribution wires (at any height) located on the same pole as KIUC infrastructure but owned by other entities are not covered by this HCP.
- **Operation and Retrofit of Existing Solar Facilities and Hydroelectric Facilities.** KIUC maintains two solar facilities and two hydroelectric facilities. None of these facilities operate nighttime security lighting. Lights at these facilities are only used in the rare case of nighttime repair work, which is a covered activity (see Section 2.2.1.2, *Night Lighting for Repair of Facilities*). The equipment and structures at these solar and hydroelectric facilities are therefore not reasonably certain to result in take of the covered species. The operation of powerlines connecting these generating facilities to the grid is a covered activity, as described in Section 2.1.1, *Powerline Operation*.
- **Operation and Retrofit of Existing Substations and Switchyards.** KIUC maintains electric substations and switchyards throughout its electric transmission system. Similar to solar and hydroelectric facilities, substations and switchyards do not operate nighttime security lighting and are only lit during nighttime repairs (which is a covered activity). The operation or retrofit of substations and switchyards is not a covered activity because there are no streetlights or exterior building lights that could result in take of the covered species due to light attraction.
- **Decommissioning Infrastructure.** Decommissioning typically involves removing all above-ground structures, lights, and/or electrical infrastructure including, but not limited to, control structures, enclosures, transformers, voltage regulators, A-frames, H-frames, and their respective footings, along with all onsite interconnections with the island-wide grid. This activity is not reasonably certain to result in take of the covered species, and in fact may result in beneficial effects on the covered species where powerlines or lights are removed. Therefore, decommissioning of infrastructure is not a covered activity in the KIUC HCP.

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Chapter 3
Environmental Setting

This chapter provides an overview of the existing environment on the Island of Kauaʻi (Kauaʻi) with a focus on factors relevant to effects of KIUC activities on the covered species and the conservation needs of those species on Kauaʻi. More information on the existing environment that could be affected by implementing the KIUC HCP may be found in the environmental impact statement (EIS) prepared pursuant to the National Environmental Policy Act and State of Hawaiʻi Revised Statutes Chapter 343 Hawaiʻi Environmental Protection Act.

Chapter 3, *Environmental Setting*, is divided into three sections.

- Section 3.1, *Affected Physical Environment*, summarizes the relevant physical environment, including physiography, geology, soils, hydrology, climate, and air quality.
- Section 3.2, *Land Use*, summarizes relevant existing and planned land use patterns on the island.
- Section 3.3, *Existing Biological Environment*, summarizes relevant aspects of the existing biological environment on Kauaʻi, including vegetation and the ecology, distribution, range, abundance, and current threats to each of the covered species.

3.1 Affected Physical Environment

3.1.1 Physiography, Geology, and Soils

3.1.1.1 Physiography

Kauaʻi has a land area of approximately 550 square miles (sq mi) (1,425 square kilometers [sq km]). Roughly circular in shape, its most striking physiographic features are a high central plateau of over 5,000 feet (ft) (1,524 meters [m]) at the summits of Mt. Waiʻaleʻale (5,148 ft [1,569 m]) and Mt. Kawaikini (5,243 ft [1,598 m]). The central plateau is characterized by steep cliffs and deeply incised valleys along the northern Nā Pali Coast, the 3,600-ft-deep (1,097 m) Waimea Canyon, the broad Līhuʻe Basin on the southeastern quadrant of the island, and extensive coastal plains. These features can be seen on the topographic relief map (Figure 3-1) and the slope map (Figure 3-2) of the island.

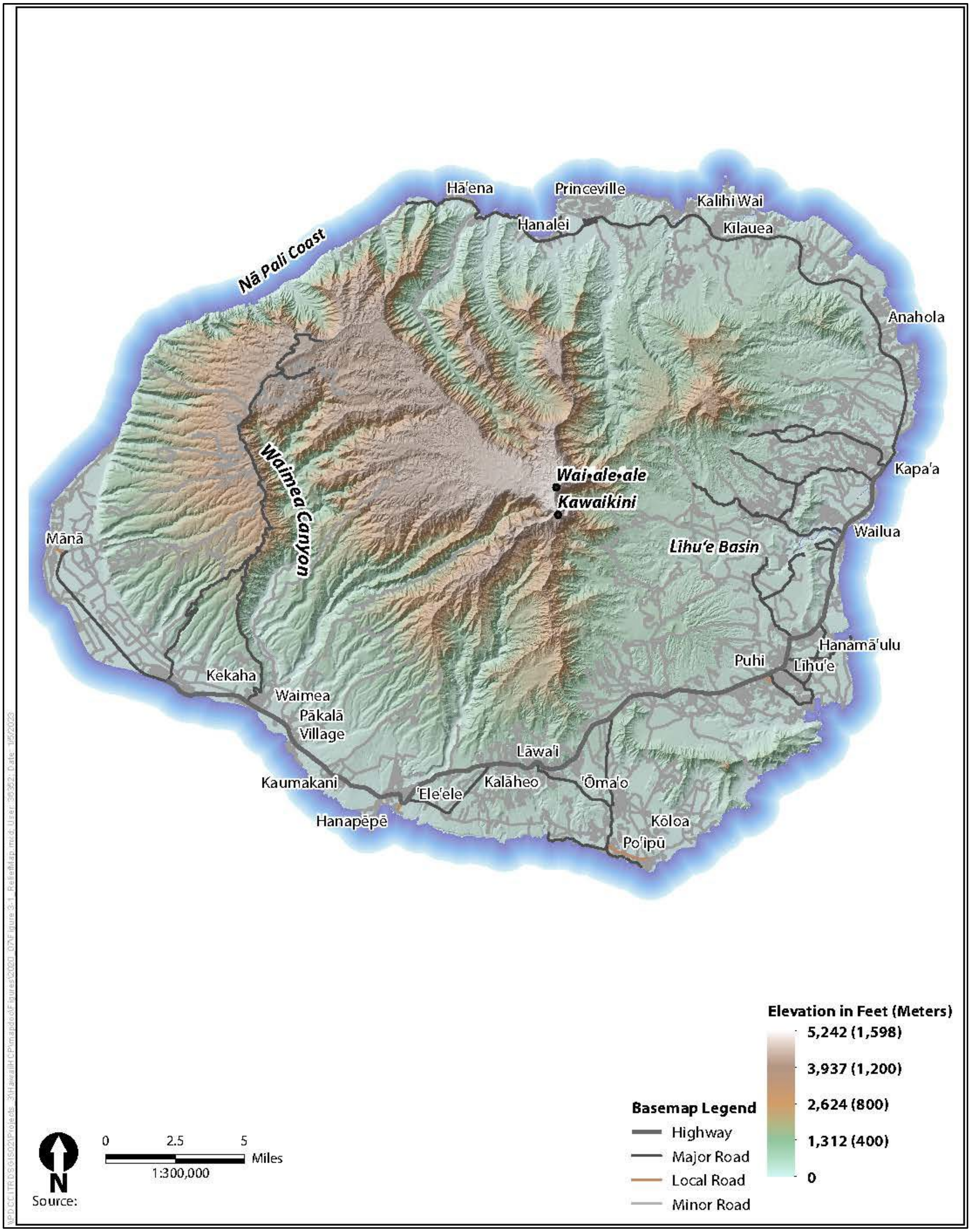

Figure 3-1. Topographic Relief of Kauaʻi

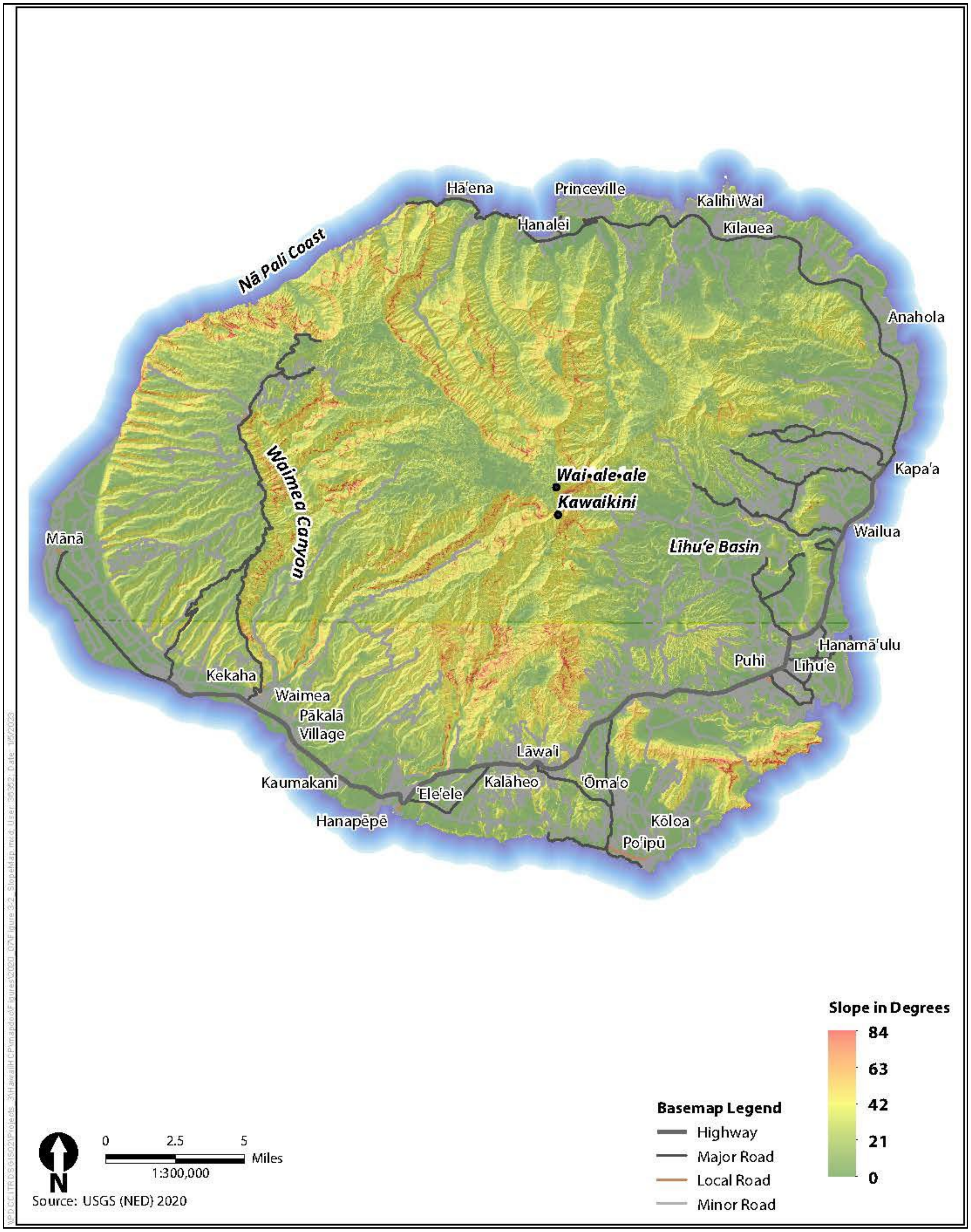

Figure 3-2. Slope Map of Kaua'i

3.1.1.2 Geology

Kauaʻi, like the other Hawaiian Islands, was formed by magma that emerged from a hotspot beneath the Earth's crust that remained stationary as the plates on the Earth's crust moved over it (Stearns and MacDonald 1960). The main mass of Kauaʻi is believed to be about 3 to 5 million years old, although there were a few small eruptions on Kauaʻi as late as about 500,000 years ago (Juvik 1998). As this magma moved towards the surface, it erupted as lava, pouring out over the ocean floor. Over time, the eruptions formed a typical Hawaiian shield volcano. Deep erosion and weathering of the flows resulted in the topographically and geologically complex landscape present today (Juvik 1998).

3.1.1.3 Soils

As one of the oldest and most geologically complex Hawaiian Islands, Kauaʻi has a relatively high diversity of soil types. The lowland areas have predominantly deep, nearly level to steep, well-drained soils that have a fine-textured or moderately fine-textured subsoil. The western half of the island also has well-drained soils over basalt bedrock. The more rugged areas in central and northwestern portions have relatively shallow, rocky soils (U.S. Department of Agriculture 1973). Seabirds play an important role in soil nutrient recycling in Hawaiʻi, depositing guano that provides an important source of nutrients to the volcanic soils from the marine environment (Rowe et al. 2017).

3.1.2 Hydrology

Figure 3-3 depicts the perennial rivers and streams on Kauaʻi. Like all of the Hawaiian Islands, Kauaʻi's streams respond rapidly to storm rainfall because drainage basins are small and the distance of overland flow is short (Juvik 1998). Most streams on Kauaʻi radiate out from the Waiʻaleʻale-Kawaikini massif[1] in all directions, cutting through intrusive dikes that retard the groundwater movement toward the ocean from high rainfall areas in the interior. In the process, streams tend to receive large influxes of groundwater throughout their length. Thus, unlike most Hawaiian streams, many of the streams on Kauaʻi gain flow as they descend.

Figure 3-4 depicts the distribution of wetlands and open water (i.e., lakes, reservoirs, and other impoundments) on Kauaʻi based on regional data from the National Wetland Inventory (U.S. Fish and Wildlife Service 2020a). Numerous estuarine and freshwater emergent wetlands skirt the lowlands of the island, along with human-made reservoirs and scattered ponds, all of which provide habitat for most of the covered waterbirds (U.S. Fish and Wildlife Service 2011). Freshwater wetlands are also present in the higher elevation, forested areas. Alakaʻi swamp (Figure 3-4) is a montane wet forest located on a high plateau and containing alpine bogs that support federally listed plant species, but the covered species do not occur in these wetlands (75 *Federal Register* 18959).

[1] A block of the earth's crust bounded by faults and shifted to form peaks of a mountain range.

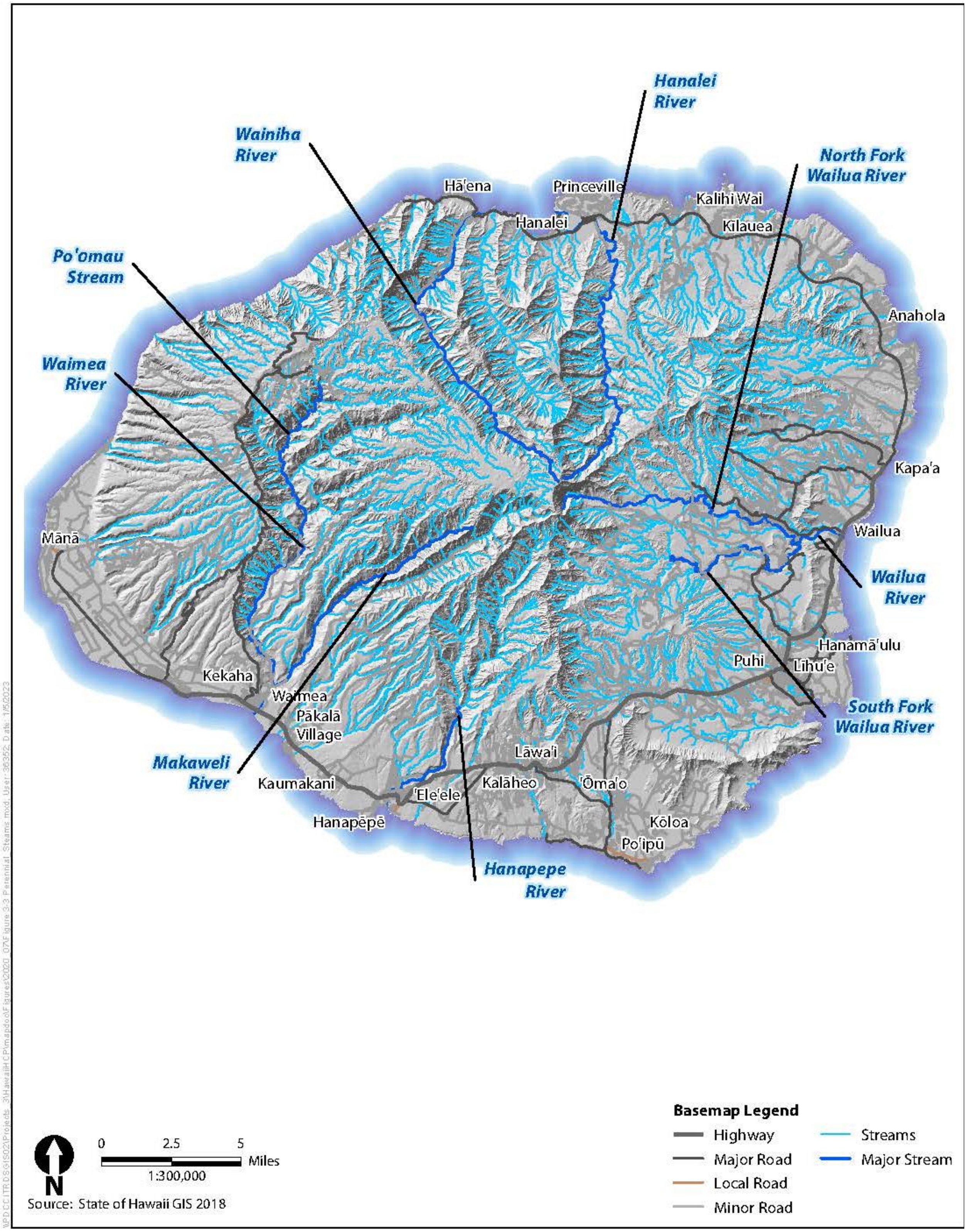

Figure 3-3. Perennial Rivers and Streams of Kauaʻi

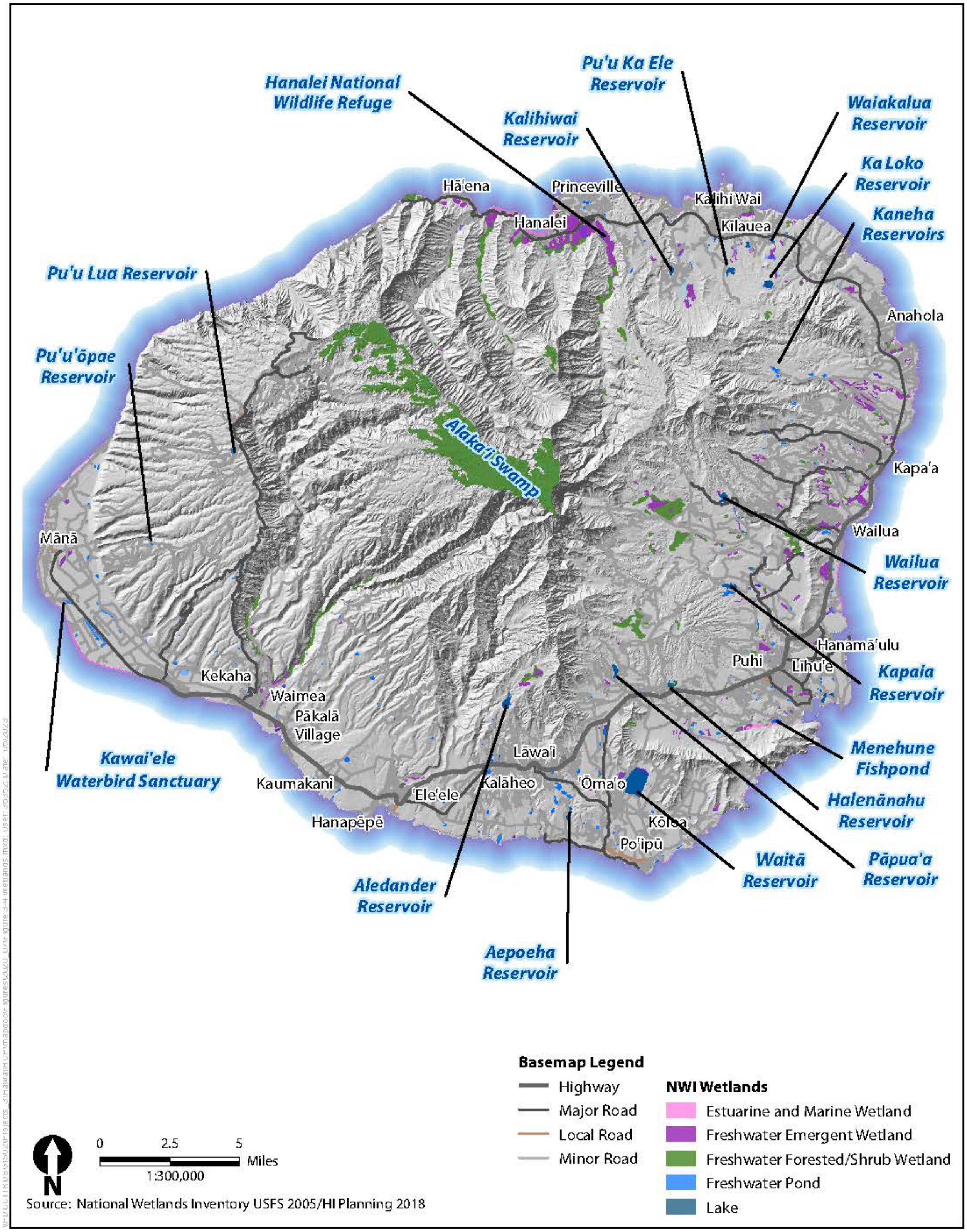

Figure 3-4. Wetlands and Open Waters of Kauaʻi

3.1.3 Climate and Weather

3.1.3.1 Wind

The northeast trade winds are the most important determinant of Kauaʻi's climate. They represent the outflow of air from the high-pressure region known as the Pacific Anticyclone, whose typical location is well north and east of Hawaiʻi (Western Regional Climate Center 2018). The trade wind zone moves north and south seasonally and reaches its northernmost position in the summer. Consequently, the trade winds are strongest and most persistent from May through September, when the trade winds are prevalent 80 to 95 percent of the time. From October through April, the heart of the trade winds are south of Hawaiʻi, and trade wind frequency decreases to about 50 percent (as a monthly average). On a few exposed headlands and in the mountains that catch and concentrate the full force of the trade winds, winds above 40 miles per hour (mph) (64.4 kilometers per hour [kph]) may occur several days each month of the year. In nearly all other locations, however, such winds are infrequent, and then only as the result of a major storm, the passage of a cold front, or an unusual local situation (Western Regional Climate Center 2018).

The land and sea circulations (due to convection air movements) are on a far smaller scale than the circulations of the trade winds or major storm systems, with the exchange of air often being confined to a few square miles. Circulations of this kind are most common on the southern and western coast in locations that are to the leeward with reference to the trade winds and topographically sheltered from them. Land and sea air circulation exhibit a diurnal rhythm. From the late morning until the early evening air moves inland on a sea breeze; sometimes these sea breezes are brisk. During the night and until shortly after sunrise, the air drifts back from land to sea; this movement is usually quite gentle.

3.1.3.2 Rainfall

Kauaʻi lies in the path of the persistent northeast trade winds that gather substantial moisture as they pass over the Pacific Ocean. Rainfall along the eastern side of the island is induced by the topographic relief of the mountains as the air is forced to rise over Mt. Waiʻaleʻale. At Mt. Waiʻaleʻale, on Kauaʻi, the annual average rainfall reaches the extraordinary total of 486 inches (in) (1,234.4 centimeters [cm])—over 40 ft (12.2 m). This is the highest recorded annual average in the world (Western Regional Climate Center 2018). As the air descends on the western side of the island, rainfall diminishes drastically towards the town of Kekaha. This results in one of the largest and steepest rainfall gradients on Earth (Ferrier et al. 2013; Juvik 1998) (see Figure 3-5). Average annual rainfall at Waimea on Kauaʻi's southwestern shore is less than 30 in (76.2 cm); 20 mi (32.2 km) away at the summit of Mt. Waiʻaleʻale, it is more than 400 in (1,016 cm).

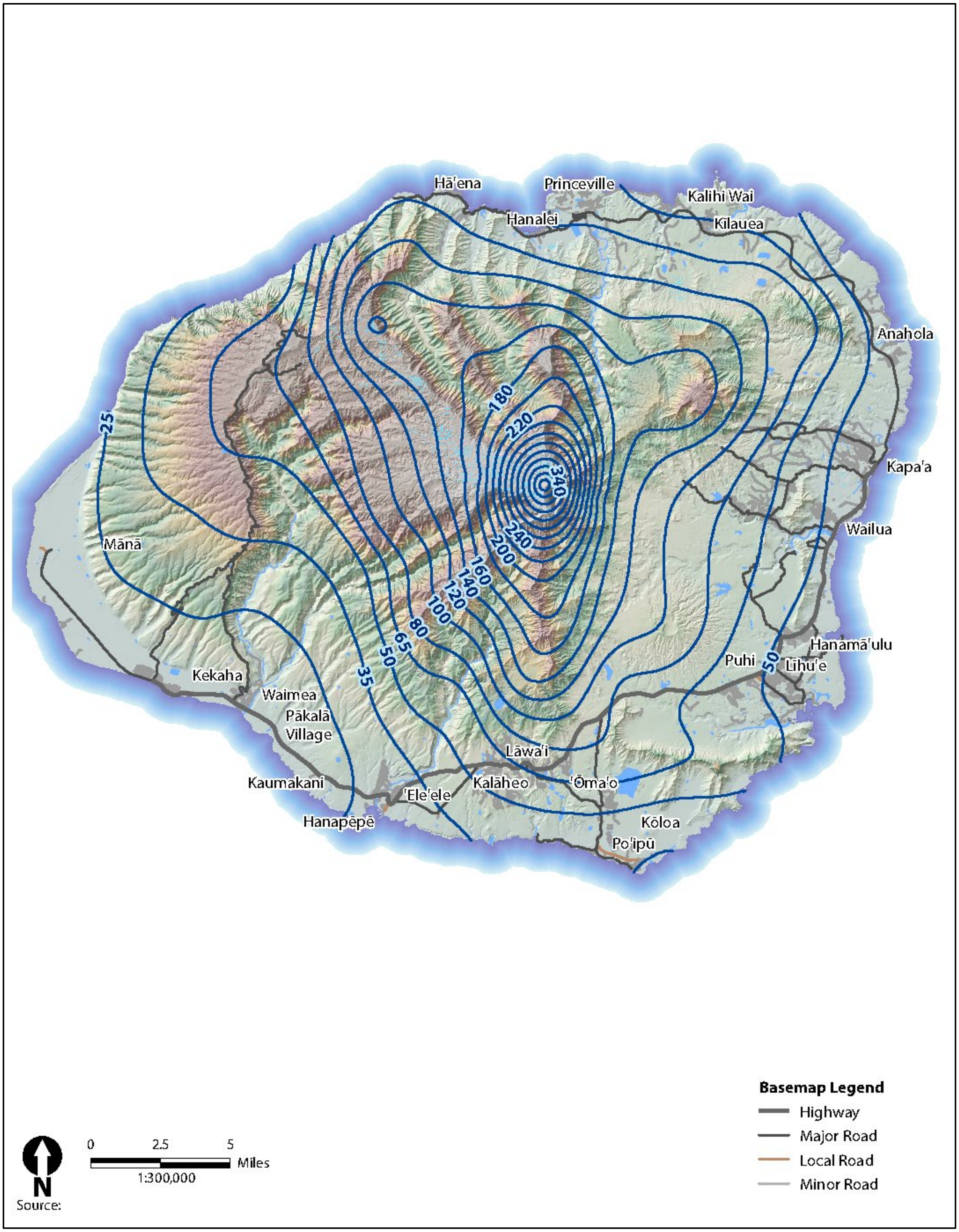

Figure 3-5. Average Annual Rainfall on Kaua'i, in Inches

Extreme rainfall intensities can occur, with the most intense rainfall events not associated with hurricanes. To take the most extreme instance on record, during the storm of April 13 to April 15, 2018, an automated rain gage near Hanalei on the North Shore recorded 53.57 in (136.1 cm) in 48 hours, including 49.69 in (126.2 cm) during a 24-hour period.

While rainfall can be extremely heavy, very light showers are frequent in most localities. On the windward coast, for example, it is common to have up to ten brief showers in a single day, each producing less than 0.01 in (0.025 cm) of rain. This seeming contradiction is explained by the fact that the usual run of trade-wind weather yields many light showers in the lowlands. Mountain slopes and crests within the cloud belt receive water in the form of fog drip or cloud mists as well as direct rainfall (Western Regional Climate Center 2018).

3.1.3.3 Air Temperature

Kauaʻi, like the other Hawaiian Islands, has one of the most stable climates on Earth. Isolated from large landmasses, Hawaiʻi has a very low annual temperature range (Giambelluca et al. 2008). This muted annual cycle of air temperature is due to the small season-to-season changes in solar radiation and the ocean's moderating influence. Differences in temperature from place to place are mainly due to elevation, with a fairly constant temperature decrease of 3.6 degrees Fahrenheit (°F) (2 degrees Celsius [°C]) per 1,000 ft (304.8 m) from sea level to about 4,100 ft (1,249.7 m) and 2.2°F (1.2°C) per 1,000 ft (304.8 m) above 4,100 ft (1,249.7 m). Small differences in temperature occur between cloudier, wetter, windward locations and sunny, dry, leeward locations at similar elevations (Juvik 1998). Diurnal temperature ranges are smallest in the lowlands, with daytime temperatures commonly in the 70s to 80s (°F) and nighttime temperatures in the 60s to 70s. Mean annual temperatures range between about 72°F (22°C) and 75°F (24°C) near sea level.

Outside the dry, leeward areas, temperatures of 90°F (32°C) and above are uncommon. In the leeward areas, temperatures in the low 90s may be reached on several days during the year, but temperatures higher than these are uncommon.[2] The warmest days are usually during what is known as *Kona weather*, when the trade winds, which come from cooler latitudes, fail and air stagnates over the heated islands (Western Regional Climate Center 2018).

3.1.3.4 Hurricanes, Tropical Storms, and Waterspouts

Major storm systems periodically affect all of the Hawaiian Islands including Kauaʻi. There are four classes of disturbances that produce major storms. Sometimes a cold front sweeps across the islands, bringing with it locally heavy showers and gusty winds. A storm eddy, or low-pressure system, can move past the islands bringing widespread heavy rains often accompanied by strong winds. These low-pressure systems are known as *Kona storms*.[3] A separate and third class of disturbance are those instances of severe weather attributable to low-pressure systems in the upper atmosphere that are not associated with the foregoing cold fronts or Kona storms (Western Regional

[2] The highest temperature on record is from Līhuʻe, which reported 99°F (37°C) on December 23, 2010 (https://www.plantmaps.com/hawaii-record-high-and-low-temperature-map.php).

[3] The term *Kona storm* was originally applied to the slow-moving subtropical cyclones that occasionally enter the Hawaiian area. Increasingly, this term is now applied by the local public to any widespread rainstorm accompanied by winds from a direction other than that of the trade winds.

Climate Center 2018). The fourth class of disturbance is the true tropical storm or hurricane.[4] These are rare, but can pass close enough to the islands to yield heavy rains, high winds, and large waves (Western Regional Climate Center 2018). The official hurricane season in Hawaiʻi is from June 1 through November 1. The number of hurricanes and tropical storms in the central Pacific per year over the last 20 years (1999–2018) has varied from 1 in multiple years to 14 in 2015 with an average of 3.4 per year. Such storms typically bring heavy rains and are sometimes accompanied by strong winds. However, the highest rainfall intensities have not been associated with hurricanes.

Hurricanes and tropical storms have struck Kauaʻi on a number of occasions over the past 50 years. Table 3-1 summarizes the important characteristics of hurricanes that have affected Kauaʻi since 1950. Hurricanes are infrequent, but have had a great effect on Kauaʻi, especially its utility infrastructure. Most recently, on September 11, 1992, Hurricane ʻIniki struck Kauaʻi with sustained winds of 130 mph (209 kph) and caused nearly $2 billion in property and infrastructure damage. Kauaʻi also received the brunt of Hurricane ʻIwa, which struck on November 23, 1982, and produced an estimated $234 million in damage. Tropical storms that do not make landfall in Hawaiʻi can still cause considerable infrastructure damage mostly due to winds and high surf (National Oceanic and Atmospheric Administration n.d.).

Table 3-1. Major Hurricanes Affecting Kauaʻi: 1950 to 2018

		Maximum recorded winds ashore (mph)		
Name	**Date**	**Sustained**	**Peak gusts**	**Category**
Hiki	Aug. 15–17, 1950	68	UNK	1
Nina	Dec. 1–2, 1957	UNK	92	1
Dot	Aug. 6, 1959	81	103	2
ʻIwa	Nov. 23, 1982	65	117	3
ʻIniki	Sept. 11, 1992	92	143	4

Source: State of Hawaiʻi Department of Business, Economic Development, and Tourism 2019:Table 5.53.
Note: Category is based on the Saffir-Simpson Hurricane Scale:
Category 1: wind speed of 74–95 mph (119–153 kph), minimal damage.
Category 2: wind speed of 96–110 mph (154.5–177 kph), moderate damage.
Category 3: wind speed of 111–130 mph (178.6–209 kph), extensive damage.
Category 4: wind speed of 131–155 mph (210.8–249.4 kph), extreme damage.

Hurricanes ʻIniki and ʻIwa both resulted in significant changes in vegetation on the Kauaʻi, especially in the more remote areas of the interior. Hurricane-force winds denuded large areas of densely forested valley walls. Harrington et al. (1997) studied hurricane ʻIniki's effect on forest structure in Puʻu Ka Pele Forest Reserve, Nā Pali Kona Forest Reserve, and Kōkeʻe State Park and found that major overstory species, namely koa (*Acacia koa*) and ʻōhiʻa (*Metrosiderous polymorpha*), were damaged less than the subcanopy species ʻaʻaliʻi kūmakani (*Dodonaea viscosa*) and guava (*Psidium guajava*). Further, the invasive species guava had much higher survival than the native kūmakani. Forest structure and productivity had recovered to a great degree within 2 years after landfall of the hurricane (Harrington et al. 1997).

[4] A *hurricane* is an intense tropical weather system with well-defined circulation and maximum sustained winds of 74 mph (64 knots) or higher. A *tropical storm* is an organized system of strong thunderstorms with a defined circulation and maximum sustained winds of 39 to 73 mph (62.8 to 117.5 kph).

3.1.3.5 Global Climate Change

Global climate change is occurring because of high concentrations of greenhouse gases in the Earth's atmosphere (National Research Council 2010; Intergovernmental Panel on Climate Change 2014). *Climate* is defined as the average weather over many years, and climate change refers to a statistically significant change in the state of the climate or its variability that persists for an extended period, typically for decades or longer (Intergovernmental Panel on Climate Change 2014). Recent assessments demonstrate the Earth is undergoing changes in climate beyond natural variation (National Research Council 2010; Intergovernmental Panel on Climate Change 2014; Melillo et al. 2014). Evidence of long-term changes in climate over the 20th century includes the following.

- An increase of 1.53°F (0.85°C) in the Earth's global average surface temperature
- An increase of 6.7 in (17 cm) in the global average sea level
- A decrease in arctic sea-ice cover at a rate of approximately 4.1 percent per decade since 1979, with faster decreases of 7.4 percent per decade in summer
- Decreases in the extent and volume of mountain glaciers and snow cover
- A shift to higher altitudes and latitudes of cold-dependent habitats
- Longer growing seasons
- More frequent weather extremes, such as droughts, floods, severe storms, and heat waves

To better understand anticipated increases in temperature, climate models are frequently used. Projections of future climate are developed at many scales, from Global Climate Models to Regional Climate Models, including Regional Climate Models based on Global Climate Model data that have been statistically downscaled to particular regions (Wang et al. 2018), including Hawaiʻi. Future greenhouse gas emissions scenarios are used in climate model projections of possible future climate conditions.

Based on regional climate models that include Hawaiʻi, the size and intensity of large-scale storms in the state are expected to increase in coming years. These changes may already be occurring; recent data shows that the proportion of Category 4 and 5 hurricanes have increased at a rate of 25–30 percent of overall recorded hurricane activity, per °C increase in global warming (Holland and Bruyere 2014). A global warming of 2.7°F (1.5°C) is expected to shift the range of many marine species to higher latitudes, reducing the productivity of fisheries and aquaculture (Intergovernmental Panel on Climate Change 2018:B.4.3). Ocean warming from climate change is expected to increase the thermal stratification in the upper ocean, reducing the upwelling of nutrients and decreasing productivity (Fabry et al. 2008). Squid, a primary food source for Newell's shearwater (ʻaʻo) (*Puffinus auricularis newelli*), Hawaiian petrel (ʻuaʻu) (*Pterodroma sandwichensis*), and many other seabird species are predicted to undergo shifts in their range and size as a result of warmer ocean temperatures. Individual squid would require more food per unit body size, require more oxygen due to faster metabolism, have a reduced capacity to cope without food, and reduced pH could affect ability for squid to uptake oxygen (Pelc and Jackson 2008). Additional threats to the covered species related to climate change are described in Appendix 3A, *Species Accounts*.

3.2 Land Use

Kauaʻi's built environment consists of small, mostly rural communities along the coast margins and plains separated by expanses of open space and agricultural lands. Steep topography across much of Kauaʻi (see Figures 3-1 and 3-2) severely limits development in the interior of the island. There are no incorporated cities on Kauaʻi. The County of Kauaʻi is the one local government agency responsible for all land use planning on the island. Figure 3-6 shows land designations consistent with the Kauaʻi Future Land Use Map in the *Kauaʻi Kākou: Kauaʻi County General Plan* (General Plan) (County of Kauaʻi 2018). The General Plan was designed to avoid urban sprawl by focusing future development, uses, and density within and around existing towns, and preserving agricultural land and open space between towns (County of Kauaʻi 2018). The land use map accommodates projected housing needs within and adjacent to existing developed areas and discourages residential and resort development in new areas not directly adjacent to existing communities. Most of the growth is steered to the Līhuʻe and South Kauaʻi areas. Additional growth is allocated to the Waimea-Kekaha, Hanapēpē-ʻEleʻele, East Kauaʻi, and North Shore areas based on historic and natural increase trends.

A majority of the island is designated as *natural* in the Future Land Use Map—these areas have either limited development potential or are not suitable for development due to topography, hazards vulnerability, sensitive resources, and other constraints. Lands designated as natural generally overlap with the areas that have been identified as existing or potential habitat for the covered species as described in Section 3.3, *Existing Biological Environment*.

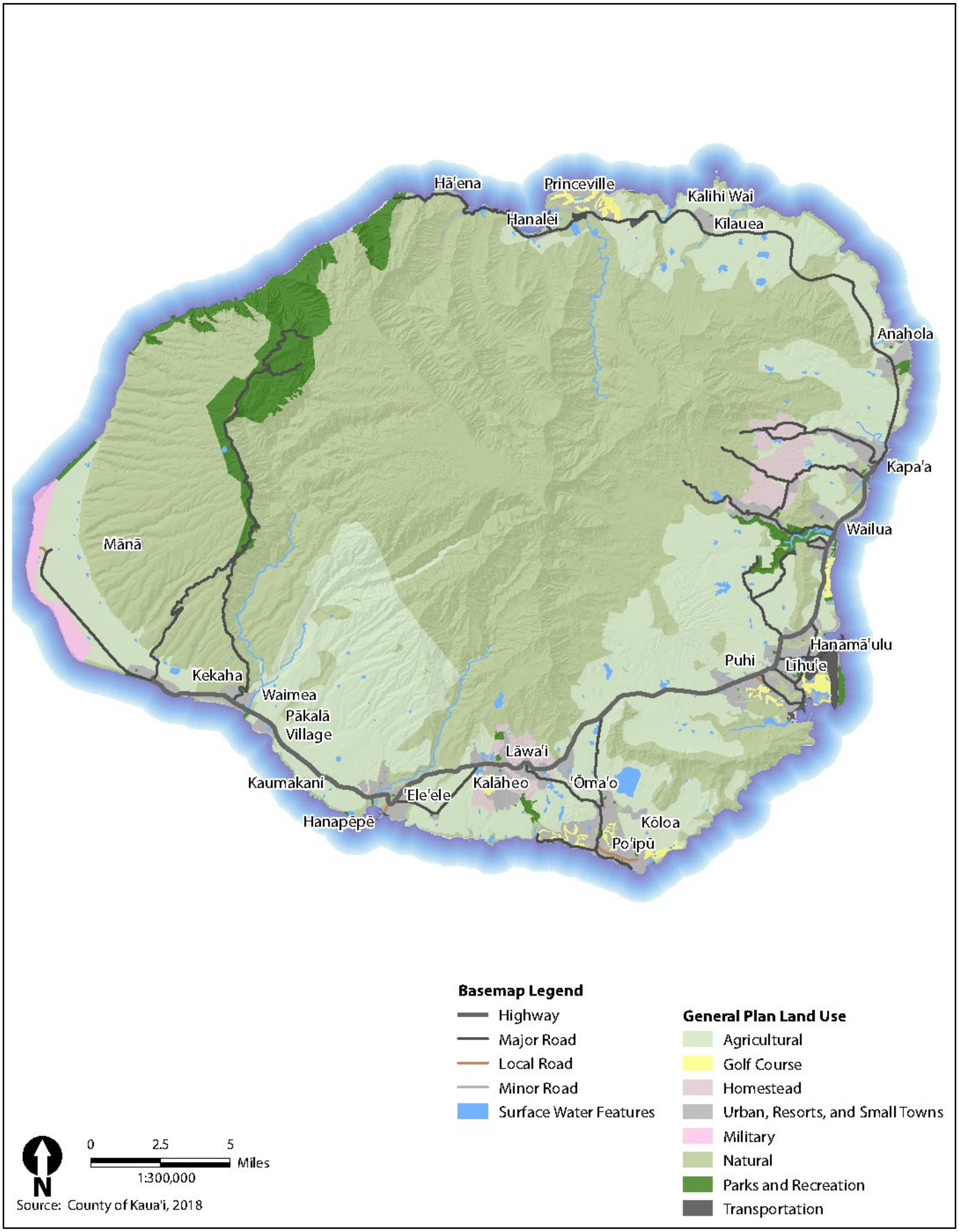

Figure 3-6. Land Use Designations on Kaua'i

3.3 Existing Biological Environment

3.3.1 Vegetation

As the oldest of the main Hawaiian Islands, Kaua‘i has relatively high levels of floristic diversity and endemism. Over time, the topography and habitats have become more fragmented, with deeper valleys and other local topographic features creating greater fragmentation of habitats and thus greater isolation and opportunities for speciation. The age of Kaua‘i (3 to 5 million years) has also provided more time for the development of floral biodiversity than on other Hawaiian Islands (Sakai et al. 2002).

Figure 3-7 depicts existing land cover types throughout Kaua‘i as distinct native and alien (i.e., invasive) vegetation types mapped by the U.S. Geological Survey Gap Analysis Program (GAP) and Carbon Assessment of Hawai‘i (CAH) (U.S. Geological Survey 2011, 2017). Terrestrial and wetland vegetation types in the CAH dataset were compared in a crosswalk to the GAP dataset. The majority of the two datasets are identical, but the CAH dataset further divides native and alien vegetation types into moisture categories (i.e., wet, mesic, or dry). To minimize the mapping units, the CAH moisture designations were grouped into corresponding vegetation macrogroups consistent with the GAP dataset. For example, the CAH vegetation types mapped as closed koa-‘ōhi‘a wet forest and closed koa-‘ōhi‘a mesic forest were merged with the GAP vegetation type mapped as closed koa-‘ōhi‘a forest. Following are general descriptions of the existing land cover types.

Native terrestrial vegetation is primarily found in the central portion of the island and consists of montane rainforest dominated by ‘ōhi‘a and/or koa trees. The dominant tree species is more often ‘ōhi‘a but a distinct type of forest in which tall koa trees emerge above the ‘ōhi‘a canopy also exists in areas with deep soils above an elevation of 3,000–4,000 ft (914–1,219 m). These forests are multilayered with smaller trees in the subcanopy including kāwa‘u (*Ilex anomala*), ‘alani (*Melicope* spp.), kōlea (*Myrsine* spp.), and olmea (*Perrottetia sandwicensis*). Epiphytic mosses, liverworts, ferns and silver-leaved lily pa‘iniu (*Astelia* spp.) are abundant on trunks and branches of large trees. In pristine areas, native ferns are abundant ground cover with scattered shrubs like kanawao (*Broussaisia arguta*) and pūkiawe (*Styphelia tameiameiae*). Lowland rainforest is typically dominated by ‘ōhi‘a with an understory of native trees including kōpiko (*Psychotria* spp.) and hame (*Antidesma platyphyllum*) (Cuddihy and Stone 1990).

Native wet cliff vegetation occurs primarily in the system of valleys running outward from the wet summit plateau region above the montane rainforests in the northern and central portions of the island. This land cover type is often dominated by the native uluhe fern (*Dicranopteris* spp.). The dry cliff vegetation on Kaua‘i occurs on steep-sided interior canyons and northern seacliffs and supports endemics like the ‘ālula (*Brighamia insignis*). Uluhe-dominated shrublands typically occur in patches throughout the island on mountain slopes (Cuddihy and Stone 1990).

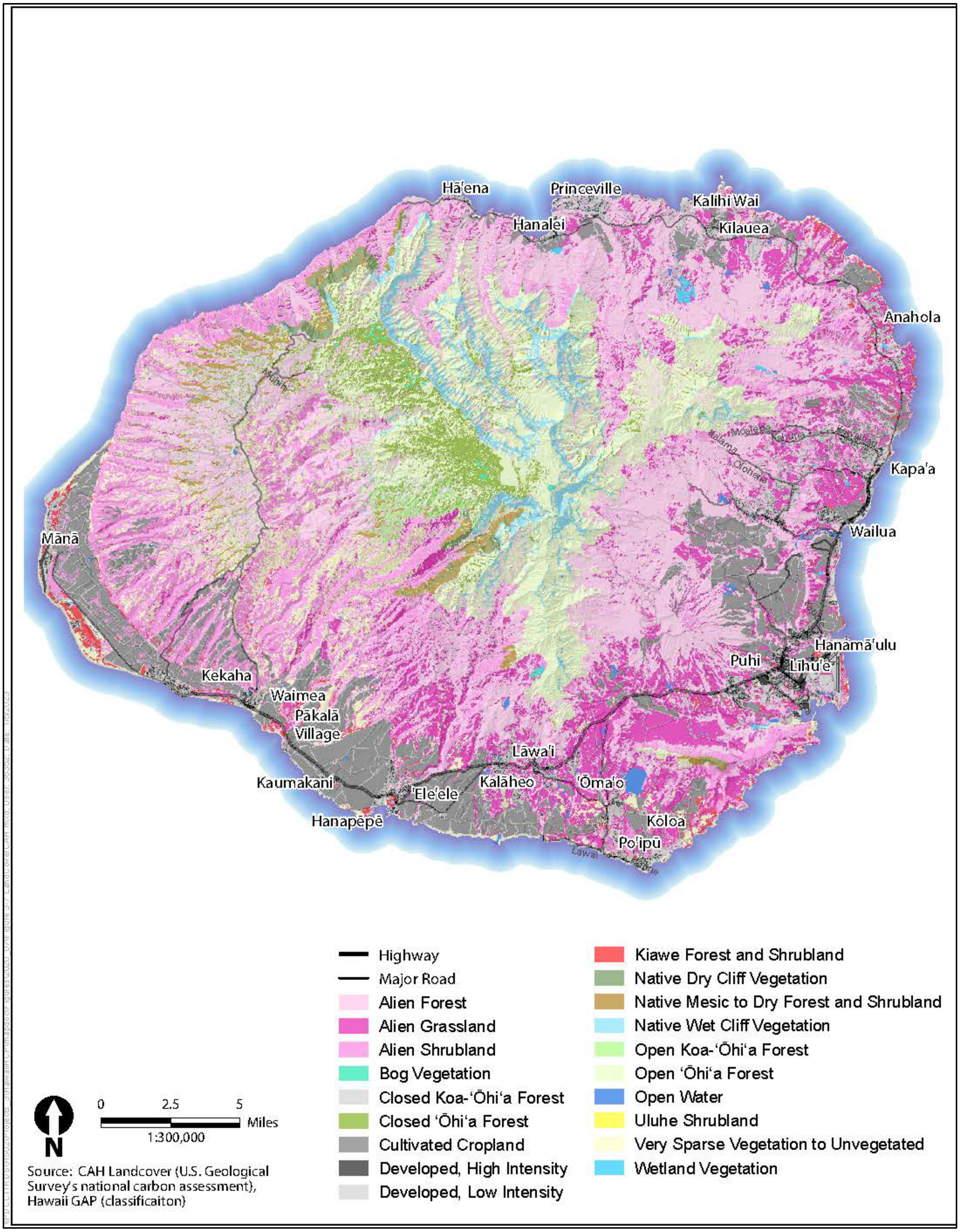

Figure 3-7. Land Cover Types of Kauaʻi

Another type of montane wet land cover is bogs, which are found in very wet, poorly drained places near mountain summits on Kauaʻi. Bogs are characterized by sedges and grasses (*Oreobolus furcatus*, *Carex* spp., *Rhynchospora* spp., *Dicanthelium* spp.) and stunted woody plants including naʻenaʻe (*Dubautia* spp.). Wahiawa Bog (Kanaele Swamp) is one of the island's known bog communities, characterized by shallow, poorly drained acidic peat soils and endemic plant species (Cuddihy and Stone 1990). Numerous estuarine and freshwater emergent wetlands skirt the lowlands throughout the island, along with human-made reservoirs and scattered ponds. Freshwater wetlands are also present in the higher-elevation, forested areas in the central region. Freshwater emergent wetlands typically consist of hydrophytic species including sedges (*Cyperus* spp.), rushes (*Mariscus* spp.), and bulrushes (*Schoenoplectella* spp.) both native and introduced to Kauaʻi (U.S. Fish and Wildlife Service 2011).

Mesic to dry forest and shrubland communities differ from wet montane forests in the relative scarcity of tree ferns (*Cibotium* spp.) and epiphytes, the abundance of shrubs such as pūkiawe in the understory, and a different complement of native ferns in the ground cover. For most of these forests the dominant trees are either ʻōhiʻa or koa, or a mixture of these two species. In a very few sites, mānele *(Sapindus saponaria)* is a co-dominant species in the ʻōhiʻa and koa mixed canopy. Mesic to dry forests have a very restricted distribution on Kauaʻi.

Vegetation known to be introduced to Kauaʻi include kiawe forest/shrubland in addition to alien grasslands, shrublands, and forests. Kiawe (*Prosopis pallida*) is a common invasive tree species known throughout the Hawaiian Islands and along the coastal zone of Kauaʻi. Alien shrublands and forests are characterized by introduced species such as jumbay (*Leucaena leucocephala*), fire tree (*Morella faya*), silk oak (*Grevillea robusta*), New Zealand laurel (*Corynocarpus laevigatus*), albizia (*Falcataria moluccana*), koa haole (*Leucaena leucocephala*) and banana poka (*Passiflora mollisima*) and occur throughout most of the island. Many invasive grasslands are also known from the eastern side of Kauaʻi and consist of a mix of invasive species including but not limited to molasses grass (*Melinis minutiflora*) and bushy beardgrass (*Andropogon glomeratus* var. *pumilus*) (Edmonds et al. 2016; Nagendra 2017; Natural Area Reserves System 2011; National Tropical Botanical Garden 2008).

Native vegetation on Kauaʻi has undergone extreme alterations because of past and present land use (primarily agriculture/cultivated croplands) and the intentional and inadvertent introduction of invasive plants and animals (Benning et al. 2002). Top crop items such as coffee, corn, taro, and fruit trees are grown on the island and over 3,000 acres (1,214 hectares) have been converted to pasture (County of Kauaʻi 2012). Remote island ecosystems such as the Hawaiian Islands have especially low biotic resistance to invasion because island species have evolved in isolation and often have little resistance to competitors, herbivores, and pathogens that have found their way to the island from continental regions (Weller et al. 2011). Browsing, digging, and trampling by introduced ungulates (i.e., pigs, goats, cattle, sheep, and deer) have resulted in the spread of invasive plants because many of the invasive plants can colonize newly disturbed areas more quickly and effectively than Hawaiʻi's native plants. Introduced ungulates are especially devastating for native island species that evolved in their absence (Milchunas and Noy-Meir 2002). Introduced rodents (rats and mice) feed on the fruits, seeds, and new growth of many endemic plants. Furthermore, even with ungulate exclusion and native seed augmentation, regeneration continues to be strongly limited by invasive grasses. Forced out by invasive plants, many endemic plants are now extinct, which now number more than 4,600 species. Many of the remaining endemic species are now listed as threatened or endangered. As a result, native forests are now limited to Kauaʻi's upper-elevation, moist, and wet regions.

The mountainous region of northwest Kauaʻi, where KIUC is managing and monitoring the covered seabirds supports semi-intact, native wet forest dominated by ʻōhiʻa and ʻōlapa (*Cheirodendron fauriei*) with openings in the forest dominated by uluhe. Other native trees common to mesic forests are scattered throughout such as hōʻawa (*Pittosporum glabrum*), pāpala kēpau (*Pisonia* sp.), hala pēpē (*Chrysodracon aurea*), and lama (*Diospyros sandwicensis*) (Edmonds et al. 2016; Nagendra 2017; Natural Area Reserves System 2011; National Tropical Botanical Garden 2008).

Despite the remoteness of these established conservation sites, invasive species are also present. They include, but are not limited to, the autograph tree (*Clusia rosea*), octopus tree (*Schefflera actinophylla*), broad-leaved paperbark (*Melaleuca quinquenervia*), Australian tree fern (*Cyathea cooperi*), Himalayan ginger (*Hedychium gardnerianum*), lantana (*Lantana camara*), molasses grass, and bushy beardgrass (Edmonds et al. 2016; Nagendra 2017; Natural Area Reserves System 2011; National Tropical Botanical Garden 2008). These invasive species are believed to be spreading when left unchecked (National Tropical Botanical Garden 2008). The National Tropical Botanical Garden, which owns and manages the Upper Limahuli Preserve, actively works to control invasive species within the Upper Limahuli Preserve with funding from KIUC and others.

3.3.2 Covered Species

Detailed information on the status, life history, distribution, population trends, and habitat use of each of the covered species is included in the species accounts provided in Appendix 3A, *Species Accounts*. The sections below summarize basic biological information to provide context for the next two chapters of the HCP (Chapter 4, *Conservation Strategy*, and Chapter 5, *Effects*). For covered seabirds, status and seasonal and local movement patterns are summarized below because they relate to species impacts resulting from the covered activities (powerline strikes and light attraction). The reproductive biology and threats to covered seabirds are also summarized below because they are relevant to the impact analysis and conservation strategy. Relevant factors summarized for covered waterbirds include threats and conservation needs, status, habitat affinities, and movement patterns. Relevant factors summarized for green sea turtle (honu) include range, life history, and current known threats.

3.3.2.1 Covered Seabirds

The seabirds covered in the KIUC HCP include Newell's shearwater (ʻaʻo), Hawaiian petrel (ʻuaʻu), and the Hawaiʻi distinct population segment (DPS) of the band-rumped storm-petrel (ʻakēʻakē) (*Oceanodroma castro*) (hereafter band-rumped storm-petrel). Newell's shearwater (ʻaʻo) is state- and federally listed as threatened: breeding is only known on Kauaʻi, Maui, and Hawaiʻi, but song meter recordings made in 2016 and 2017 indicate that a small number of Newell's shearwaters (ʻaʻo) regularly prospect on Oʻahu (Young et al. 2019). The Hawaiian petrel (ʻuaʻu) is state- and federally listed as endangered: once abundant and widely distributed across Hawaiʻi, the majority of the breeding population is now found on Kauaʻi, Maui and Lānaʻi, with smaller populations on Hawaiʻi. Hawaiian petrel (ʻuaʻu) is nearly extirpated on Oʻahu and Molokaʻi (Pyle and Pyle 2017). The band-rumped storm-petrel (ʻakēʻakē) is also state- and federally listed as endangered: their current distribution is poorly known (Raine et al. 2017a), but potential breeding sites have been recorded on Hawaiʻi (Banko et al. 1991; Galase et al. 2016), Maui (Banko et al. 1991), Kahoʻolawe (Hawaiʻi Heritage Program 1992), Lehua Islet (VanderWerf et al. 2007), and Kauaʻi (Raine et al. 2017a; Wood et al. 2002). No band-rumped storm-petrel (ʻakēʻakē) nests have been located on

Kauaʻi, but based on auditory survey data, breeding likely occurs at several locations on Kauaʻi, primarily in the steep cliff areas of the Nā Pali Coast (Raine et al. 2017a).

The covered seabirds are pelagic, spending most of their time at sea and coming to land only to breed (Ainley et al. 2014; Simons 1985; Spear et al. 2007). During the non-breeding season they travel well away from Hawaiʻi in the tropical Pacific. Newell's shearwaters (ʻaʻo) are absent from waters within 125 mi (201 km) of the Hawaiian Islands in the non-breeding season (winter and autumn) (King and Gould 1967; Spear et al. 1995). Some band-rumped storm-petrels (ʻakēʻakē) remain near their breeding island during the non-breeding season, while others make long-distance movements as far as over 990 mi (1,593 km) south of Hawaiʻi to the Phoenix Islands and Japan (Slotterback 2002; Mitchell et al. 2005).

During the breeding season (March through December, with slight variability in the breeding window by species), the seabirds return to land, where they nest in burrows beneath ferns and tree roots in dense forest and on steep slopes and cliffs. Adult Newell's shearwaters (ʻaʻo) only fly to and from their burrows at night. Breeding adults fly from the ocean to their breeding site after sunset and leave their burrows and fly from the breeding site to the ocean in the early morning before sunrise. Newell's shearwaters (ʻaʻo) travel between the sea and nests generally nightly to forage and feed their chicks (Ainley et al. 2020). Hawaiian petrels (ʻuaʻu) transit over land to and from the breeding sites mostly in darkness, though some begin to fly ashore just at sunset (Ainley et al. 1997). Unlike Newell's shearwaters (ʻaʻo), Hawaiian petrels (ʻuaʻu) have highly variable flight schedules, with arrivals and departures occurring from sunset to sunrise (Raine et al. 2017b). Band-rumped storm-petrels (ʻakēʻakē) have been observed feeding during the day, but likely also feed at night (Harris 1969; Kauaʻi Endangered Seabird Recovery Project 2019).

Newell's shearwaters (ʻaʻo) remain at sea for the first few years of life, and subadults are thought to start visiting their breeding sites at 2–3 years of age and start breeding at approximately 6 years of age (Ainley et al. 2001; Griesemer and Holmes 2011; Raine et al. 2020). In late March/early April through late April, adults arrive at inland breeding sites to check on their burrows and maintain them. In late April and possibly through mid-May, breeding adults forage at sea to build up reserves (Raine and Banfield 2015; Raine and McFarland 2013), during which time females are gone for 25 to 30 days while males visit the burrows occasionally (Ainley et al. 2020). In early June through July, each breeding pair lays a single egg and parents take turns incubating the egg and going out to sea to feed. Peak overland passage rates for Newell's shearwaters (ʻaʻo) coincide with the late incubation (July) and chick-rearing stages (August) (Travers et al. 2013). In late July through early October, both parents go to sea during the day with one returning each night to feed the chick. Provisioning by both adults continues through September with individual adults being at sea for periods of 1 to 3 nights (Ainley et al. 2014; Raine and McFarland 2013). From late September through mid-November the fledgling flies from its burrow to the sea, with a peak in October.

Hawaiian petrels (ʻuaʻu) on Kauaʻi arrive at their colonies mid- to late March and engage in a period of burrow maintenance or building and socialization. In mid-April, they return to the ocean for approximately 1 month to forage and build up reserves. Upon returning to the colonies in May, each pair lays a single egg and alternates incubating for approximately 55 days. Chicks typically hatch in July, at which point both parents fly to the ocean to forage and return to feed the nestling. Petrel offspring require up to 5 months of care from both parents to fledge. Both adult male and female Hawaiian petrels (ʻuaʻu) attend to nest duties equally (Simons and Hodges 1998). Fledging typically occurs in late October through mid-December, peaking in November.

Band-rumped storm-petrels (ʻakēʻakē) on Kauaʻi return to nest sites in late May, complete egg laying by mid-June, and fledge in October (Raine et al. 2016a). Incubation averages 42 days and young fledge 70–78 days after hatching (Harris 1969). Fledglings leave the nest between mid-September and late November, with peak fledging occurring in October (Raine et al. 2016a). Based on acoustic data, adults likely leave the nesting grounds in October.

For species with naturally low reproductive rates that rely on high adult survivorship, introduced threats that increase mortality rates, such as powerline collisions and invasive predators, can result in significant population declines. The covered seabirds share these characteristics of low reproductive rates and high adult survivorship, making their populations particularly vulnerable to introduced threats. Newell's shearwaters (ʻaʻo) breed at a late age (6 years to first breeding) and have low fecundity (only one chick per pair each breeding year), and high adult survival (Warham 1990, 1996; Ainley et al. 2001; Griesemer and Holmes 2011; Raine et al. 2020). No specific data exist on the longevity for Newell's shearwater (ʻaʻo) but based on what has been observed among other shearwaters it is reasonable to assume that they can reach a maximum age of 30 years or more (Ainley et al. 2001). Similarly, Hawaiian petrels (ʻuaʻu) have a long lifespan (up to 35 years), do not reproduce until 6 years of age, and lay only one egg per year (Simons and Hodges 1998). They also tend to have high adult survival (Ainley et al. 2001; Griesemer and Holmes 2011; Raine et al. 2020). Band-rumped storm-petrel (ʻakēʻakē) reach sexual maturity between 3 and 7 years of age (Harrison 1990), have only one chick per year, and likely live for 15 to 20 years (State of Hawaiʻi Division of Forestry and Wildlife 2005).

Kauaʻi supports 90 percent of the total Newell's shearwater (ʻaʻo) population (Pyle and Pyle 2009; Ainley et al. 2020) and 33 percent of the total Hawaiian petrel (ʻuaʻu) population (Raine pers. comm.). Archipelago Research and Conservation (ARC) developed a theoretical population estimate for each species based on the most current data available, which estimated a minimum Newell's shearwater (ʻaʻo) population on Kauaʻi of approximately 34,546 individuals and a minimum Hawaiian petrel (ʻuaʻu) population of approximately 25,277 individuals. There is insufficient data available to estimate the band-rumped storm-petrel (ʻakēʻakē) population on Kauaʻi.

At conservation sites which have been actively managed and acoustically monitored, there have been statistically significant increases in call rates between the first year of monitoring (either 2014 or 2015, depending on the site) and 2021. The rates of increase in Newell's shearwater (ʻaʻo) call rates range between 8.23 percent at Hanakoa and 18.29 percent at North Bog and Hawaiian petrel (ʻuaʻu) range between 8.76 percent at Hanakoa to 26.48 percent at North Bog (Archipelago Research and Conservation 2022).

Covered seabirds on Kauaʻi are subject to the following threats (Slotterback 2002; State of Hawaiʻi Division of Forestry and Wildlife 2005).

- Depredation at breeding sites by introduced predators such as pigs (*Sus scrofia*), rats (*Rattus rattus*), feral cats (*Felis silvestris*), barn owls (*Tyto alba*), and feral honeybees (Order: Hymenoptera) (Raine et al. 2020).
- Loss and degradation of breeding habitat caused by introduced ungulates such as pigs and goats (*Capra hircus*) and introduced plants.
- Artificial lighting from various sources (e.g., streetlights, resorts), which attracts and causes "fallout" of seabirds and increases their chance of colliding with artificial structures.
- Collisions with powerlines, buildings, towers, and wind turbines.

- Pollution (e.g., mercury, plastic ingestion, oil spills).
- Factors affecting seabird prey availability in the ocean such as overharvesting by the fishing industry, as well as bycatch.
- Climate change, potentially affecting both terrestrial and ocean conditions.

The daily movement patterns of the covered seabirds between breeding and foraging habitats and their relatively low maneuverability make them particularly susceptible to colliding with artificial structures, predominantly utility lines (Travers et al. 2019, 2020). Their nocturnal movements, in addition to the phototropic tendencies of fledglings (i.e., tendency to be attracted to light), make them susceptible to fallout from artificial lighting (Telfer et al. 1987). In addition to human-caused factors, stochastic events such as storms are likely to influence population numbers (Vorsino 2016). Both local and regional storms, depending on their severity and type, can result in significant habitat degradation and loss due to high winds, landslides, and flooding, as well as loss of burrows, chicks, and eggs. In 2021, a Hawaiian petrel (ʻuaʻu) chick was rescued from a flooded burrow in the Hono O Nā Pali Natural Area Reserve (Archipelago Research and Conservation 2022). Habitat loss and conversion historically has had a major negative effect on the covered seabird species as civilization has expanded into natural areas along with its accompanying pets, farm animals, vehicles, and other infrastructure (Raine et al. 2016b, 2016c, 2016d).

Compared to Newell's shearwater (ʻaʻo), fewer Hawaiian petrels (ʻuaʻu) are found grounded and turned in to Save Our Shearwaters (SOS) during the fledging season, likely related to a lower level of attraction to artificial light. On average, 9.6 Hawaiian petrels (ʻuaʻu) (compared to 179 Newell's shearwater [ʻaʻo]) were received by the SOS program annually between 2014 and 2018 (Anderson 2015, 2016, 2017, 2018, 2019).

3.3.2.2 Covered Waterbirds

Waterbirds covered in the KIUC HCP are the Hawaiian stilt (aeʻo) (*Himantopus mexicanus knudseni*), Hawaiian duck (koloa maoli) (*Anas wyvilliana*), Hawaiian coot (ʻalae keʻokeʻo) (*Fulica alai*), Hawaiian common gallinule (ʻalae ʻula) (*Gallinula galeata sandvicensis*), and the Hawaiian goose (nēnē) (*Branta sandvicensis*). The covered waterbirds are endemic to Hawaiʻi and are state- and federally listed as endangered, except for Hawaiian goose (nēnē), which was federally downlisted to threatened in January 2020 (84 *Federal Register* 69918).

Except for the Hawaiian goose (nēnē), the covered waterbird species are associated only with wetlands and open water habitat in Kauaʻi (Figures 3-3 and 3-4). Hawaiian geese (nēnē) use a wide variety of habitats including coastal dune vegetation and grasslands, sparsely vegetated lava flows, shrublands, and woodlands in areas that typically have less than 90 in (228.6 cm) of annual rainfall (U.S. Fish and Wildlife Service 2004). The Hawaiian goose (nēnē) also inhabits highly altered landscapes such as pastures, agricultural fields, and golf courses (U.S. Fish and Wildlife Service 2004).

All the covered waterbird species are non-migratory, but movements within Kauaʻi and between islands vary by species. Interisland movement is an important strategy for Hawaiian stilts (aeʻo) to exploit food resources, and individuals on Kauaʻi move seasonally to Niʻihau in response to water level changes in Niʻihau's ephemeral lakes (VanderWerf 2012). Breeding habitat differs from foraging habitat for Hawaiian stilts (aeʻo), and individuals move between the two habitats daily. Some seasonal, altitudinal, and interisland movements occur for Hawaiian ducks (koloa maoli), although the timing and mechanics are not well understood (Engilis and Pratt 1993). Hawaiian coots

(ʻalae keʻokeʻo) travel long distances, including between islands, in response to rainfall and food source depletion and many move to Niʻihau when suitable temporary ponds are available. It is unknown whether Hawaiian common gallinules (ʻalae ʻula) are capable of interisland movement. Historically, Hawaiian goose (nēnē) flocks have moved between high-elevation feeding habitats and lowland nesting areas and although they are capable of interisland flight, their wings are reduced in size when compared to closely related species.

Long-term census data indicate that the statewide population of the covered waterbirds are stable or increasing, within global population trends being heavily influenced by Kauaʻi population trends (Paxton et al. 2022). Over the last two decades the Hawaiian stilt (aeʻo) population has averaged 1,500 individuals (U.S. Fish and Wildlife Service 2020b). The Hawaiian duck (koloa maoli) population is estimated to be about 2,200 individuals, with 2,000 true (non-hybrid) Hawaiian ducks (koloa maoli) on Kauaʻi and Niʻihau, and 200 on the Island of Hawaiʻi (Engilis et al. 2020). The State's biannual surveys typically do not include remote wetlands and streams (Engilis et al. 2002), where an estimated 50 to 80 percent of Hawaiian ducks (koloa maoli) are believed to reside on Kauaʻi (Schwartz and Schwartz 1953). The Hawaiian coot (ʻalae keʻokeʻo) population is currently estimated to be between 1,248 and 2,577 individuals. The current population of the Hawaiian common gallinule (ʻalae ʻula) is small but relatively stable, with a minimal 5-year average of 927 (678 to 1,235) individuals. The 2020 statewide population of Hawaiian geese (nēnē) totaled 3,865 individuals (Nēnē Recovery Action Group 2022) (in comparison to the 2,855 individuals reported in 2016 (Nēnē Recovery Action Group 2017), and the fewer than 300 individuals at the time of listing in 1967 (U.S. Fish and Wildlife Service 2004).

The most consequential threat to the covered waterbird species has been the loss of wetland habitat. In the last 110 years, approximately 31 percent of coastal plain wetlands have been lost (U.S. Fish and Wildlife Service 2011). Many remaining wetland areas have been invaded by invasive plant species, altering the plant communities, and rendering the habitat unsuitable for some native species such as stilts. Predation by invasive animals such as feral cats and rats continues to negatively affect the covered waterbird species on Kauaʻi (U.S. Fish and Wildlife Service 2011). Environmental contaminants such as fuel spills, water pollution, and pesticides continues to degrade habitats that support covered waterbirds. Collisions with vehicles and structures (e.g., powerlines) are also a threat to the covered waterbirds. For example, when taking off and landing, the long, low flight path of Hawaiian geese (nēnē) makes them vulnerable to collisions with stationary structures and moving objects such as vehicles and aircraft (Banko et al. 2020; State of Hawaiʻi Division of Forestry and Wildlife 2015). The most significant threat facing the Hawaiian duck's (koloa maoli) continued existence is hybridization with feral mallards; as a result, it is now among the rarest of the world's birds (Engilis et al. 2020).

Disease is also a significant cause of mortality for the covered waterbird species in Hawaiʻi. The most prevalent avian disease that continues to endanger Hawaiian waterbirds is avian botulism. The disease can reappear annually in wetland habitats with stagnant water. The deadly effect, which includes flaccid paralysis and eventual leg paralysis, is caused by a toxin produced by the anaerobic bacteria known as *Clostridium botulinum* (type C). Avian botulism has been documented in the following locations: ʻŌhiʻapilo Pond on Molokaʻi, Hanalei National Wildlife Refuge on Kauaʻi, ʻŌpaeʻula Pond and ʻAimakapā Pond on Hawaiʻi, Keālia Pond National Wildlife Refuge and Kanahā Pond Wildlife Sanctuary on Maui, and at the lake on Laysan Island. Two emerging avian diseases also pose significant threats to the covered waterbirds: West Nile virus and avian influenza H5N1 or "bird flu". Both diseases have yet to be identified in the covered waterbird populations in Hawaiʻi (U.S. Fish and Wildlife Service 2011).

3.3.2.3 Green Sea Turtle

Green sea turtle (honu) (*Chelonia mydas*) was listed under the federal Endangered Species Act on July 28, 1978 (43 *Federal Register* 32800). On February 16, 2012, both the U.S. Fish and Wildlife Service and National Marine Fisheries Service (referred to herein as the Services) received a petition to identify the Hawaiian green sea turtle (honu) population as a DPS and delist it. After conducting a status review, the Services determined on April 6, 2016, that the Hawaiian population of the green sea turtle (honu) met the definition of threatened and identified it as the Central North Pacific Distinct Population Segment (CNPDPS) (81 *Federal Register* 20057). The CNPDPS of the green sea turtle (honu) (hereafter green sea turtle) is also protected by Chapter 195D of the Hawaiʻi Revised Statutes and Section 13-124 of Hawaiʻi Administrative Rules.

The range of the green sea turtle (honu) includes the Hawaiian Archipelago and Johnston Atoll. The Hawaiian Archipelago represents the most geographically isolated chain of islands globally and this DPS's distribution reflects that isolation. From 1965 to 2013, 17,536 individuals of green sea turtle (honu) have been tagged, an effort that has involved all post-pelagic size classes from juveniles to adults. With only three exceptions, the 7,360 recaptures of these tagged turtles have been made within the Hawaiian Archipelago. The outliers involved one recovery each in Japan, the Marshall Islands, and the Philippines (Seminoff et al. 2015).

Most green sea turtles (honu) spend most of their lives in open coastline and protected bays and lagoons (Seminoff et al. 2015). While in these areas, green sea turtles (honu) rely on marine algae and seagrass as their primary food, although some populations also forage heavily on invertebrates at different parts of their life cycle. On shore, green sea turtles (honu) rely on beaches characterized by intact dune structures, native vegetation, lack of artificial lighting, and normal beach temperatures for nesting (Limpus 1971; Salmon et al. 1992; Ackerman 1997; Witherington 1997; Lorne and Salmon 2007). In Kauaʻi, green sea turtle (honu) monitoring data collected from 2010 to 2012 were used to calculate an estimated nesting abundance of 16 females (Seminoff et al. 2015). In 2015, Parker and Balazs documented 20 nesting sites[5] around Kauaʻi. Average annual nesting density of green sea turtles (honu) at all Kauaʻi sites is very low, ranging from less than one (i.e., one nest every several years) to one to two nests per year between 2015 and 2020 (State of Hawaiʻi Division of Aquatic Resources 2020). Although nesting density is low, observations of nesting have increased over the past 5 years (State of Hawaiʻi Division of Aquatic Resources 2020).

The primary causes of the decline of green sea turtle (honu) are attributed to a variety of anthropogenic threats; development and public use of beaches, vessel strikes, attraction to artificial lights, bycatch in fishing gear, pollution, interactions with recreational and commercial vessels, beach driving, and major storm events all negatively affect green sea turtles (honu). Three of the most common reasons for sea turtle injury and mortality in Hawaiʻi are entanglement in fishing lines, interactions with fishing hooks, and interaction with marine debris (usually entanglement in nets). Coastal development and construction, vehicular and pedestrian traffic, beach pollution, tourism, and other human-related activities are increasing threats to the basking and nesting population in the main Hawaiian Islands and negatively affect hatchling and nesting turtles on Hawaiʻi's beaches.

[5] Nesting data reported from Kauaʻi are speculative due to the lack of systematic surveys. Estimates may also be skewed toward high-use beaches and beaches that regularly have resting seals (as this is how green sea turtle [honu] nests have been opportunistically found).

Threats resulting from climate change, including habitat loss and effects from warming sea and air temperatures, are characterized as high and the extent to which green sea turtles (honu) can adapt to these changes in nesting beach location and quality is unknown. Climate change will likely also cause higher sand temperatures, leading to increased feminization of surviving hatchings (i.e., changes in sex ratio), which in turn can lead to lower fecundity rates and ultimately population declines (Blechschmidt et al. 2020). Some beaches will also experience lethal incubation temperatures that will result in complete losses of hatchling cohorts (Glen and Mrosovsky 2004; Fuentes et al. 2010, 2011, Blechschmidt et al. 2020). Changes in sea temperatures will also likely alter seagrass, macroalgae, and invertebrate populations in coastal habitats in many regions (Scavia et al. 2002). Coastal areas denuded of vegetation or with construction can also affect thermal regimes on beaches; thus, they can affect incubation rates and increase the probability of biased sex ratios in hatchling sea turtles. Because of potential tidal inundation associated with lack of vegetation, nests laid in these areas are at a higher risk than those on more pristine beaches (Schroeder and Mosier 2000).

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Chapter 4
Conservation Strategy

4.1 Introduction

The KIUC HCP conservation strategy is the program that KIUC will implement over the permit term to contribute to the recovery of the covered species and fully offset the impacts of the taking of the covered activities on each covered species. The conservation strategy is designed to meet or exceed the regulatory requirements of the federal Endangered Species Act (federal ESA) and Hawaiʻi Revised Statutes (HRS) Chapter 195D, as well as to streamline compliance with the National Environmental Policy Act, Hawaiʻi Environmental Policy Act, and other applicable environmental regulations (see discussion in Chapter 1, *Introduction and Background*). Based on the biological needs of the covered species, the conservation strategy also minimizes the effects of the covered activities on the covered species. The conservation strategy provides mitigation and conservation for the effects of KIUC's covered activities on the covered species that remain, after minimization. See Chapter 5, *Effects*, for a full description of the effects of KIUC's covered activities on each of the covered species.

4.1.1 Overview

The conservation strategy is composed of two primary components that are closely linked—the biological goals and objectives and a set of conservation measures. The biological goals and objectives, described in Section 4.3, *Biological Goals and Objectives,* reflect the expected ecological outcomes of full implementation of the KIUC HCP. The biological goals set out the broad principles KIUC used to guide the development of the conservation strategy. The biological objectives describe the specific conservation commitments. Objectives are measurable and quantitative; they clearly state a desired result and will collectively achieve the biological goals. Biological goals and objectives are the foundation of the conservation strategy and are intended to provide the following functions.

- Describe the desired biological outcomes of the conservation strategy and how those outcomes will provide for the conservation of covered species and their habitats.
- Provide quantitative commitments and timeframes for achieving the desired outcomes.
- Serve as benchmarks by which to measure progress in achieving those outcomes across multiple temporal and spatial scales.
- Provide metrics for the monitoring program that will evaluate the effectiveness of the conservation measures and, if necessary, provide a basis to adjust the conservation measures to achieve the desired outcomes.

To achieve the biological goals and objectives, KIUC commits to implementing the conservation measures, described in Section 4.4, *Conservation Measures*. The conservation measures are the actions KIUC will implement to meet the biological goals and objectives.

4.2 Methods and Approach

The conservation strategy was developed through extensive discussions and collaboration with the U.S. Fish and Wildlife Service (USFWS) and State of Hawaiʻi Department of Land and Natural Resources (DLNR), Division of Forestry and Wildlife (DOFAW), during and after implementation of KIUC's *Short-Term Seabird Habitat Conservation Plan* (Short-Term HCP; Kauaʻi Island Utility Cooperative 2011). It incorporates engineering and biological information regarding the cost, feasibility, and biological effectiveness of various minimization and conservation measures, drawing on techniques and information KIUC has developed through the Short-Term HCP for seabirds.

The conservation strategy is based on the best scientific data available as listed in Section 4.2.3, *Information Sources*, and was designed to be quantitative and measurable (Noss 1987).

4.2.1 Regulatory Background on Biological Goals and Objectives and Conservation Measures

HCPs are required to include biological goals and objectives for the covered species, either individually or in groups (U.S. Fish and Wildlife Service and National Marine Fisheries Service 2016). HRS Chapter 195D does not require biological goals and objectives in HCPs.

Biological goals are broad, guiding principles based on the biological needs of the covered species, and should broadly describe the desired future conditions for covered species in the Plan Area in succinct statements (U.S. Fish and Wildlife Service and National Marine Fisheries Service 2016:9-8). Each biological goal steps down to one or more biological objectives that define how to achieve the goal in measurable terms. As such, biological objectives are expressed as specific desired conditions that are measurable and quantitative when practicable and provide the foundation for evaluating effectiveness of the conservation strategy.

Biological goals and objectives should be developed based on existing conservation information relevant to the covered species. Biological goals and objectives should also be developed to remain attainable given the projected effects of climate change in the Plan Area during the permit term (U.S. Fish and Wildlife Service and National Marine Fisheries Service 2016:9-5).

Biological objectives are met through one or more *conservation measures*. Conservation measures can include actions that do any of the following to meet the goals and objectives of the HCP.

- Avoid effects on the covered species, or on other non-covered species (called *avoidance measures*)
- Reduce or minimize effects on the covered species (called *minimization measures*)
- Offset effects on the covered species that remain after minimization (called *mitigation*)

In sum, the entire conservation strategy (i.e., all conservation measures together) are intended to meet the regulatory standards under both the federal ESA[1] and HRS Chapter 195D[2] to do the following.

- Minimize and mitigate the impacts of the take to the maximum extent practicable (federal ESA and HRS Chapter 195D)

[1] 50 Code of Federal Regulations Section 17.22(b)(2)(i).

[2] Hawaiʻi Revised Statute Sections 195D-4(g) and 195D-21(c)(1) and (2).

- Not appreciably reduce the likelihood of survival and recovery of the covered species in the wild (federal ESA)
- Increase the likelihood that the covered species will survive and recover (HRS Chapter 195D)
- Result in an overall net gain in the recovery of the covered species (HRS Chapter 195D)

4.2.2 Process of Developing the Biological Goals and Objectives and Conservation Measures

The biological goals and objectives were developed first for the covered seabirds to address the complexities associated with the high level of effects (see Chapter 5, *Effects*) that has degraded the status of the species (Appendix 3A, *Species Accounts*). The seabird biological goals and objectives focus first on minimizing KIUC's impact from powerline strikes and light attraction from KIUC streetlights. Second, the biological goals and objectives for covered seabirds focus on mitigating to the maximum extent practicable the remaining unavoidable effects and contributing to species recovery.

The biological goals and objectives for the covered waterbirds are very similar to the goals and objectives for the covered seabirds. For example, the covered waterbird biological goals and objectives also focus on minimizing and mitigating the effects of powerline strikes. However, the covered waterbird strategy focuses on minimization efforts at specific locations with the highest probability of waterbird strikes rather than throughout the Plan Area.

The biological goals and objectives for green sea turtle (honu) focus on minimizing the effects of streetlights at active nests in order to minimize hatchling disorientation.

As with any biological system, there is some uncertainty regarding the effectiveness of the conservation measures. To address this uncertainty, the adaptive management program is a critical component of the KIUC HCP. Adaptive management will allow KIUC to adjust the conservation measures based on the monitoring results so that they are more likely to meet the biological goals and objectives of the HCP. See Chapter 6, *Monitoring and Adaptive Management Program*, for the KIUC HCP's prescriptive adaptive management strategy.

4.2.3 Information Sources

The conservation strategy was developed by KIUC in close collaboration with USFWS, DOFAW, and other local conservation partners such as Archipelago Research and Conservation (ARC) (species experts formerly with the Kaua'i Endangered Seabird Recovery Project). It is based on the biological needs of the covered species and the need to meet the regulatory standards described at the beginning of this chapter and in Chapter 1, *Introduction and Background*. The biological needs of the covered species are summarized in the species accounts in Appendix 3A, *Species Accounts*. In addition, several key sources of literature were used to inform the conservation strategy.

- *Hawaiian Dark-Rumped Petrel and the Newell's Manx Shearwater Recovery Plan* (U.S. Fish and Wildlife Service 1983)
- *Hawaiian Dark-rumped Petrel and Newell's Manx Shearwater Recovery Plan: Newell's Townsend's Shearwater Recovery Criteria* (U.S. Fish and Wildlife Service 2019)
- *Draft Recovery Plan for the Nene or Hawaiian Goose* (U.S. Fish and Wildlife Service 2004)

- *Recovery Plan for Hawaiian Waterbirds*, Second Revision (U.S. Fish and Wildlife Service 2011)
- *Regional Seabird Conservation Plan* (U.S. Fish and Wildlife Service 2005)
- *Hawaii's Comprehensive Wildlife Conservation Strategy* (Mitchell et al. 2005)
- *Hawai'i's State Wildlife Action Plan* (State of Hawai'i Department of Land and Natural Resources 2015)
- *Newell's Shearwater and Hawaiian Petrel Recovery: A Five-Year Action Plan* (Holmes et al. 2015)
- *Newell's Shearwater Landscape Strategy* (U.S. Fish and Wildlife Service 2017a)
- Newell's Shearwater Landscape Strategy Appendix II, *Modelling Methods and Results used to Inform the Newell's Shearwater Landscape Strategy* (U.S. Fish and Wildlife Service 2017b)
- *Short-Term Seabird Habitat Conservation Plan* (Kaua'i Island Utility Cooperative 2011)
- *Kaua'i Seabird Habitat Conservation Plan* (State of Hawai'i Division of Forestry and Wildlife 2020)
- *Final Environmental Assessment for Newell's Shearwater Management Actions* (U.S. Fish and Wildlife Service 2016)
- *Managing the Effects of Introduced Predators on Hawaiian Endangered Seabirds* (Raine et al. 2020a)
- *Underline Monitoring Project Review Draft—Bayesian Acoustic Strike Model* (Travers et al. 2020a)
- *Assessing the Reliability of Existing Newell's Shearwater* Puffinus newelli *and Hawaiian Petrel* Pterodroma sandwichensis *Population Estimates Using Contemporary Tracking Data* (Raine et al. 2021a)
- *Post-release Survival of Fallout Newell's Shearwater Fledglings from a Rescue and Rehabilitation Program on Kaua'i, Hawai'i* (Raine et al. 2020b)
- *2017 Annual Radar Monitoring Report* (Raine et al. 2017a)
- *2020 Annual Radar Monitoring Report* (Raine and Rossiter 2020)
- *Underline Monitoring Project-Power Line Minimization Briefing Document* (Travers et al. 2019a)
- *Underline Monitoring Project Power Line Minimization Briefing Document Supplement 2* (Travers and Raine 2020a)
- *Underline Monitoring Project Annual Reports* for field seasons 2012 through 2019 (Travers et al. 2012, 2013, 2014, 2015, 2016, 2017a, 2018, 2019b, and 2020b)
- *Using Automated Acoustic Monitoring Devices to Estimate Population Size of Endangered Seabird Colonies on Kaua'i* (Raine et al. 2019a)
- *KIUC Long-Term HCP Conservation Strategy for the Newell's Shearwater and Hawaiian Petrel to Address Power Line Strikes* (U.S. Fish and Wildlife Service and State of Hawai'i Division of Forestry and Wildlife 2018)
- *Declining Population Trends of Hawaiian Petrel and Newell's Shearwater on the Island of Kaua'i, Hawaii, USA* (Raine et al. 2017b)
- *Post-collision impacts, crippling bias, and environmental bias in a study of Newell's Shearwater and Hawaiian Petrel powerline collisions* (Travers et al. 2021)

- *Endangered Seabird Management Site Ranking Matrix* (Raine et al. 2020c)
- *2020 KIUC Fence Prioritization Evaluation* (Young 2020)

New analysis associated with this HCP included extensive computer modeling of the predicted effects of the covered activities on the covered species and the expected conservation benefits of the conservation measures. These models, which are included as appendices to Chapter 5, *Effects*, informed many of the quantitative population targets and types and amount of mitigation necessary to fully offset KIUC's impacts and result in a net benefit to each of the covered species.

4.2.4 Relationship to KIUC Short-Term HCP

The biological goals and objectives and conservation measures for covered seabirds are based on a long history (over 10 years) of implementing and refining the same or similar measures based on monitoring and data collected during and following KIUC's implementation of the Short-Term HCP (Kaua'i Island Utility Cooperative 2011). KIUC's Short-Term HCP was approved in May 2011 and was implemented over 5 years, until 2016. As described in Chapter 1, *Introduction and Background*, before the Short-Term HCP was prepared, relatively little was known about the distribution, population, and behaviors of the three listed seabirds on Kaua'i. In addition, little was known about the extent of the effects of KIUC's facilities and operations on these species. Thus, an important goal of the Short-Term HCP was to have KIUC work with conservation partners to implement a suite of specific monitoring and research projects to address this scientific uncertainty.

After the Short-Term HCP expired in 2016, KIUC continued to implement the same conservation measures and conduct extensive monitoring and research on the listed seabirds. KIUC reported the results of this work to USFWS and DOFAW annually in order to improve techniques and share best practices. This monitoring and research continue today, focused on the effectiveness of conservation measures for the covered seabirds and the nature of impacts of KIUC's facilities on the covered seabirds. More details on the ongoing monitoring program that will be incorporated into the monitoring program for this HCP can be found in Chapter 6, *Monitoring and Adaptive Management Program*. The biological goals and objectives and conservation measures for this HCP built on the extensive, long-term monitoring and research program that KIUC began before 2011.

4.3 Biological Goals and Objectives

The biological goals and objectives for the KIUC HCP describe what the conservation strategy is intended to achieve. The biological goals and objectives are organized by species group: seabirds, waterbirds, and turtles. Each covered seabird species is listed individually to address differences in metapopulation size, colony location, and data availability. The covered waterbirds are grouped under one goal because the actions to minimize and mitigate KIUC's effects are the same for all five species and because each species' population is generally thought to be either stable or increasing.

The biological goals and objectives are summarized in Table 4-1. Each biological objective will be met through one or more conservation measures listed in Table 4-1. Detailed descriptions of the conservation measures are found in Section 4.4, *Conservation Measures*.

In addition, this section includes a detailed description of the rationale for each biological objective, which follows each objective.

Table 4-1. Biological Goals and Objectives and Applicable Conservation Measures

Biological Goals and Objectives	Applicable Conservation Measures (see Section 4.4 for full descriptions of conservation measures)
Newell's Shearwater ('a'o) (*Puffinus auricularis newelli*)	
Goal 1. Provide for the survival of the Kaua'i metapopulation of Newell's shearwater ('a'o) and contribute to the species' recovery by minimizing and fully offsetting the impacts of KIUC's taking of this species over the term of the HCP to an extent that is likely to result in numbers of breeding pairs, demography and age structure, population growth rate, and spatial distribution that is representative of a viable metapopulation on Kaua'i.	
Objective 1.1. Substantially reduce the extent and effect of collisions of adult/subadult Newell's shearwaters ('a'o) with KIUC powerlines island-wide, as measured against the pre-HCP strike estimate (Appendix 5D), in accordance with the location, extent, and schedule outlined in the HCP.	**Conservation Measure 1.** Implement Powerline Collision Minimization Projects
Objective 1.2. Minimize the adverse effects of artificial light attraction on Newell's shearwater ('a'o) fledglings from all existing and future KIUC streetlights and existing covered facilities by continuing to implement practicable conservation measures throughout the permit term.	**Conservation Measure 2.** Implement Measures to Minimize Light Attraction, **Conservation Measure 3.** Provide Funding for the Save Our Shearwaters Program
Objective 1.3. Increase the number of Newell's shearwater ('a'o) breeding pairs and new chicks produced annually throughout the duration of the permit by managing and enhancing suitable Newell's shearwater ('a'o) breeding habitat and breeding colonies across 10 conservation sites and reducing the abundance and distribution of key seabird predators in northwestern Kaua'i. The success of this objective will be measured by the following metrics within all of the 10 conservation sites combined: **Metric 1**. Maintain an annual minimum of 1,264 breeding pairs as determined by call rates and burrow monitoring. **Metric 2.** Reach a target of 2,371 breeding pairs by year 25 of the permit term and 4,313 breeding pairs by the end of the permit term. **Metric 3.** Growth rate for breeding pairs annually of at least 1% as measured by a 5-year rolling average. **Metric 4.** Maintain a 5-year rolling average 87.2% reproductive success rate. **Metric 5.**Eradicate terrestrial predators within predator exclusion fencing. **Metric 6.** Produce at least one breeding pair within each of the four social attraction sites by Year 10 of the permit term **Metric 7.** Ensure that invasive plant and animal species do not preclude meeting the objective metrics above.	**Conservation Measure 4.** Manage and Enhance Seabird Breeding Habitat and Colonies at Conservation Sites

Biological Goals and Objectives	Applicable Conservation Measures (see Section 4.4 for full descriptions of conservation measures)
Hawaiian Petrel (ʻuaʻu) (*Pterodroma sandwichensis*)	
Goal 2. Provide for the survival of the Kauaʻi metapopulation of Hawaiian petrel (ʻuaʻu) and contribute to the species' recovery by minimizing and fully offsetting the impacts of KIUC's taking on this species over the term of the HCP to an extent that is likely to result in numbers of breeding pairs, demography and age structure, population growth rate, demography, and spatial distribution that is representative of a viable metapopulation on Kauaʻi.	
Objective 2.1. Substantially reduce the extent and effect of collisions of adult/subadult Hawaiian petrels (ʻuaʻu) with KIUC powerlines island-wide, as measured against the pre-HCP estimate (Appendix 5D) in accordance with the location, extent, and schedule outlined in the HCP.	**Conservation Measure 1.** Implement Powerline Collision Minimization Projects
Objective 2.2. Minimize the adverse effects of artificial light attraction on Hawaiian petrel (ʻuaʻu) fledglings from all existing and future KIUC streetlights and existing covered facilities by continuing to implement practicable conservation measures throughout the permit term.	**Conservation Measure 2.** Implement Measures to Minimize Light Attraction, **Conservation Measure 3.** Provide Funding for the Save Our Shearwaters Program
Objective 2.3. Increase the number of Hawaiian petrel (ʻuaʻu) breeding pairs and new chicks produced annually throughout the duration of the permit by managing and enhancing suitable Hawaiian petrel (ʻuaʻu) breeding habitat and breeding colonies across 10 conservation sites and reducing the abundance and distribution of key seabird predators in northwestern Kauaʻi. The success of this objective will be measured by the following metrics within all of the 10 conservation sites combined: **Metric 1.** Maintain an annual minimum of 2,257 breeding pairs as determined by call rates and burrow monitoring. **Metric 2.** Reach a target of 2,926 breeding pairs by year 25 of the permit term and 3,751 breeding pairs by the end of the permit term. **Metric 3**. Growth rate for breeding pairs annually of at least 1.0% as measured by a 5-year rolling average. **Metric 4.** Maintain a 5-year rolling average 78.7% reproductive success rate. **Metric 5**. Ensure that invasive plant and animal species do not preclude meeting the objective metrics above.	**Conservation Measure 4.** Manage and Enhance Seabird Breeding Habitat and Colonies at Conservation Sites

Biological Goals and Objectives	Applicable Conservation Measures (see Section 4.4 for full descriptions of conservation measures)
Band-Rumped Storm-Petrel (ʻakēʻakē) (*Oceanodroma castro*)	
Goal 3. Contribute to the recovery of the band-rumped storm-petrel (ʻakēʻakē) by reducing threats associated with existing and future KIUC streetlights, existing covered facility lights, and introduced predators on Kauaʻi.	
Objective 3.1. Minimize artificial light attraction on band-rumped storm-petrel (ʻakēʻakē) fledglings from all existing and future KIUC streetlights and existing covered facilities by continuing to implement practicable conservation measures throughout the permit term.	**Conservation Measure 2.** Implement Measures to Minimize Light Attraction
Objective 3.2. Facilitate the rescue, rehabilitation, and release of band-rumped storm-petrel (ʻakēʻakē) fledglings through funding of the Save Our Shearwaters Program or other certified rehabilitation facility to offset light attraction by KIUC streetlights.	**Conservation Measure 3.** Provide Funding for the Save Our Shearwaters Program
Objective 3.3. Implement predator control, including barn owl control, within the conservation sites to reduce threats to band-rumped storm-petrel (ʻakēʻakē) in areas near the conservation sites (e.g., Nā Pali Coast).	**Conservation Measure 4.** Manage and Enhance Seabird Breeding Habitat and Colonies at Conservation Sites
Covered Waterbirds: Hawaiian Coot (ʻalae keʻokeʻo) (*Fulica alai*), Hawaiian Gallinule (ʻalae ʻula) (*Gallinula galeata sandvicensis*), Hawaiian Stilt (aeʻo) (*Himantopus mexicanus knudseni*), Hawaiian Goose (nēnē) (*Branta sandvicensis*), and Hawaiian Duck (koloa maoli) (*Anas wyvilliana*)	
Goal 4. Contribute to the recovery of covered waterbird species by reducing threats associated with KIUC powerlines on Kauaʻi.	
Objective 4.1. Reduce covered waterbird collisions with KIUC powerlines in Hanalei and Mānā (Kawaiʻele Waterbird Sanctuary), in accordance with the location, extent, and schedule outlined in the HCP, and relative to measured collisions in 2021.	**Conservation Measure 1.** Implement Powerline Collision Minimization Projects
Objective 4.2. Facilitate the rescue, rehabilitation, and release of grounded covered waterbirds through funding of the Save Our Shearwaters Program or other certified rehabilitation facility to offset collisions with KIUC powerlines.	**Conservation Measure 3.** Provide Funding for the Save Our Shearwaters Program
Green Sea Turtle (honu) (*Chelonia mydas*) (Central North Pacific Distinct Population Segment)	
Goal 5. Contribute to the recovery of the species by increasing the ability for green sea turtles (honu) to successfully transit Kauaʻi beaches.	
Objective 5.1. Locate and temporarily shield green sea turtle (honu) nests at all locations that are visually affected by KIUC streetlights on an annual basis.	**Conservation Measure 5.** Implement a Green Sea Turtle Nest Detection and Temporary Shielding Program
Objective 5.2. For the duration of the permit permanently minimize light effects to the extent practicable from existing and future KIUC streetlights onto beaches with suitable green sea turtle (honu) nesting habitat by implementing practicable minimization techniques that will further reduce or eliminate these light effects.	**Conservation Measure 6.** Identify and Implement Practicable Streetlight Minimization Techniques for Green Sea Turtle

4.3.1 Newell’s Shearwater (‘a‘o)

Goal 1. Provide for the survival of the Kaua‘i metapopulation of Newell’s shearwater (‘a‘o) and contribute to the species’ recovery by minimizing and fully offsetting KIUC’s impacts on this species over the term of the HCP to an extent that is likely to result in numbers of breeding pairs, demography and age structure, population growth rate, and spatial distribution that is representative of a viable metapopulation on Kaua‘i.

Objective 1.1. Substantially reduce the extent and effect of collisions of adult/subadult covered seabirds with KIUC powerlines island-wide, as measured against the estimated pre-HCP strike estimate (Appendix 5D) in accordance with the location, extent, and schedule outlined in the HCP.

Rationale

Reduction of powerline collisions is key to reducing overall human-caused seabird injury and mortality (Travers et al. 2020a, 2020b, 2021; Travers and Raine 2020a), and hence to retaining the potential for Newell’s shearwater (‘a‘o) recovery. The current rate of seabird powerline collision is affecting the age structure of the population by removing large portions of subadult and adult individuals annually from the population. Because the reproductive strategy of this species evolved to have high adult survivorship with a relatively low number of offspring, increased levels of adult mortality are particularly harmful to this species and its population viability. Left unchecked, low adult survivorship (or conversely high adult mortality) will depress populations to levels where they can become vulnerable to extirpation. A reduction in these collisions will retain more adults and subadults, thereby improving the existing population rate of change, demography and age class structure, and population size, and contribute to population numbers that represent a viable metapopulation for Newell’s shearwater (‘a‘o) by the end of the permit term.

Based on KIUC’s pre-implementation monitoring data showing that strikes are reduced from between 42 percent to over 95 percent depending on the minimization technique (or combination of techniques), KIUC’s powerline minimization projects will reduce seabird powerline collisions by at least 65.3 percent by the end of 2023 (Travers and Raine 2020a).

The comparison point (i.e., baseline) for all future measurements of powerline strike minimization is proposed as estimated strikes calculated by a Bayesian model using powerline strike date collected between 2013 and 2019 (Travers et al. 2020b). To avoid double counting strike reductions from early implementation of the KIUC HCP (counted as 2020–2022) versus KIUC’s Short-Term HCP (counted as 2011–2019), the baseline only includes the effect of minimization actions that were implemented during the 7-year period counted as part of KIUC’s implementation of its Short-Term HCP.[3]

See Section 4.4.1, *Conservation Measure 1. Implement Powerline Collision Minimization Projects*, for details of the conservation measure proposed to achieve this biological objective.

Objective 1.2. Minimize the adverse effects of artificial light attraction on Newell’s shearwater (‘a‘o) fledglings from all existing and future KIUC streetlights and existing covered facilities by continuing to implement practicable conservation measures throughout the permit term.

[3] KIUC did not carry out any minimization projects in 2017, 2018, or 2019.

Rationale

Conservation measures with proven success at reducing covered seabird fledgling light attraction have been implemented for KIUC's existing streetlights (full-cutoff shields for lights), in partnership with the County of Kauaʻi (County) and State of Hawaiʻi (State), and KIUC's covered facility lights. An early study on Kauaʻi showed that the shielding of bright lights reduced fallout of Newell's shearwater (ʻaʻo) by 40 percent (Reed et al. 1985). Recent studies continue to indicate that the reduction of lateral light spillage is beneficial to reducing light-induced fallout of seabirds (Rodríguez et al. 2017a, 2017b). KIUC also began dimming or turning off covered facility lights at the Port Allen Generating Station in 2019, which reduced Newell's shearwater (ʻaʻo) fallout from an average of 5.5 fledglings per year to an average of 1 fledgling per year (Kauaʻi Island Utility Cooperative 2020).

These conservation actions would continue to be implemented for existing and new facility lights, as well as for all new streetlights installed during the permit term. Increased fledgling survival would benefit from recruitment and lead to more future breeding-age individuals in the Kauaʻi metapopulation. Because this species has very low reproductive productivity, increasing recruitment to the breeding-age population, and hence increasing the number of chicks that can be produced by the metapopulation each year, is a key conservation strategy that would contribute to population numbers that represent a viable metapopulation for Newell's shearwater (ʻaʻo) by the end of the permit term.

See Section 4.4.2, *Conservation Measure 2. Implement Measures to Minimize Light Attraction*, and Section 4.4.3, *Conservation Measure 3. Provide Funding for the Save Our Shearwaters Program*, for details of the conservation measures proposed to achieve this biological objective.

Objective 1.3. Increase the number of Newell's shearwater (ʻaʻo) breeding pairs and new chicks produced annually throughout the duration of the permit by managing and enhancing suitable Newell's shearwater (ʻaʻo) breeding habitat and breeding colonies across 10 conservation sites and reducing the abundance and distribution of key seabird predators in northwestern Kauaʻi. The success of this objective will be measured by the following metrics within all of the 10 conservation sites combined:

a. Maintain an annual minimum of 1,264 Newell's shearwater (ʻaʻo) breeding pairs as determined by call rates and burrow monitoring.

b. Reach a target of 2,371 breeding pairs by year 25 of the permit term and 4,313 Newell's shearwater (ʻaʻo) breeding pairs by the end of the permit term.

c. Growth rate for breeding pairs annually of at least 1 percent as measured by a 5-year rolling average.

d. Maintain a 5-year rolling average 87.2 percent reproductive success rate.

e. Eradicate terrestrial predators within predator exclusion fencing.

f. Produce at least one breeding pair within each of the four social attraction sites by Year 10 of the permit term.

g. Ensure that invasive plant and animal species do not preclude meeting the objective metrics above.

Rationale

Operation of KIUC infrastructure has had substantial effects on the Kauaʻi metapopulation of this species and is one of the primary reasons the metapopulation is at historically low levels. Because at least 90 percent of the breeding population of Newell's shearwater (ʻaʻo) occurs on Kauaʻi, a viable metapopulation in the Plan Area is critical to retaining the potential for species recovery. A viable metapopulation for Newell's shearwater (ʻaʻo) is quantified as 2,500 breeding pairs and a total population size of 10,000 individuals (Nagatani pers. comm.).

The densest colonies of Newell's shearwater (ʻaʻo) in the Plan Area are concentrated in the remote northwestern portion of Kauaʻi (Raine et al. 2020c). This area has been determined by species experts to have the greatest potential to resulting in a viable metapopulation by increasing the number of Newell's shearwater (ʻaʻo) breeding pairs and new chicks produced (see Conservation Measure 4 for the reasons), and therefore this area has been the focus of conservation efforts for the last decade (Raine et al. 2020c). KIUC has secured nine conservation sites and will select a tenth conservation site (which is still being evaluated) in this part of the island (see Section 4.4.4, *Conservation Measure 4. Manage and Enhance Seabird Breeding Habitat and Colonies at Conservation Sites*) at which to manage and enhance habitat for existing breeding colonies of Newell's shearwater (ʻaʻo). The nine selected sites total approximately 2,216 acres (896 hectares).[4]

Management actions with proven success at improving the reproductive productivity of Newell's shearwater (ʻaʻo) breeding colonies are ongoing at all the selected conservation sites and would continue and be expanded by the HCP for the duration of the permit term. For example, predator control has been shown to be the most effective tactic to increase the reproductive success rate of Newell's shearwater (ʻaʻo), with estimated increases of 35.8 percent in managed areas (Raine et al. 2020a). Expanding the scale and types of predator control (e.g., installing and/or maintaining predator exclusion fencing at four conservation sites and predator eradication within predator exclusion fences) will further reduce this significant threat and increase the survivorship of chicks produced each year. Social attraction within the fenced conservation sites is also expected to accelerate colony recruitment and colony increases and expansion.

All of the conservation measures that support this objective are designed to result in population increases at the conservation sites. In combination with a substantial reduction in powerline strikes (see Objective 1.1), the HCP's conservation strategy will improve the status of the Newell's shearwater (ʻaʻo) metapopulation by continuing to protect and manage existing colonies within conservation sites. See Conservation Measure 4. Manage and Enhance Seabird Breeding Habitat and Colonies at Conservation Sites (Section 4.4, *Conservation Measures*).

Collectively, these measures would result in a viable metapopulation of Newell's shearwater (ʻaʻo) that leads to a viable metapopulation on Kauaʻi, as stated in Goal 1. We cannot measure population viability directly, but important characteristics of the metapopulation can be estimated by evaluating the following components of population dynamics that contribute to viability and that can be measured.

- Numbers of breeding pairs
- Population growth rate

[4] See Appendix 4A, *Conservation Site Selection*, for further details on these conservation sites, their specific characteristics, and how and why they were selected.

- Demography and age structure
- Spatial distribution

Each of these components of a viable metapopulation is explained below.

Numbers of breeding pairs. The word *viable* often refers to a population (or metapopulation) that is not expected to become or has a low likelihood of becoming extinct, or quasi-extinct, during a specified timeframe. In other words, the number of individuals would have a high probability of persistence over the long term. Quasi-extinction can occur when some number of individuals remains alive, but the population itself is no longer viable because it has fallen below a threshold number of individuals below which it cannot recover. This threshold is also known as a minimum viable population size (Schaffer 1981). Extinction or quasi-extinction below a minimum viable population can be associated with a population too small to allow individuals to find mates. In other cases, small populations can result in reductions in fitness (i.e., called inbreeding depression) that reduces reproductive success below levels necessary for population replacement (also known as Allee effects; Courchamp et al. 1999; Schippers et al. 2011). Populations below a minimum viable level are also at much greater risk of adverse stochastic events such as extreme weather events, diseases, novel predators, or demographic shifts such as adversely skewed sex ratios.

No population viability analysis has been conducted for the covered seabirds. However, USFWS (pers. comm.) estimates that for the Kauaʻi metapopulation of Newell's shearwater (ʻaʻo), 10,000 individuals (and 2,500 breeding pairs) represents a minimum viable level for the Plan Area. This estimate considers the roles of age structure, catastrophes, random demographic and environmental fluctuations (stochasticity), and inbreeding depression. Populations that are maintained above minimum viable levels ensure a higher likelihood of population persistence. For the covered seabirds, a key metric related to population viability is the number of breeding pairs.

Metric 1 of Objective 1.3 is designed to ensure that the number of breeding pairs in the 10 conservation sites does not fall below the current level of 1,264 Newell's shearwater (ʻaʻo) breeding pairs. Metric 2 of Objective 1.3 is designed to ensure that progress is always being made to expand the subpopulations of all conservation sites to the ultimate target of 4,313 breeding pairs by the end of the permit term, which is well above the minimum viable population target of 2,500 breeding pairs. Metric 2 also includes an interim target of 2,371 breeding pairs by year 25 of the permit term (halfway) to ensure that progress is being met towards the target at the end of the permit term. These values were derived from the population dynamics model, described in Chapter 5, *Effects*, and Appendix 5E, *Population Dynamics Model for Newell's Shearwater (ʻaʻo) on Kauaʻi*, presents the methods and results for the effect of KIUC's minimization and conservation actions on the Kauaʻi metapopulations of Newell's shearwater (ʻaʻo). Metrics 5 and 7 in Objective 1.3 are qualitative; they are included to help ensure that the population-based metrics are met.

Population growth rate. Declining populations are populations with declining trends in abundance (i.e., with negative rates of population change through time). Populations that are consistently in decline are, by definition, not viable over the long term unless the negative trend in abundance can be stabilized (no longer in decline) or reversed (positive growth) before abundance has been reduced below a minimum viable population size. For a population to be viable, trends in abundance must be increasing, or at least under certain circumstances be stable (i.e., not increasing or decreasing) through time. For example, stable trends in abundance are consistent with a viable population if abundance is at high levels relative to the carrying capacity of the environment. In the case of endangered species, however, abundance levels are often by definition lower than the carrying capacity of the environment, and therefore achieving positive trends in abundance is necessary for population viability.

Metrics 3 and 4 in Objective 1.3, in combination with Metric 2, are designed to ensure that the subpopulations within the 10 conservation sites combined continue to grow annually. Meeting or exceeding the annual minimum population growth rate (Metric 3) and minimum reproductive success rate (Metric 4) will ensure that the 10 conservation sites combined are growing at rates that will ensure a minimum viable population is met or exceeded by the end of the permit term. Metrics 5 and 7 in Objective 1.3 are qualitative; they are included to help ensure that the population-based metrics are met.

Demography and age structure. Age structure reflects the proportions of individuals at different life stages, and this variable is an indicator of population status. Growing populations tend to have larger proportions of individuals in younger age classes, while declining populations tend to have lower proportions of younger individuals (although populations with larger proportions of younger individuals may also reflect low adult survivorship). Although age structure cannot be directly measured, a stable age structure is assumed when the growth rate for breeding pairs is increasing, which indicates that the population is increasing and recruitment is occurring.

Sex ratios are another important demographic factor influencing population viability for species that have long-term pair bonding. Although it is not possible to measure or track sex ratios, a 50:50 sex ratio is assumed if reproduction is occurring. For the KIUC HCP, modeled metapopulation numbers that are increasing would be consistent with demography that indicates viability because an increase in the modeled metapopulation size occurs when the total annual number of fledglings produced is greater than the number of deaths on an island-wide basis.

Metrics 1, 2, 3, and 4 of Objective 1.3 are designed to ensure that the subpopulations in the 10 conservation sites combined are growing in ways to provide an age structure and sex ratio consistent with a viable metapopulation (i.e., no metrics can be included to measure age structure or sex ratio directly).

Spatial distribution. Spatial distribution is often an important component of population viability. For example, the more populations or subpopulations present in a species, all else being equal, the greater the chance that the species can persist in the long term because some stochastic events may operate independently or semi-independently in different populations or subpopulations. Species with more subpopulations have a greater chance of withstanding these events. For example, a species with 10 separate subpopulations might lose two of these subpopulations because of a major hurricane, but the remaining eight subpopulations can persist. A species with only two subpopulations is at much greater risk of losing half or all of the subpopulations in a major hurricane.

Spatial distribution is a component of a viable metapopulation for Newell's shearwater (ʻaʻo) (U.S. Fish and Wildlife Service 2019). One reason KIUC proposes to protect and maintain so many conservation sites (10) is to help increase the spatial distribution of the Kauaʻi metapopulation. Having numerous protected and managed conservation sites, including four with predator-proof fencing, will help ensure that populations persist even in the face of extreme weather and changing climate, for example. The proposed conservation sites represent the best remaining available habitat for this species on Kauaʻi because of their remote location, rugged terrain, and distance from powerlines and lights.

Metric 6 in Objective 1.3 supports the goal of maintaining sufficient spatial distribution because this metric will ensure that all of the social attraction sites are occupied and producing new breeding pairs. All or almost all of the 10 conservation sites need to be occupied in order to meet Metrics 1, 2, 3, and 4 of Objective 1.3, ensuring that the spatial distribution of the species by the end of the permit term is consistent with a viable metapopulation.

In conclusion, metapopulation numbers within the conservation sites that exceed 10,000 individuals (2,500 breeding pairs) that are increasing at the end of the permit term would be consistent with a viable metapopulation on Kauaʻi (U.S. Fish and Wildlife Service pers. comm.).

4.3.2 Hawaiian Petrel (ʻuaʻu)

Goal 2. Provide for the survival of the Kauaʻi metapopulation of Hawaiian petrel (ʻuaʻu) and contribute to the species' recovery by minimizing and fully offsetting KIUC's impacts on this species over the term of the HCP to an extent that is likely to result in a population size, age structure, population growth rate, demography, and distribution that is representative of a viable metapopulation on Kauaʻi.

Objective 2.1. Substantially reduce the extent and effect of collisions of adult/subadult Hawaiian petrels (ʻuaʻu) with all KIUC powerlines island-wide, as measured against the 2020 strike estimate (Travers et al. 2020b) in accordance with the location, extent, and schedule outlined in the HCP.

Rationale

Reduction of powerline collisions is key to reducing overall human-caused seabird injury and mortality (Travers et al. 2020a; Travers and Raine 2020a), and hence to retaining the potential for Hawaiian petrel (ʻuaʻu) recovery. The current rate of seabird powerline collision is affecting the age structure of the population by removing large portions of subadult and adult individuals annually from the population. Because the reproductive strategy of this species evolved to have high adult survivorship with a relatively low number of offspring, increased levels of adult mortality are particularly harmful to this species and its population viability. Left unchecked, low adult survivorship (or conversely high adult mortality) will depress populations to levels where they can become vulnerable to extirpation. A reduction in these collisions will retain more adults and subadults, thereby improving the existing population rate of change, demography and age class structure, and population size, and move toward numbers that represent a viable metapopulation for Hawaiian petrel (ʻuaʻu).

Based on KIUC's pre-implementation monitoring data showing that strikes are reduced from between 42 percent to over 95 percent depending on the minimization technique (or combination of techniques), the powerline minimization projects in progress by KIUC will reduce seabird powerline collisions by at least 65.3 percent (Travers and Raine 2020a).The comparison point (i.e., baseline) for all future measurements of powerline strike minimization is proposed as estimated strikes in 2020 as calculated by a Bayesian model using powerline strike data collected between 2013 and 2019 (Travers et al. 2020b). To avoid double counting strike reductions resulting from early implementation of the KIUC HCP (counted as 2020–2022) versus KIUC's Short-Term HCP (counted as 2011–2019), the baseline only includes the effect of minimization actions that were implemented during the 7-year period counted as part of KIUC's implementation of its Short-Term HCP.[5]

See Conservation Measure 1. Implement Powerline Collision Minimization Projects (Section 4.4, *Conservation Measures*) for details of the conservation measure proposed to achieve this biological objective.

Objective 2.2. Minimize the adverse effects of artificial light attraction on Hawaiian petrel (ʻuaʻu) fledglings from all existing and future KIUC streetlights and existing covered facilities by continuing to implement practicable conservation measures throughout the permit term.

Rationale

Conservation measures with proven success at reducing covered seabird fledgling light attraction have been implemented for KIUC's existing streetlights (full-cutoff shields for lights), in partnership with the County and State, and KIUC's covered facility lights. An early study on Kauaʻi showed that the shielding of bright lights reduced fallout of Newell's shearwater (ʻaʻo) by 40 percent (Reed et al. 1985). Recent studies continue to indicate that the reduction of lateral light spillage is beneficial to reducing light-induced fallout of seabirds (Rodríguez et al. 2017a, 2017b). KIUC also began dimming or turning off covered facility lights at the Port Allen Generating Station in 2019. Although there has been no change in the documented Hawaiian petrel (ʻuaʻu) fallout at KIUC covered facilities before or after light dimming (only one individual was recorded in 2012), as described in Section 4.3.1, *Newell's shearwater (ʻaʻo*), fallout for Newell's shearwater (ʻaʻo) was reduced from an average of 5.5. fledglings per year to an average of 1 fledgling per year (Kauaʻi Island Utility Cooperative 2020), so it is assumed light dimming also benefits Hawaiian petrel (ʻuaʻu).

These conservation actions would continue to be implemented for existing and new facility lights, as well as for all new streetlights installed during the permit term. Increased fledgling survival would benefit from recruitment and lead to more future breeding-age individuals in the Kauaʻi metapopulation. Because this species has very low reproductive productivity, increasing recruitment to the breeding-age population, and hence increasing the number of chicks that can be produced by the metapopulation each year, is a key conservation strategy that would contribute to population numbers that represent a viable metapopulation for Hawaiian petrel (ʻuaʻu) by the end of the permit term.

See Conservation Measure 2. Implement Measures to Minimize Light Attraction and Conservation Measure 3. Provide Funding for the Save Our Shearwaters Program (Section 4.4, *Conservation Measures*) for details of the conservation measures proposed to achieve this biological objective.

Objective 2.3. Increase the number of Hawaiian petrel (ʻuaʻu) breeding pairs and new chicks produced annually throughout the duration of the permit by managing and enhancing suitable Hawaiian petrel (ʻuaʻu) breeding habitat and breeding colonies across 10 conservation sites and reducing the abundance and distribution of key seabird predators in northwestern Kauaʻi. The

[5] KIUC did not carry out any minimization projects in 2017, 2018, or 2019.

success of this objective will be measured by the following metrics within all of the 10 conservation sites combined:

a. Maintain an annual minimum of 2,257 Hawaiian petrel (ʻuaʻu) breeding pairs

b. Reach a target of 2,926 breeding pairs by year 25 of the permit term and 3,715 breeding pairs by the end of the permit term.

c. Growth rate for breeding pairs annually of at least 1 percent as measured by a 5-year rolling average.

d. Maintain a 5-year rolling average 78.7 percent reproductive success rate.

e. Ensure that invasive plant and animal species do not preclude meeting the objective metrics above.

Rationale

Operation of KIUC infrastructure has had substantial effects on the Kauaʻi metapopulation of this species and is one of the primary reasons the metapopulation is at historically low levels. Because a large share of the breeding individuals of Hawaiian petrel (ʻuaʻu) occur on Kauaʻi, a viable metapopulation in the Plan Area is critical to retaining the potential for species recovery. A viable metapopulation for Hawaiian petrel (ʻuaʻu) is quantified as 2,500 breeding pairs and a total population size of 10,000 individuals.

The densest colonies of Hawaiian petrel (ʻuaʻu) in the Plan Area are concentrated in the remote northwestern portion of Kauaʻi (Raine et al. 2020c). This area has been determined by species experts to have the greatest potential to result in a viable metapopulation by increasing the number of Hawaiian petrel (ʻuaʻu) breeding pairs and new chicks produced (see Conservation Measure 4 for the reasons), and this area has been the focus of conservation efforts for the last decade (Raine et al. 2020c). KIUC has secured nine conservation sites and will select a tenth conservation site (which is still being evaluated) in this part of the island (see Section 4.4.4, *Conservation Measure 4. Manage and Enhance Seabird Breeding Habitat and Colonies at Conservation Sites*) at which to manage and enhance habitat for existing breeding colonies of Hawaiian petrel (ʻuaʻu). The nine selected sites total approximately 2,216 acres (896 hectares).[6]

Management actions with proven success at improving the reproductive success of Hawaiian petrel (ʻuaʻu) breeding colonies are ongoing at all the selected conservation sites and would continue and be expanded by the HCP for the duration of the permit term. For example, predator control has been shown to be the most effective tactic to increase the reproductive success rate of Hawaiian petrel (ʻuaʻu) by a mean of 35.8 percent in managed areas (Raine et al. 2020a). Expanding the scale and types of predator control (e.g., installing and/or maintaining predator exclusion fencing at two conservation sites, predator eradication within predator exclusion fences) will further reduce this significant threat and increase the survivorship of chicks produced each year. Social attraction within the fenced conservation sites is also expected to accelerate colony recruitment and colony increases and expansion.

All the conservation measures that support this objective are designed to result in population increases at the conservation sites. In combination with a substantial reduction in powerline

[6] See Appendix 4A, *Conservation Site Selection*, for further details on these conservation sites, their specific characteristics, and how and why they were selected.

strikes (see Objective 1.1), the HCP's conservation strategy will improve the status of the Hawaiian petrel (ʻuaʻu) metapopulation by continuing to protect and manage existing colonies within conservation sites. Collectively, these measures would result in a viable metapopulation of Hawaiian petrel (ʻuaʻu) on Kauaʻi, as stated in Goal 2. We cannot measure population viability directly, but this important characteristic of the metapopulation can be estimated by evaluating the following components of population dynamics that that contribute to viability that we can measure.

- Number of breeding pairs
- Population growth rate
- Demography and age structure
- Spatial distribution

These components of a viable metapopulation are explained above for Newell's shearwater (ʻaʻo) under Objective 1.3. The same principles apply to Hawaiian petrel (ʻuaʻu) but are not repeated here. The discussion for Hawaiian petrel (ʻuaʻu) is limited to how each of the five metrics of Objective 2.3 support each of the components of a viable metapopulation.

Metric 1 of Objective 2.3 is designed to ensure that the number of breeding pairs in the 10 conservation sites does not fall below the current level of 2,257 Hawaiian petrel (ʻuaʻu) breeding pairs. Metric 2 of Objective 2.3 is designed to ensure that progress is always being made to expand the subpopulations of all conservation sites to the ultimate target of 3,751 breeding pairs by the end of the permit term, which is well above the minimum viable population target of 2,500 breeding pairs. Metric 2 also includes an interim target of 2,926 breeding pairs by year 25 of the permit term (halfway) to ensure that progress is being met towards the target at the end of the permit term. These values were derived from the population dynamics model, described in Chapter 5, *Effects*, and Appendix 5F, *Population Dynamics Model for Hawaiian Petrel (ʻuaʻu) on Kauaʻi*, presents the methods and results for the effect of KIUC's minimization and conservation actions on the Kauaʻi metapopulations of Hawaiian petrel (ʻuaʻu). Metric 5 in Objective 2.3 is qualitative; it is included to help ensure that the population-based metrics are met.

Metrics 3 and 4 in Objective 2.3, in combination with Metric 2, are designed to ensure that the subpopulations within the 10 conservation sites combined continue to grow annually. Meeting or exceeding the annual minimum population growth rate (Metric 3) and minimum reproductive success rate (Metric 4) will ensure that the 10 conservation sites combined are growing at rates that will ensure a minimum viable population is met or exceeded by the end of the permit term.

Metrics 1, 2, 3, and 4 of Objective 2.3 are designed to ensure that the subpopulations in the 10 conservation sites combined are growing in ways to provide an age structure and sex ratio consistent with a viable metapopulation (i.e., no metrics can be included to measure age structure or sex ratio directly). All or almost all of the 10 conservation sites need to be occupied in order to meet Metrics 1, 2, 3, and 4 of Objective 2.3, thus ensuring that the spatial distribution of the species by the end of the permit term is consistent with a viable metapopulation.

See Conservation Measure 4. Manage and Enhance Seabird Breeding Habitat and Colonies at Conservation Sites (Section 4.4, *Conservation Measures*).

4.3.3 Band-Rumped Storm-Petrel (‘akē‘akē)

There have been no documented collisions of band-rumped storm-petrel (‘akē‘akē) with KIUC powerlines, despite extensive annual monitoring efforts since 2011 (Travers et al. 2019b). Band-rumped storm-petrels (‘akē‘akē) are less common and more difficult to detect and also have a different flight pattern and body type than Newell’s shearwaters (‘a‘o) and Hawaiian petrels (‘ua‘u). KIUC assumes band-rumped storm-petrels (‘akē‘akē) are rarely affected by powerline collisions. Biological objectives 1.2 and 2.2 for the other covered seabirds are expected to address the impacts on and conservation needs of band-rumped storm-petrel (‘akē‘akē) with respect to the very rare occurrence (once every several years) of powerline collisions. Powerline collision minimization projects to reduce powerline collisions for the other two covered seabird species in this HCP are also expected to minimize powerline collisions of band-rumped storm-petrel (‘akē‘akē).

The biological objectives for this species focus on the primary threats of artificial light attraction and predation from introduced wildlife species.

Goal 3. Contribute to the recovery of the band-rumped storm-petrel (‘akē‘akē) by reducing threats associated with existing and future KIUC streetlights, existing covered facilities on Kaua‘i, and introduced predators on Kaua‘i.

Objective 3.1. Minimize artificial light attraction on band-rumped storm-petrel (‘akē‘akē) fledglings from all existing and future KIUC streetlights and existing covered facilities.

Rationale

Conservation measures with proven success at reducing covered seabird fledgling light attraction have been implemented for KIUC’s existing streetlights (full-cutoff shields for lights), in partnership with the County and State, and KIUC’s covered facility lights. An early study on Kaua‘i showed that the shielding of bright lights reduced fallout of Newell’s shearwater (‘a‘o) by 40 percent (Reed et al. 1985). Recent studies continue to indicate that the reduction of lateral light spillage is beneficial to reducing light-induced fallout of seabirds (Rodríguez et al. 2017a, 2017b). KIUC also began dimming or turning off covered facility lights at the Port Allen Generating Station in 2019. Although there has been no documented band-rumped storm-petrel (‘akē‘akē) fallout at KIUC covered facilities before or after light dimming, as described in Section 4.3.1, *Newell’s shearwater (‘a‘o*), fallout for Newell’s shearwater (‘a‘o) was reduced from an average of 5.5. fledglings per year to an average of 1 fledgling per year (Kaua‘i Island Utility Cooperative 2020). It is assumed that light dimming also benefits band-rumped storm-petrel (‘akē‘akē) in similar ways as Newell’s shearwater (‘a‘o). These conservation actions would continue to be implemented for existing and new facility lights, as well as for all new streetlights installed during the permit term.

See Conservation Measure 2. Implement Measures to Minimize Light Attraction (Section 4.4, *Conservation Measures*) for details of the conservation measure proposed to achieve this biological objective.

Objective 3.2. Facilitate the rescue, rehabilitation, and release of band-rumped storm-petrel (‘akē‘akē) fledglings through funding of the Save Our Shearwaters (SOS) Program or other certified rehabilitation facility to offset light attraction by KIUC streetlights.

Rationale

The SOS Program is an established avian rescue and rehabilitation program on Kauaʻi with proven success in improving the survivorship of grounded seabirds (Raine et al. 2020b). The SOS Program rescues between zero and two band-rumped storm-petrels (ʻakēʻakē) annually (Bache 2020). The SOS Program also has established protocols for collecting and rehabilitating a variety of avian species, including all the covered seabirds. Since 2003, KIUC has been the predominate funder of the SOS Program. KIUC's continued funding of this program at an increased level[7] from previous years is expected to benefit band-rumped storm-petrels (ʻakēʻakē).

See Conservation Measure 3. Provide Funding for the Save Our Shearwaters Program (Section 4.4, *Conservation Measures*) for details of the conservation measures proposed to achieve this biological objective.

Objective 3.3. Implement predator control, including barn owl control, within the conservation sites to reduce threats to band-rumped storm-petrel (ʻakēʻakē) in areas near the conservation sites (e.g., Nā Pali Coast).

Rationale

Management actions with proven success at reducing Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu) depredations are ongoing at all the selected conservation sites and would continue and be expanded by the HCP for the duration of the permit term. This includes actions to reduce the abundance of rats, cats, and barn owls within the conservation sites. These predators are a significant constraint for the current abundance and distribution of band-rumped storm-petrel (ʻakēʻakē) based on documented depredations (Raine et al. 2017c). Although there are no documented band-rumped storm-petrel (ʻakēʻakē) colonies within the conservation sites, they are known to occur along the Nā Pali Coast based on call rates detected during auditory surveys (Raine et al. 2017c). Given that rats, cats, and barn owls produce many offspring in a short period of time and are highly mobile, it is assumed that predator control efforts at the conservation sites will benefit band-rumped storm-petrel (ʻakēʻakē) in the greater region.

See Conservation Measure 4. Manage and Enhance Seabird Breeding Habitat and Colonies at Conservation Sites (Section 4.4, *Conservation Measures*) for details of the conservation measure proposed to achieve this biological objective.

4.3.4 Covered Waterbirds: Hawaiian Coot (ʻalae keʻokeʻo), Hawaiian Gallinule (ʻalae ʻula), Hawaiian Stilt (aeʻo), Hawaiian Goose (nēnē), and Hawaiian Duck (koloa maoli)

Goal 4. Contribute to the recovery of the covered waterbird species by reducing threats associated with KIUC powerlines on Kauaʻi.

Objective 4.1. Reduce covered waterbirds collisions along KIUC powerlines in Hanalei and Mānā (Kawaiʻele Waterbird Sanctuary) (Figure 4-1) from 2021 levels in accordance with the location, extent, and schedule outlined in the HCP.

[7] Chapter 7, Section 7.4, *Costs of KIUC HCP Implementation*, provides details of KIUC's funding commitment for this program.

Rationale

Powerlines at two locations, Hanalei (spans 462–478 and 1297–1328) and Mānā (spans 1–113), likely have the greatest effect on the covered waterbird species (Travers and Raine 2020b) because the powerlines cross protected habitat with a high abundance of waterbirds (Figure 4-1). Transmission line removal, static wire removal, and installing bird flight diverters (most spans use a combination of multiple techniques) on high-risk line segments for covered waterbirds on Kaua'i will substantially reduce collisions of covered waterbirds (Raine pers. comm. [a]). In a study of blue cranes (*Grus paradisea*) in South Africa, Shaw et al. (2021) found that line markers (i.e., same as diverters or similar in style and effect) reduced powerline collisions by 92 percent in comparison to control spans. Outcomes for covered waterbirds in the Plan Area are expected to be similar to the results of the Shaw et al. study, which shows that diverters can be highly effective for waterbird species.

See Conservation Measure 1. Implement Powerline Collision Minimization Projects (Section 4.4, *Conservation Measures*) for details of the conservation measure proposed to achieve this biological objective.

Objective 4.2. Facilitate the rescue, rehabilitation, and release of grounded covered waterbirds through funding of the SOS Program or other certified rehabilitation facility to offset collisions with KIUC powerlines.

Rationale

The SOS Program is an established avian rescue and rehabilitation program on Kaua'i with proven success in improving the survivorship of grounded seabirds (Raine et al. 2020b). The SOS Program also has established protocols for collecting and rehabilitating a variety of waterbird species, including the covered waterbirds. For example, between 2012 and 2019, SOS has rescued and rehabilitated approximately 177 Hawaiian geese (nēnē) and 121 Hawaiian ducks (koloa maoli). KIUC has provided almost all of the funding for this program for over 15 years.

See Conservation Measure 3. Provide Funding for the Save Our Shearwaters Program (Section 4.4, *Conservation Measures*) for details of the conservation measure proposed to achieve this biological objective.

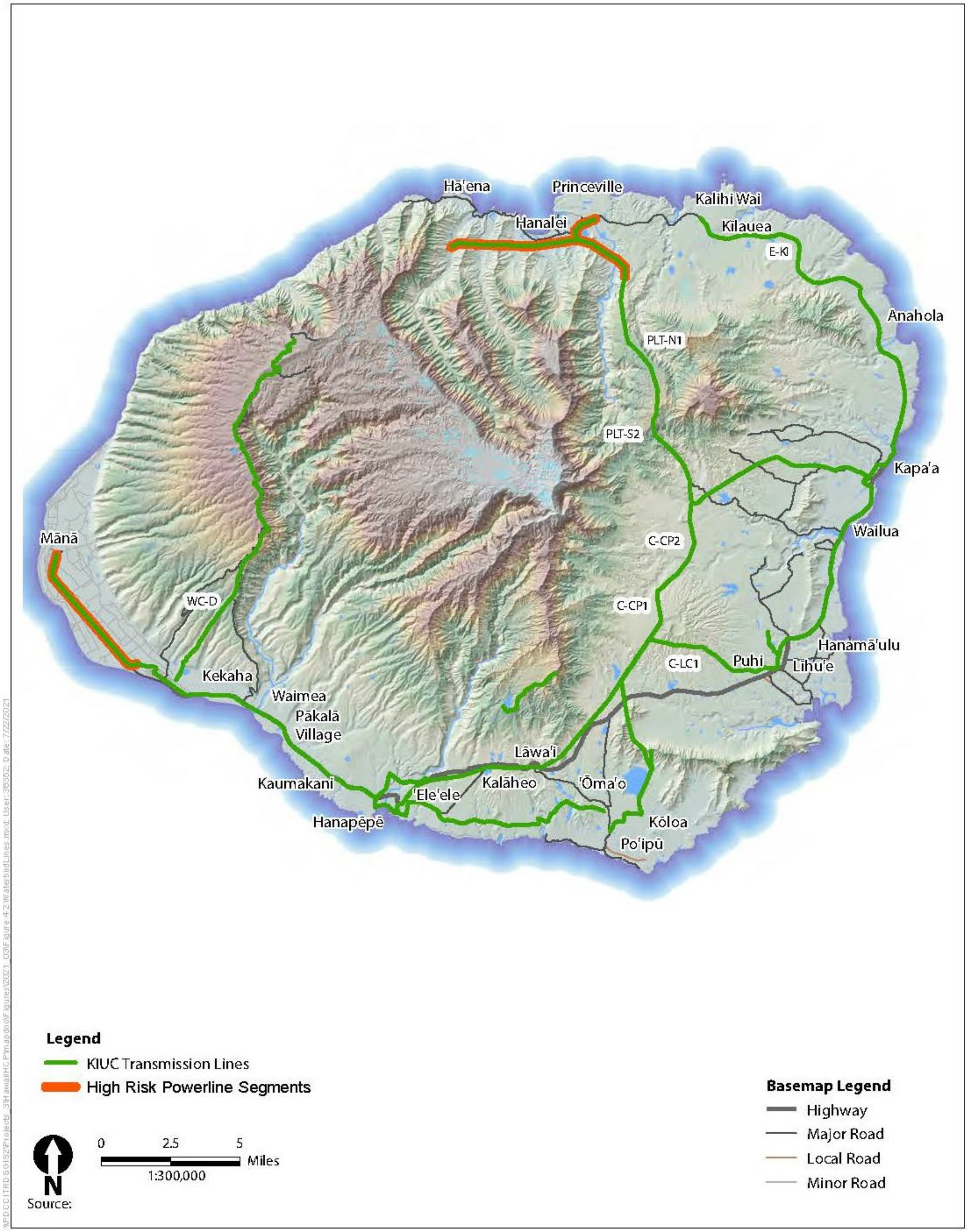

Figure 4-1. High-Risk Powerline Spans for Waterbirds

4.3.5 Central North Pacific Distinct Population Segment of the Green Sea Turtle (honu)

Goal 5. Contribute to the recovery of the species by increasing the ability for green sea turtles (honu) to successfully transit Kauaʻi beaches.

Objective 5.1. Locate and temporarily shield green sea turtle (honu) nests on beaches that are visually affected by KIUC streetlights on an annual basis.

Rationale

Artificial lights shining on green sea turtle (honu) hatchlings as they emerge from nests at night can cause the hatchlings to move toward the lights instead of toward the ocean. There was an incident in September 2020 on Kauaʻi where green sea turtle (honu) hatchlings from a nest on Kekaha Beach crossed a street and moved toward a KIUC streetlight, and some of the hatchlings were crushed by vehicles. There has been no documented disorientation of nesting adults on Kauaʻi; however, monitoring to date on Kauaʻi has not been systematic.

The DLNR Division of Aquatic Resources (DAR) currently monitors nesting sea turtles on Kauaʻi, but this program is informal and lacks consistent funding. This HCP will require systematic surveys to locate and protect green sea turtle (honu) nests and placement of temporary shields at locations at risk of light attraction from streetlights. Green sea turtle (honu) nests can be temporarily shielded from artificial light sources at the nest site, minimizing the risk of disorientation from streetlights.

See Conservation Measure 5. Implement a Green Sea Turtle Nest Detection and Temporary Shielding Program (Section 4.4, *Conservation Measures*) for details of the conservation measure proposed to achieve this biological objective.

Objective 5.2. Permanently minimize light effects to the extent practicable from existing and future KIUC streetlights onto beaches with suitable green sea turtle (honu) nesting habitat by implementing practicable minimization techniques that will reduce or eliminate these light effects.

Rationale

Coastal streetlights have the potential to cause disorientation of hatchling green sea turtles (honu) if they are visible from suitable green sea turtle (honu) nesting habitat. To date, there has only been a single incident of documented disorientation of green sea turtle (honu) hatchlings attributable to KIUC streetlights. KIUC has identified as part of this HCP a total of 29 streetlights that are currently visible from green sea turtle (honu) nesting habitat.[8] Existing coastal streetlights with vegetation or structures currently blocking visible light from the beach could also result in light effects during the 50-year permit term if the physical setting changes, or entirely new streetlights are installed near beaches in the future.

Although KIUC owns and operates the streetlights on Kauaʻi, the County and State determine the location, height, wattage, and shielding, and must approve any modification. KIUC will work with the County and State to identify practicable minimization measures to permanently reduce

[8] KIUC's 2020 streetlight assessment found that the current condition of the beach has limited suitability for nesting green sea turtles (honu). However, to be conservative, six streetlights along Kūhiō Highway in Wailua are included in the total in the event this habitat becomes more suitable due to future weather patterns.

streetlight visibility from green sea turtle (honu) nesting habitat. Permanent minimization measures on streetlights that eliminate or reduce lateral light spillage (e.g., shields) could greatly decrease the potential for disorientation of green sea turtle (honu) hatchlings. Permanent minimization measures are those that would, once installed, remain in place in perpetuity. If an entire streetlight is repaired or replaced, the shield would be repaired or replaced as well at the same time, as needed.

See Conservation Measure 6. Identify and Install Practicable Permanent Light Minimization Techniques for Green Sea Turtle (Section 4.4, *Conservation Measures*) for details of the conservation measure proposed to achieve this biological objective.

4.4 Conservation Measures

This section describes the conservation measures KIUC will implement or fund to meet the biological goals and objectives described in Section 4.3, *Biological Goals and Objectives*. There are six conservation measures in total.

- **Conservation Measure 1**. Implement Powerline Collision Minimization Projects
- **Conservation Measure 2**. Implement Measures to Minimize Light Attraction
- **Conservation Measure 3**. Provide Funding for the Save Our Shearwaters Program
- **Conservation Measure 4**. Manage and Enhance Seabird Breeding Habitat and Colonies at Conservation Sites
- **Conservation Measure 5**. Implement a Green Sea Turtle Nest Detection and Temporary Shielding Program
- **Conservation Measure 6**. Identify and Install Practicable Permanent Light Minimization Techniques for Green Sea Turtle

Related management actions that KIUC will implement to achieve the biological goals and objectives are grouped under a single conservation measure. For example, all the actions that KIUC will implement to minimize powerline collisions, which includes powerline reconfiguration, static wire removal, and flight diverters, are described under Conservation Measure 1.

The conservation measures are described with sufficient detail and specificity to allow their implementation. Most of the conservation measures address several biological goals and objectives. As a result of the large scale and long timeframe over which the KIUC HCP will be implemented, the conservation measures are also designed to be flexible and allow adaptive management with increasing knowledge over time. The flexibility provided by the adaptive management program (Chapter 6, *Monitoring and Adaptive Management Program*) is an important component of the conservation strategy.

4.4.1 Conservation Measure 1. Implement Powerline Collision Minimization Projects

This conservation measure describes the actions KIUC will apply to meet the covered seabird and covered waterbird biological goals and objectives for powerline collision minimization. Powerline collision is one of, if not the most, important conservation issue for the Newell's shearwater ('a'o) and Hawaiian petrel ('ua'u) on Kaua'i (Travers et al. 2012, 2013, 2014, 2015, 2016, 2017a, 2018, 2019b, 2021). Seabird mortality from collisions with KIUC powerlines has significantly contributed to the decline of Newell's shearwater ('a'o) and Hawaiian petrel ('ua'u) populations and continues to suppress populations of both species (Travers et al. 2013, 2014, 2015, 2016, 2017a, 2018; Raine et al. 2017b). Collisions occur most often with the overhead static wire due its tall height and position above all other wires (Chapter 2, *Covered Activities*, Figure 2-2a), and because the static wire has a smaller diameter than energized conductors and therefore is less visible. Static wires are widespread across KIUC's electric system (Chapter 2, Section 2.1.1, *Powerline Operation*) and are present in nearly all high-collision locations. The other contributing factors for seabird powerline collision risks are the number or wires in a vertical stack, the total wire height, and the position of powerlines along ridgelines and in areas between active colonies and the ocean (i.e., along seabird migration routes). The greater the number of wires in the vertical stack and the higher the wires, the greater the risk of seabird collision. Powerline aboveground height is highest when wires are strung from ridgeline to ridgeline across a drainage or valley. On Kaua'i many of the powerline spans with the highest seabird collision risk are strung across mountain drainages.

The minimization actions for the covered seabirds under this conservation measure include reconfiguration of powerlines (i.e., changing the profile from vertical to horizontal and reducing the number of layers) (Chapter 2, Section 2.1.2, *Powerline Retrofits: Additional Powerlines and Changes in Wire Numbers and Configuration*), static wire removal[9] to substantially reduce powerline collisions, and installation of bird flight diverters on many powerlines (reconfigured lines or not) to further reduce powerline collisions by making remaining lines far more visible to covered seabirds at night. Bird flight diverters are regularly spaced devices that make powerlines more visible to birds, reducing the number of collisions. KIUC uses two types of flight diverters—reflective diverters and light-emitting diode (LED) diverters. Reflective diverters are made of plastic and have a shiny, reflective surface; LED diverters utilize a blinking LED light. The minimization actions for the covered waterbirds under this conservation measure include 69-kilovolt distribution line removal, static wire removal, and the installation of bird flight diverters (both reflective and LED); no reconfiguration projects are proposed for the covered waterbird species.

4.4.1.1 Background

KIUC completed six minimization projects that are consistent with this conservation measure in 2015 and 2016 during implementation of the Short-Term HCP.

- Installed reflective diverters from the Waimea Bridge to Kaumakani from spans 244 to 254 (approximately 1 mile [mi] [1.6 kilometers {km}])
- Installed reflective diverters from Moloa'a to Kīlauea from spans 1196 to 1214 (approximately 1.8 mi [2.9 km])

[9] Powerline reconfiguration can include static wire removal but static wire can occur in locations where powerline reconfiguration is not planned.

- Removed static wire from spans 328 to 342 from Waialo Road to Brydeswood
- Removed static wire at span 352 (Fujita Tap) (0.5 mile [0.8 km])
- Removed static wire from spans 328 to 342 (2.2 mi [3.5 km])
- Removed static wire at span 581 (0.3 mi [0.5 km]) (Halewili Positron to Aepo Substation)
- Buried underground spans 2030, and 6000 to 6005 (approximately 0.5 mile [0.8 km]) of distribution wires on Kāhili mountain.[10]

These minimization actions completed for the KIUC Short-Term HCP are similar to what KIUC will implement for this HCP under this conservation measure.

4.4.1.2 Powerline Collision Minimization Projects

Additional Bird Flight Diverter and Static Wire Projects

KIUC will install additional bird flight diverters and remove additional static wire to further reduce covered seabird and covered waterbird collisions. Most of KIUC's minimization projects use both bird flight diverters and static wire removal on the same spans to maximize strike reductions, except in a small number of instances where engineering or legal constraints prohibited the use of one technique. Appendix 4B, *Minimization Projects*, identifies all of the bird flight diverters and static wire projects by span and year. All projects shown in Appendix 4B, *Minimization Projects*, pertain to the covered seabirds except for those at Mānā (spans 1–113) and Hanalei (spans 462–478 and 1297–1328). Figures 4-2 and 4-3 show the location of each bird flight diverter and static wire minimization project identified in Appendix 4B, *Minimization Projects*. In a concerted effort to reduce the severity of the effects of the covered activities on the covered seabird and waterbird species prior to completion of the KIUC HCP, KIUC intends to complete all of the static wire removal and bird flight diverters projects identified in Appendix 4B, *Minimization Projects*, and Figures 4-2 and 4-3 by the end of 2023. These early implementation projects will total approximately 188.1 mi (302.7 km) of KIUC powerlines (Table 4-2).

Based on KIUC's pre-implementation monitoring data showing that strikes are reduced from between 42 percent to over 95 percent depending on the minimization technique (or combination of techniques), KIUC's powerline minimization projects will reduce seabird powerline collisions by at least 65.3 percent (Travers and Raine 2020a). For the covered waterbirds, the estimated percent of strikes avoided through the implementation of minimization techniques is even higher (90 percent) based on other data (Section 4.3.4, *Covered Waterbirds: Hawaiian Coot ('alae ke'oke'o), Hawaiian Gallinule ('alae 'ula), Hawaiian Stilt (ae'o), Hawaiian Goose (nēnē), and Hawaiian Duck (koloa maoli)*, provides more information).

[10] KIUC buried these wires underground because Underline Monitoring Program observation data indicated that these very short powerlines (19.7–26.2 feet [6–8 meters] above ground) had the highest collision rate on the island because the wires were mounted on a steep mountain ridge running directly through colonies of Newell's shearwaters ('a'o) and Hawaiian petrels ('ua'u).

Table 4-2. Amount of Powerline Collision Minimization Activity by Year (2020–2023)

Type of Minimization Activity	Year Complete	Linear Distance (mi)	Linear Distance (km)
Static wire removal	2020	17.0	27.3
Reflective diverters		6.8	10.9
Static wire removal	2021	30.2	48.6
Reflective diverters		37.4	60.2
LED diverters		5.4	8.7
Static wire removal	2022	20.6	33.1
Reflective diverters		41.2	66.3
LED diverters		11.7	18.9
Static wire removal	2023	3.8	6.2
Reflective diverters		12.8	20.6
LED diverters		1.2	1.9
Static wire removal	2020-2023 Totals	71.6	115.2
Reflective diverters		98.2	158
LED diverters		18.3	29.5
Total[1]	**--**	**188.1**	**302.7**

[1] Total mileage of all activities some of which overlap

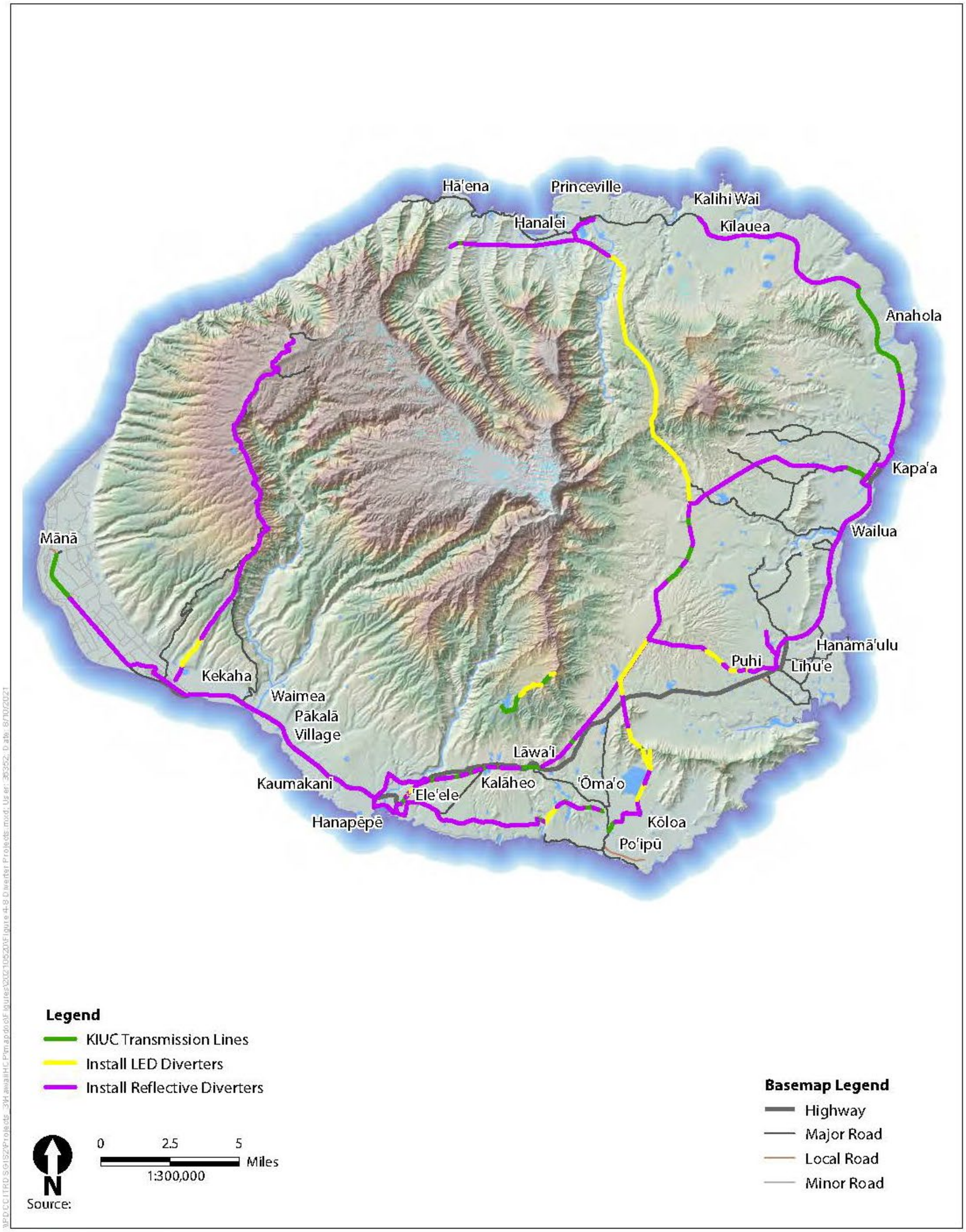

Figure 4-2. KIUC Bird Flight Diverter Minimization Project Locations

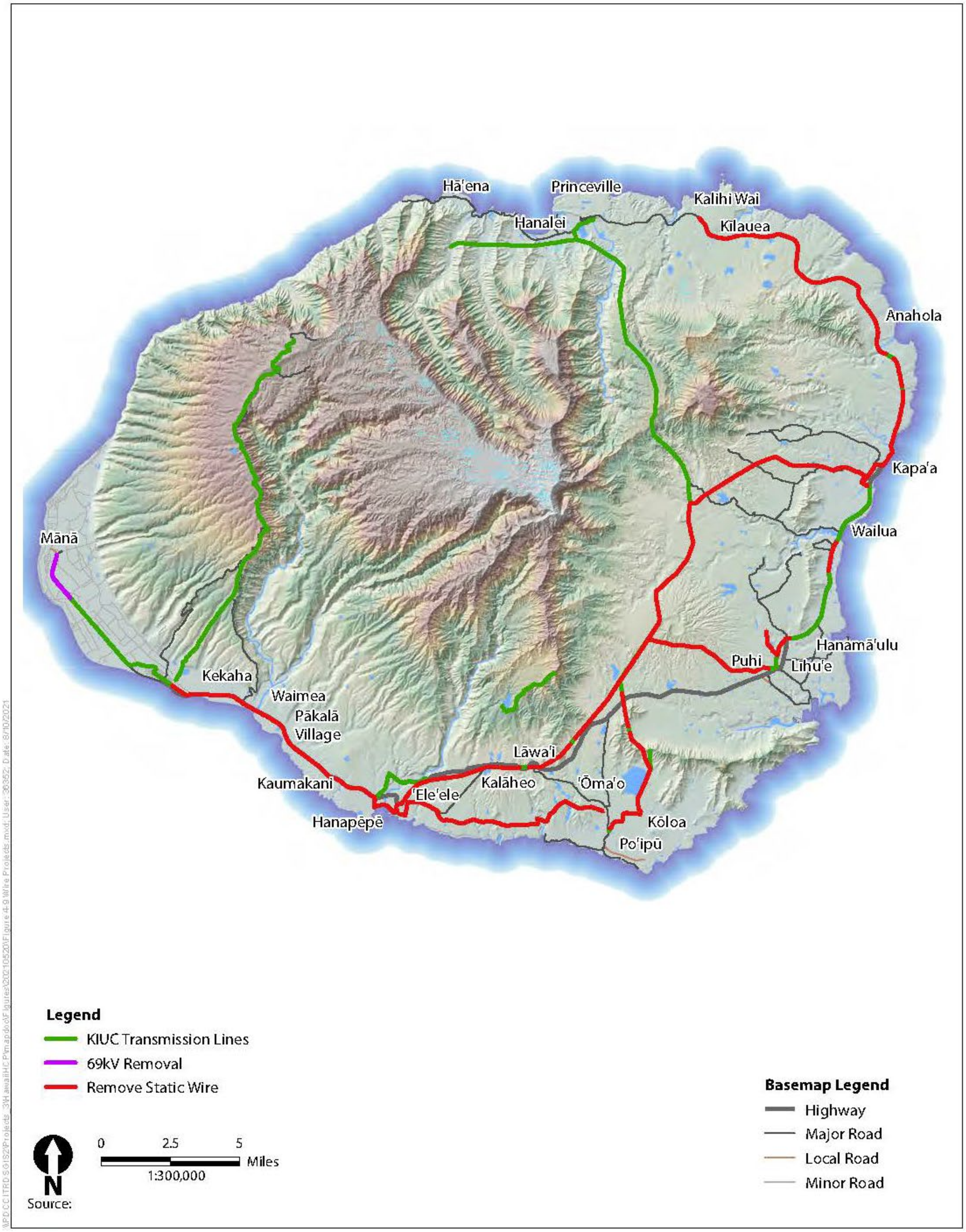

Figure 4-3. KIUC Wire Minimization Project Locations

Powerline Reconfiguration Projects

KIUC implemented three powerline reconfiguration projects in 2020 to reduce covered seabird collisions (Table 4-3, Figure 4-4). The three projects, which total 8.2 mi (13.2 km; 5 percent of the 171 mi [275.2 km] of transmission lines), include static wire removal. In summary, these projects accomplished the following.

- **Reduce maximum wire heights**. As shown in Table 4-3, the maximum height of wires along the project segments was reduced by more than 20 feet (6.1 meters [m]).
- **Reduce the number of vertical wire levels**. The collision risk in these line segments was reduced by reducing the number of vertical *wire levels* (Figure 2-2), which reduces the number of wires a level flying bird could fly at directly. The number of wire levels was reduced in these three projects by 50 percent or more.
- **Reduce the vertical profile.** To reduce the number of wire levels, the wires were positioned in a horizontal profile. This reduces the vertical profile of all wires that covered birds are exposed to in their travel path. The vertical distance of wire arrays was reduced substantially in all three projects.

No additional powerline reconfiguration projects are planned as part of this HCP.

Table 4-3. Powerline Reconfiguration Projects Implemented in 2020

Project ID	Spans	Linear Distance (mi)	Linear Distance (km)	Condition	No. of Wire Levels	Vertical Distance of Array (feet)	Vertical Distance of Array (m)	Highest Wire at Structure (feet AGL[a])	Highest Wire at Structure (m AGL)
C-LC1	702–718	2.6	4.2	Original	9	60.5	18.4	n/a[b]	n/a[b]
				Reconfiguration	3	20	6.1	29	8.8
C-CP1	389–400	2.6	4.2	Original	4	36	11.0	100	30.5
				Reconfiguration	2	11	3.4	75	22.9
C-CP2	401–417	3.0	4.8	Original	4	36	11.0	100	30.5
				Reconfiguration	2	11	3.4	75	22.9

[a] Above ground level
[b] Information not available

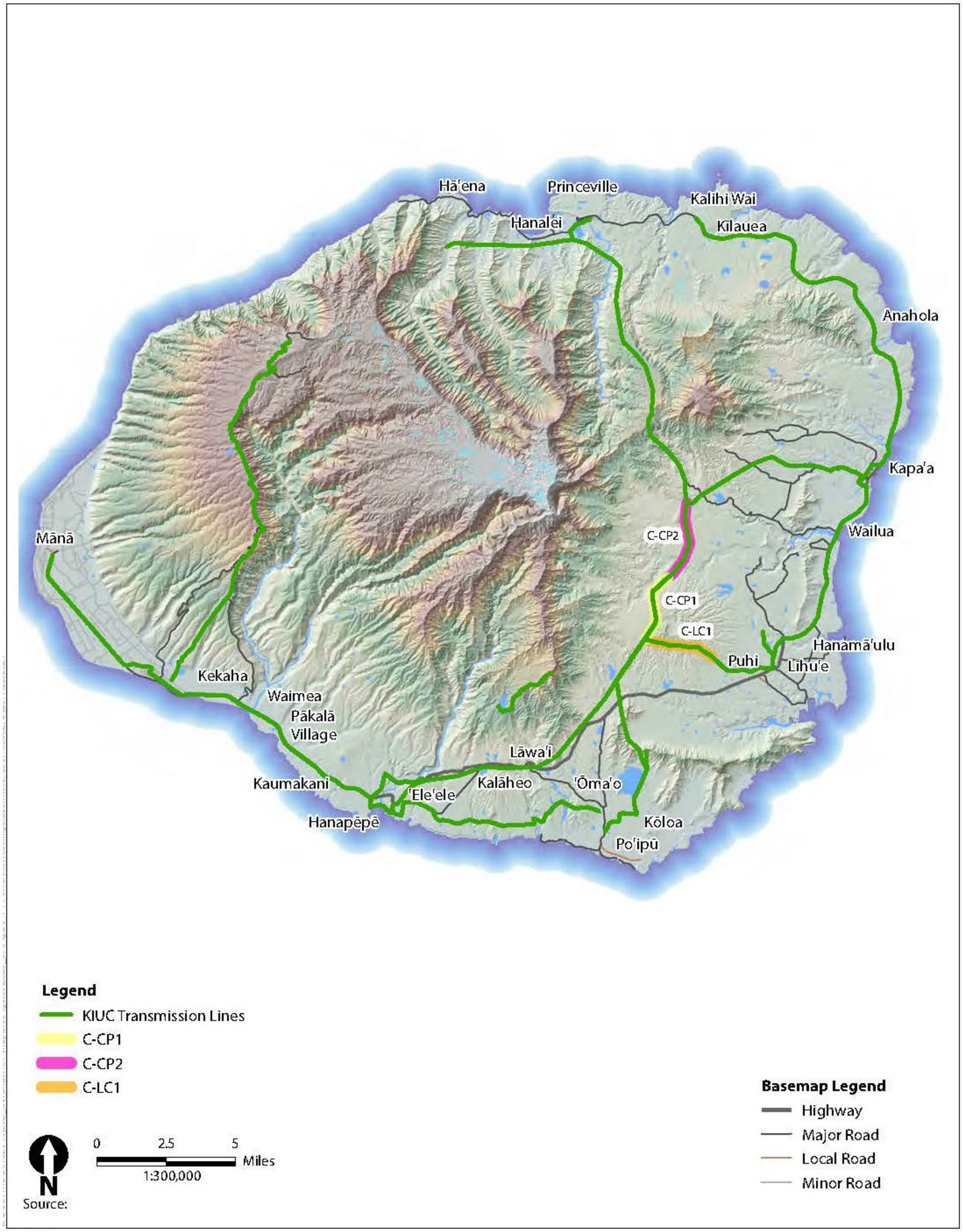

Figure 4-4. KIUC Powerline Reconfiguration Projects Implemented in 2020

4.4.1.3 Future Transmission and Distribution Lines

As described in Chapter 2, *Covered Activities*, KIUC will need to construct new transmission and distribution lines during the 50-year permit term to service new development on Kauaʻi. New transmission and distribution lines are defined as either new powerlines in new locations (including powerline extensions) or powerline retrofits that increase wire height or expose wires, as described in Chapter 2, Section 2.1.2, *Powerline Retrofits: Additional Powerlines and Changes in Wire Numbers and Configuration*. New powerlines will be reviewed with USFWS and DOFAW according to Chapter 2, *Covered Activities*, for compliance with the KIUC HCP and to minimize impacts. All new powerline installations will be planned and implemented with potential covered species impacts in mind. Appropriate minimization will be deployed on new powerlines applying the standards described below and with the goal of achieving the greatest practicable level of reduction to potential strikes in any given location.

KIUC will avoid construction of new transmission and distribution lines in high-collision zones in the Plan Area, to the maximum extent practicable. During the planning process for each new covered transmission or distribution line, existing data, predictive models (Travers et al. 2017b), and/or consultation with a qualified biologist will be used to determine the potential strike rate (strikes per year) per span. Proposed alignments that are modeled to have high strike rates will be avoided unless there is no alternative route.

KIUC will minimize the potential for collisions on all new transmission and distribution lines by applying the following standards for all new transmission and distribution lines.

- **No static wire.** New powerline configurations will not have a static wire.
- **Minimize powerline height.** New distribution lines will be no more than 45 feet (13.7 m) above ground.[11] KIUC commits to maintaining this horizontal design standard (or an equivalent or better standard) for new distribution lines throughout the 50-year term of the HCP consistent with engineering and safety requirements. There is no maximum aboveground height for transmission lines because they are dictated by Public Utilities Commission standards and engineering regulations; however, KIUC will minimize transmission line height when and where practicable.
- **One vertical wire level.** New distribution and transmission lines will be installed in one horizontal plane to the greatest extent practicable consistent with KIUC's 2007 standards already in place for distribution lines.
- **Powerline placement.** To the extent practicable, new powerlines will be located in areas that will reduce and minimize collision risk such as in valleys or along the bottom of slopes (instead of along ridgelines or at the top of slopes). To the extent practicable, long powerline span placement across valleys will also be avoided (i.e., perpendicular to valleys).
- **Bird flight diverters.** All new powerlines will be evaluated to determine if bird flight diverters are a practicable minimization technique. If bird flight diverters are practicable, they will be

[11] KIUC adopted a *Flat Design Standard for New 12.47 kV Electrical Distribution Lines* in 2007 (Kauaʻi Island Utility Cooperative 2007). This design standard requires new distribution circuits to utilize a horizontal arrangement with a single wire layer that is no more than 45 feet (13.7 m) above ground, minimizing the potential for seabirds to collide with new overhead 12.47-kilovolt distribution lines. KIUC will also apply this design standard to all new transmission lines.

installed at the time of construction. Where powerlines are adjacent to or near roads, reflective diverters will be used. Where powerlines are farther from roads, LED diverters will be used.

These new or extended transmission and distribution lines would be connected to the grid using one of the following methods.

- Conductors that descend downward in a single run from the existing transmission or distribution circuit into the new renewable energy project site.
- Conductors placed on an existing powerline alignment with existing and new wires configured such that no wires exceed a height of 45 feet (13.7 m) above ground at the poles.
- Conductors placed co-linear to an existing powerline (i.e., parallel to existing powerlines) and the new wires configured such that they do not exceed a height of 45 feet (13.7 m) above ground at the poles.

Based on the same monitoring data described above for existing powerlines under A*dditional Bird Flight Diverters and Static Wire Projects* (Travers and Raine 2020a), KIUC has estimated that 80 percent[12] of the anticipated seabird powerline collisions and 90 percent of the anticipated waterbird powerline collisions resulting from the installation of new powerlines under unminimized conditions would be avoided with the implementation of minimization techniques. The estimated reduction in powerline collisions for new powerlines assumes that all new spans will lack static wire and include bird flight diverters. These estimated strike reductions are considered conservative because KIUC also has the opportunity to further minimize collisions by siting new powerlines in lower-risk areas, when practicable, and using a horizontal wire configuration.

4.4.2 Conservation Measure 2. Implement Measures to Minimize Light Attraction

This conservation measure describes the actions KIUC will apply to meet the covered seabird biological goals and objectives for light attraction minimization. Bright artificial lights attract and confuse the covered seabird fledglings, causing them to become grounded (Imber 1975; Telfer et al. 1985). If the light-attracted individuals that become grounded are not rescued, they are at risk of succumbing to injury or mortality due to starvation, predation, collisions with cars, or a combination thereof. KIUC's streetlights and covered facility lights are one source of artificial light in the Plan Area that can result in these effects. Under this conservation measure, KIUC will take actions to reduce and minimize this impact, as described below.

4.4.2.1 Streetlights

All KIUC streetlights were retrofitted in 2017 to minimize light attraction and reduce the risk of seabird fledgling fallout while still maintaining lighting necessary for public health and safety of public roads and neighborhoods. KIUC installed full-cutoff shielded fixtures on the approximately 4,150 streetlights it owns and operates. These fixtures effectively direct all light toward the ground

[12] This is based on data collected by Travers and Raine (2020a) for the Infrastructure Monitoring and Minimization Project on existing powerline spans that have a combination of static wire removal and reflective diverters. On average, static wire removal reduces strikes by 50 percent and installation of reflective diverters reduces strikes by an additional 42 percent (92 percent total combined). However, because other factors can affect strike rates, KIUC conservatively assumes unminimized strikes (no HCP) resulting from new powerlines will be reduced a minimum of 80 percent with the minimization techniques presented in this chapter.

and minimize the amount of light directed outward or upward toward the sky. With these full-cutoff shielded fixtures, all KIUC-owned streetlights do not produce light that shines above the 90-degree horizontal plane (Figure 4-5). At the same time, all KIUC streetlights were converted from high-pressure sodium bulbs to more energy-efficient 3000-kilowatt LED bulbs. In 2019, KIUC replaced all green light bulbs in streetlights with white light bulbs to further reduce light attraction.

Figure 4-5. Example of Full-Cutoff Shield Installed by KIUC on a Kauaʻi Streetlight

KIUC has estimated that approximately 1,050 new streetlights (see Chapter 2, Section 2.2.2.2, *New Streetlights*) will be installed during the permit term. All future streetlights will utilize the same light minimization features, installed by KIUC at the time of construction.

4.4.2.2 Covered Facility Lights

KIUC also operates night lighting at two facilities covered by this HCP, the Port Allen Generating Station and the Kapaia Generating Station, called the *covered facilities* (see Chapter 2, Section 2.2.1.1, *Existing Facilities*). KIUC will continue to dim the exterior lighting at Port Allen Generating Station during the fledgling fallout season (September 15 to December 15) to minimize light attraction. At the beginning of the fallout season, all exterior facility lights are dimmed to the lowest extent practicable (i.e., consistent with all applicable laws and regulations and allowing KIUC to conduct its work in a safe manner). KIUC began this practice in 2019 and saw significant reductions in fallout at this covered facility. Between 2016 and 2018 prior to dimming the lights, KIUC recorded between 4 and 10 grounded Newell's shearwaters (ʻaʻo). Following dimming, KIUC recorded no fallout in 2019 and one grounded Newell's shearwater (ʻaʻo) in 2020 (Kauaʻi Island Utility Cooperative 2020, 2021).

Interior building lights at covered facilities will be turned off at night during the fledgling fallout season (September 15 to December 15) to avoid light attraction. If interior building lights must be turned on for any portion of the night, retractable screens or shades will be used to block lights from emitting from the building.

In 2019, KIUC retrofitted all the exterior lights at the Port Allen Generating Station and at the Kapaia Generating Station. At the Port Allen Generating Station, KIUC replaced its existing freestanding[13] exterior facility lights with full-cutoff white LED lights and shielded wall-mounted white LED box lighting. Similarly, at the Kapaia Generating Station, all the 150-watt high-pressure sodium streetlights and building lights were shielded to direct light downward, away from the sky. Any new lights installed within the two covered facilities by KIUC during the permit term will utilize the same minimization features.

4.4.2.3 Night Lighting for Restoration of Power

KIUC may also need to utilize artificial lighting during the seabird fallout season if power outages occur between September 15 and December 15. KIUC will search for grounded birds at work sites operating at night to restore power during these 3 months according to the same protocol used at the covered facilities (Section 4.4.2.2, *Covered Facility Lights*). Due to the emergency nature of this work, minimization of lighting at night for the restoration of power is not possible. If KIUC documents that significant fallout is occurring from night lighting for restoration of power, KIUC will address this issue through the adaptive management program. Chapter 6, Section 6.4.2, *Light Attraction Monitoring and Adaptive Management*, provides more details.

4.4.2.4 Annual Training

KIUC will continue to conduct its ongoing annual seabird training program prior to the start of the seabird fallout period (September 15 to December 15) using the *KIUC Site Monitoring Protocols and Procedures for Protected Seabirds* (Appendix 6A, *Protocols and Procedures*). Training will continue to be provided for staff who conduct or supervise grounded seabird searches at facilities and for staff at nighttime work sites to address power outages with artificial lighting. KIUC will provide the training both in person and online so that staff can review it at any time. The Protocols and Procedures will be updated prior to the first seabird fallout season in Year 1 of HCP implementation. The Protocols and Procedures will continue to be updated on an as-needed basis when adaptive management is implemented.

The annual training will include an overview of the KIUC HCP, the importance of compliance with the HCP and all relevant environmental laws, and a summary of all the relevant avoidance and minimization measures, best management practices, and conservation measures outlined in the HCP. A qualified professional will lead the training on the covered species and provide specific information regarding the species' appearance and their life histories. The trainer will also describe the covered species rescue protocol should a staff member or contractor encounter live or dead covered species consistent with the Protocols and Procedures. KIUC will maintain a log of the names of staff and contractors who attend and complete the annual training.

4.4.2.5 Predator Removal at Covered Facilities

KIUC will remove predators from the covered facilities (Port Allen Generating Station and Kapaia Generating Station) to minimize depredation of grounded covered seabirds and waterbirds. KIUC will trap and remove feral cats and dogs observed at their covered facilities. These animals will be transferred to a suitable animal shelter or sanctuary. KIUC will also trap and remove mice and rats if they are observed within the covered facilities. Daily predator management at the KIUC covered

[13] Stand-alone fixtures on their own stanchions or attached to power poles.

facilities and near the covered facilities on KIUC-owned land will occur throughout the entire permit term. Traps will be placed throughout the facility in locations where target predators have been observed or at ingress points (e.g., gates, roads, along the edges of buildings) and will be checked on a regular basis to remove trapped animals.

4.4.3 Conservation Measure 3. Provide Funding for the Save Our Shearwaters Program

The SOS Program is an avian rescue and rehabilitation program that operates year-round on Kaua'i. The initial focus of the program was on rescue and rehabilitation of Newell's shearwater ('a'o) and Hawaiian petrel ('ua'u). The program has since been expanded to include all native bird species including all covered seabirds and waterbirds, as well as other, non-covered birds. Under the SOS Program, grounded seabirds, waterbirds, and other birds that are rescued by members of the public or businesses can be turned into SOS Program staff. Injured birds are assessed, rehabilitated if possible, and released back into the wild by trained staff and volunteers and professional veterinary staff. All rehabilitation actions occur at an accredited animal rescue facility with extensive equipment and facilities for any necessary procedure to treat minor injuries or perform major surgery or treatment, including extended stays prior to release back into the wild.

To date, the SOS Program has recovered and released more than 30,500 seabirds since the 1970s (Raine et al. 2020b). Approximately 80 to 85 percent of the covered seabirds and 40 to 70 percent of the covered waterbirds that are handled by the SOS Program are rehabilitated and released back into the wild[14] (Anderson 2018, 2019; Bache 2019), with the expectation that they will successfully reproduce in future nesting seasons. While rehabilitated and released fledglings of covered seabirds do have reduced survivorship compared with wild fledglings, research has shown that a proportion of rehabilitated fledglings have been documented to successfully migrate to their wintering grounds (Raine et al. 2020b). Using satellite tags, Raine et al. (2020b) found that after 21 days, 28.9 percent of SOS-rehabilitated fledglings were still transmitting in comparison with 50 percent of wild fledglings. However, it is assumed that all the rehabilitated seabirds would have died as a result of collision or grounding injuries, starvation, dehydration, predation, vehicle interactions, or other sources of mortality, if not retrieved, treated, and released by the SOS Program. Consequently, operation of the SOS Program plays a significant role in maintaining sustainable populations of the covered species on Kaua'i.

Beginning in 2003, KIUC began funding and largely implementing the SOS Program with DOFAW oversight and assistance. KIUC has continued to provide the majority of the funding for the SOS Program annually. For this conservation measure, KIUC commits to fund the SOS Program at an increased level of $300,000 annually (in constant 2023 dollars) for the duration of the permit term. As described in Chapter 7, *Plan Implementation*, KIUC funding will increase annually to keep pace with inflation. This funding is anticipated to adequately support the SOS Program (or other adequate program) for the rescue, rehabilitation, and release of covered seabirds and covered waterbirds affected by KIUC's covered activities and that are found by the public and volunteers. Because KIUC has been the primary source of funding for the SOS Program for most of its history, KIUC's continued

[14] The remaining 15 to 20 percent of the covered seabirds and 30 to 60 percent of the covered waterbirds are dead on arrival, their injuries are so severe they must be euthanized, or they succumb to their injuries within 24 hours of admittance.

financial support at this level ($300,000 annually in constant 2023 dollars) will ensure that these benefits to the covered species continue for 50 years.

For the purposes of this HCP, funding the SOS Program is considered both minimization and mitigation for the covered seabirds and mitigation for the covered waterbirds. For the covered seabird species that are grounded due to KIUC covered activities (i.e., KIUC streetlights and facility lights), the SOS Program minimizes the impact of the taking by rescuing, treating, and releasing the seabirds, thereby minimizing the extent of the injury and the amount of mortality. Covered seabirds that are grounded because of light attraction from non-KIUC sources (e.g., lights from shopping malls or other commercial facilities), and then rescued, rehabilitated, and released by the SOS Program contribute to the mitigation in this HCP.[15]

For covered waterbird species injured due to threats unrelated to KIUC powerlines (e.g., botulism, vehicle collisions), funding the SOS Program by the HCP is considered mitigation.

4.4.3.1 Public Outreach and Education

Conservation Measure 3 includes public outreach and education to inform and educate the public about the risks of powerline strikes and light attraction to threatened and endangered species on Kauaʻi. The SOS Program has its own public outreach and education program that KIUC will support as part of its financial support of that program. Also, as part of this measure, KIUC will continue to conduct its own public outreach and education in coordination with the SOS Program. These efforts may include, but are not limited to, the following actions.

- Encourage developers of new commercial and residential development on Kauaʻi to bury powerlines in the areas to be developed, especially in areas with high risk of collision by the covered species.
- Encourage the County to adopt new zoning regulations that require all new developments on Kauaʻi to bury new utility lines.
- Prepare and distribute information on the covered species, the SOS Program, and the HCP in the *Currents* magazine, which is sent via direct mail to all KIUC customers.
- Publicize the SOS Program and the HCP with radio, newspaper, or television announcements, as well as community school programs.
- Develop, assemble, and disseminate a variety of education materials. The SOS Program staff distributes these materials.
    - SOS Program posters
    - SOS Program brochures
    - Seabird activities coloring book
    - Seabird "tattoos"

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[15] The exception to this are covered seabirds that fallout due to activities covered by the Kauaʻi Seabird Habitat Conservation Plan (State of Hawaiʻi Division of Forestry and Wildlife 2020) or the Kauaʻi Lagoons Habitat Conservation Plan (Kauaʻi Lagoons LLC 2012). These two HCPs also provide funding to the SOS Program to minimize the effects of light attraction at their covered facilities. KIUC is not responsible for the rescue, rehabilitation, or release of covered seabirds that fallout due to activities covered by other approved HCPs on Kauaʻi.

  - Reusable shopping bags
  - Tee-shirts
- Perform annual seabird public blessings (pule) and release events to promote the cultural connection between the people of Kauaʻi and the covered seabirds.
- Publicize the program at outreach events such as Earth Day, Lighthouse Day, or Agricultural and Environmental Awareness Day.

4.4.4 Conservation Measure 4. Manage and Enhance Seabird Breeding Habitat and Colonies at Conservation Sites

This conservation measure describes the actions KIUC will apply to meet the Newell's shearwater (ʻaʻo) Hawaiian petrel (ʻuaʻu), and band-rumped storm petrel (ʻakēʻakē) (related only to predator control) biological goals and objectives. The management and enhancement actions identified under this conservation measure will occur exclusively within designated conservation sites on Kauaʻi throughout the permit term.

4.4.4.1 Conservation Sites

Conservation sites are specific parcels in the Plan Area where KIUC will continue to implement management actions (e.g., predator control, social attraction) to increase the reproductive success of Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu) breeding colonies, and to benefit band-rumped storm petrel (ʻakēʻakē) occurring in the region. As part of the early planning process for this HCP, KIUC went through an extensive site selection process to identify and secure suitable conservation sites for the HCP. As part of this selection process, KIUC considered 19 sites throughout the Plan Area and evaluated them against a set of 14 criteria, which fall into the following eight summary categories. A site could be selected and secured only if it met all of these criteria.

- Covered species presence
- High habitat quality
- Low to moderate predator abundance
- Existing management
- Management feasibility
- Accessibility by foot or helicopter
- Landowner willingness
- Low degree of anthropogenic threats (light attraction and powerlines)

This assessment was informed by experts at ARC, Pacific Rim Conservation, and Hallux Ecosystem Restoration LLC, who have been conducting these management actions for many years, including as part of the KIUC Short-Term HCP. Details of the evaluation criteria, site assessment, and the evaluation process are found in Appendix 4A, *Conservation Site Selection Process.*

Based on this assessment, ten conservation sites have been included in the KIUC HCP (Figure 4-6). Nine of these sites have been selected and were judged to meet all the major criteria listed above.[16] Pōhākea PF (i.e., predator fence) and Honopū PF are smaller areas within their respectively named sites; although they are located within a larger conservation area, they are identified as separate conservation sites for the purposes of this HCP.

1. Upper Limahuli Preserve
2. North Bog
3. Pōhākea
4. Pōhākea PF
5. Honopū
6. Honopū PF
7. Pihea
8. Hanakoa
9. Hanakāpīʻai

Most of the nine conservation sites that were selected for the KIUC HCP are the same sites where KIUC has been funding predator control and seabird monitoring (and invasive plant species control) annually since 2011 for the Short-Term HCP and in the interim period between the Short-Term HCP and commencement of this KIUC HCP. This provided KIUC, USFWS, and DOFAW with a large amount of data that was used to determine if management at these sites would continue to benefit the covered seabird species during HCP implementation. Because management had been occurring at these sites for such a long time, it also led to the decision to include these sites as conservation sites for the KIUC HCP rather than replace them with new sites.

Other significant factors for selection of the conservation sites in the KIUC HCP included site adjacency and presence of existing fences. The Upper Limahuli Preserve already has an ungulate fence surrounding the entire boundary. North Bog, Pōhākea, Hanakoa, and Hanakāpīʻai are located in the Hono O Nā Pali Natural Area Reserve (NAR), managed by DOFAW. KIUC added the Hanakoa and Hanakāpīʻai conservation sites in 2021 in large part due to the fact that seabird management was already occurring in the Hono O Nā Pali NAR. In addition, the Hono O Nā Pali NAR contains sections of pig fences that prevent pigs from damaging the covered seabird colonies within these conservation sites. Pihea and Honopū are part of the Nā Pali Coast State Wilderness Park owned by the Division of State Parks. In addition, DOFAW and DOFAW's partners constructed predator exclusion fences to create the Pōhākea PF and Honopū PF conservation sites; this allowed KIUC to begin social attraction in these conservation sites in 2022 prior the permit term.

[16] Many other sites failed the evaluation because of a failure to meet key criteria necessary for management such as landowner willingness, documented presence of the covered species, site access, or a combination of these factors. Appendix 4A, *Conservation Site Selection Process*, provides details.

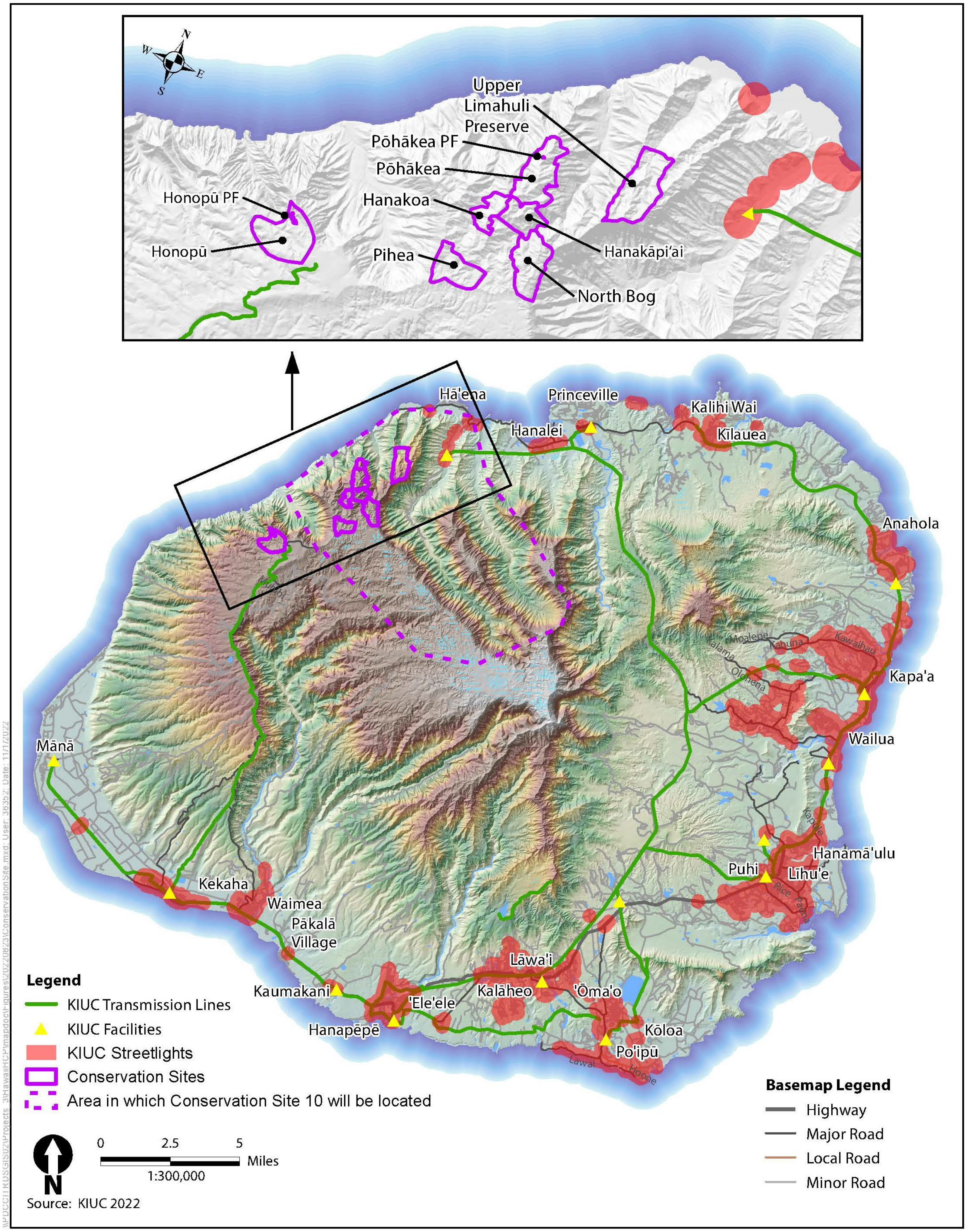


Figure 4-6. Conservation Sites

KIUC will select a tenth conservation site but the final location of this site is still under evaluation. The final site is identified temporarily as "Conservation Site 10" and will occur in the area shown as a dashed purple line on Figure 4-6 in the northwest corner of Kaua'i. KIUC is currently evaluating four candidate locations for Conservation Site 10 against the selection criteria listed in Appendix 4A, *Conservation Site Selection Process*. Specifically, Conservation Site 10 will be selected based on the presence of Newell's shearwater ('a'o) colonies and the feasibility of establishing a predator exclusion fencing and initiating social attraction. KIUC will select and commit to a specific location for Conservation Site 10 no later than the end of 2023 and before permit issuance.

During the development of this HCP, KIUC was planning to include a tenth conservation site near the Upper Limahuli Preserve called Upper Mānoa Valley. KIUC had included the Upper Mānoa Valley site in many drafts of the HCP and planned on including it in the final HCP. However, in late 2022 this site proved infeasible due to an inability to reach agreement with the landowner. KIUC will select the new site (Conservation Site 10) in coordination with and approval from USFWS and DOFAW. The conservation benefits of Conservation Site 10 identified in this HCP are based on the previously selected site (Upper Mānoa Valley). KIUC will ensure that Conservation Site 10 will provide equal or greater benefit than the Upper Mānoa Valley site it is replacing. KIUC will continue management of the previously selected conservation site until such time as the new site has been selected to replace it, to ensure that there are no gaps in the HCP's conservation benefits for the covered seabird species.

Five of the 10 sites currently support Newell's shearwater ('a'o) and Hawaiian petrel ('ua'u) breeding colonies (Table 4-4). Of the remaining five sites, Honopū primarily supports Newell's shearwater ('a'o) but contains suitable habitat for Hawaiian petrel ('ua'u). Conversely, Pihea currently contains very few Newell's shearwater ('a'o) breeding pairs but supports a robust Hawaiian petrel ('ua'u) population. The Pōhākea PF and Honopū PF sites are small social attraction sites within predator exclusion fences that contain suitable habitat for the covered seabird species but are currently unoccupied. Lastly, for Conservation Site 10, KIUC will ensure that the selected conservation site encompasses, at a minimum, Newell's shearwater ('a'o) colonies and is suitable habitat for Hawaiian petrel ('ua'u). None of the conservation sites support band-rumped storm petrel ('akē'akē).

Together, the 10 conservation sites (assuming Conservation Site 10 will have an equal or greater number of Newell's shearwaters ['a'o] than the previously selected site) currently support an estimated colony population of 1,264 to 1,605 Newell's shearwater ('a'o) breeding pairs and an estimated colony population of 2,257 to 3,675 Hawaiian petrel ('ua'u) breeding pairs (Table 4-4). A detailed description of each of the nine selected conservation sites is included in Appendix 4A, *Conservation Site Selection Process*.

Table 4-4. Breeding Pairs of Newell's Shearwater ('a'o) and Hawaiian Petrel ('ua'u) at the HCP Conservation Sites in 2021, Based on Acoustic Monitoring Data

Conservation Site	Total Site Size (acres/hectares)	Low/High Newell's Shearwater ('a'o) Breeding Pairs[a]	Low/High Hawaiian Petrel ('ua'u) Breeding Pairs[a]
Upper Limahuli Preserve	378/153	498/617	112/135
North Bog	348/141	67/80	880/1,261
Pōhākea	363/147	290/464	161/611
Pōhākea PF[b]	0.34/0.14	0	0

Conservation Site	Total Site Size (acres/hectares)	Low/High Newell's Shearwater (ʻaʻo) Breeding Pairs[a]	Low/High Hawaiian Petrel (ʻuaʻu) Breeding Pairs[a]
Honopū	239/97	90/92	0
Honopū PF[b]	3.3/1.3	0	0
Pihea	515/208	0/1	645/815
Hanakoa	186/75	45/74	171/455
Hanakāpīʻai	187/76	76/85	289/398
Conservation Site 10	TBD[c]	198/283[c]	0
Total	**2,216/896**	**1,264/1,605**	**2,257/3,675**

Source: Raine 2022

[a] The breeding pair estimates are informed by acoustic call rate and nesting burrow monitoring studies, which have demonstrated a significant relationship between call rates and estimated densities of active nesting burrows (e.g., Raine et al. 2019a). These acoustic call rates are used in combination with published habitat suitability models (Troy et al. 2014, 2017).

[b] Both of these conservation sites are bound by small predator exclusion fences that will be managed and maintained as social attraction sites by KIUC. Both social attraction areas contain suitable habitat for the covered seabirds.

[c] To be determined once Conservation Site 10 is selected. Assumes Conservation Site 10 will have an equal or greater number of Newell's shearwaters (ʻaʻo) than Upper Mānoa Valley.

Because KIUC or other entities have been managing most of these sites for covered seabird species well before the start of the permit term, the measurable benefits to the covered seabirds will be realized much earlier in the permit term than if site management began after permit issuance. Management actions such as predator exclusion fence construction, predator control, and social attraction take several years to implement fully and several years after that to begin to measurably benefit the covered seabirds, but predator control will benefit the covered seabirds during Year 1 of HCP implementation due to KIUC's long history of predator management within these conservation sites.

4.4.4.2 Management Actions

This conservation measure is the primary means of offsetting the impacts of the taking on Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu) and providing a net benefit for each species (see Chapter 5, *Effects*, for modeling that quantifies this benefit). This conservation measure includes four management actions that KIUC will employ within the conservation sites.

- Predator control
- Predator exclusion fencing
- Social attraction
- Invasive plant species control (limited to areas with predator exclusion fencing)

Table 4-5 shows which management actions are planned for each of the 10 conservation sites during the 50-year permit term.

Table 4-5. Management Actions Implemented in Each Conservation Site

Conservation Site	Predator Control	Predator Exclusion Fencing	Social Attraction	Invasive Plant Species Management[a]
Upper Limahuli Preserve	X	X[b]	X	X
North Bog	X	--	--	--
Pōhākea	X	--	--	--
Pōhākea PF	X	X	X	X
Honopū	X	---	--	--
Honopū PF	X	X	X	X
Pihea	X	--	--	--
Hanakoa	X	--	--	--
Hanakāpiʻai	X	--	--	--
Conservation Site 10	X	X[b]	X	X
Total	**10**	**4**	**4**	**4**

[a] Invasive plant species management occurs primarily in the social attraction sites. Invasive plant species management in other areas within the conservation sites is conducted on an as-needed basis.

[b] The predator exclusion fence is located within the larger conservation site

The management actions described in this measure have been applied in the field for most of the sites over the past 10 years, as described in *Interim Management Actions*, allowing extensive field testing and refining of tools, equipment, and techniques. However, new technology or approaches may become available during the permit term to improve the effectiveness or cost-efficiency of these measures. If that is the case, the details of these measures may be modified through adaptive management based on results of monitoring and the best available scientific and technical information, as described in Chapter 6, Section 6.4.4, *Conservation Site Monitoring and Adaptive Management*. Each of these four management actions is described below.

Predator Control

Predator control is the primary management action to establish predator-free breeding habitat or substantially reduce predation, which is critical to successfully restore productive seabird colonies (Buxton et al. 2014; Jones and Kress 2012; Young et al. 2018; Raine et al. 2020a). Given the length of time necessary for birds to reach sexual maturity and successfully start fledging chicks (5–6 years), adult mortality is extremely harmful to the species (Raine et al. 2020a).

Terrestrial Predator Control

Terrestrial predator control has been proven to be very effective at increasing seabird nesting productivity on Kauaʻi. Raine et al. (2020a) found that between 2011 and 2017, Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu) reproductive success rates increased by a mean of approximately 36 percent and 48 percent, respectively, following predator control operations within managed breeding sites. Without predator control, Raine et al. (2020a) found that modeled population trajectories within all management sites declined rapidly over a 50-year period, with many colonies approaching extirpation.

Terrestrial predator control methods may include traps, bait stations, snares, hunting, and other control methods. Predator control at all sites will be designed to achieve the conservation benefits in

Chapter 5, *Effects*. Predator control efforts may be timed based on seasonality, rainfall, and the phenology and/or vulnerability to toxicants of endemic species within the fenced area. Traps will also be deployed in other areas where there are high levels of human use such as weatherports, campsites, and other small facilities within the conservation sites. Terrestrial predator control in areas without predator exclusion fencing will focus on high-traffic locations for predators near known breeding colonies.

At four of the conservation sites, predator exclusion fences will be constructed in a portion of the conservation site to eradicate terrestrial predators (cats, rats, mice, pigs, goats) in areas where social attraction will be initiated. Depending on terrestrial predator abundance and the total size of the fenced area, complete terrestrial predator eradication can take anywhere from 3 to 12 months to achieve (Young pers. comm.); individuals must be removed at a rate faster than they can reproduce. Where there are fencing gaps at drainage crossings, traps will be placed 66 feet (20 m) apart to intercept any animals that enter the containment zone. Once terrestrial predators are eradicated within the exclusion fence boundary, as determined by the results of the monitoring program (Chapter 6, *Monitoring and Adaptive Management Program*), this HCP assumes that the habitat within the fenced area will remain free of terrestrial predators except when fences are breached or damaged. In cases of a fence breach or damage immediate terrestrial predator control will occur within the fenced area in order to remove any predators that may have entered the breach and to maintain predator-free habitat. In addition, the fences will have no effect on barn owls (and may even facilitate perching), so barn owl control within the fenced areas will still be necessary for the duration of the 50-year permit term. Some of the conservation sites also have ungulate fences or pig fences that partially or entirely surround the conservation site, as described below.

Upper Limahuli Preserve

- Predator exclusion fence (approximately 12 acres [5 hectares]) around a social attraction site. Predators will be eradicated within the fenced area.
- Entire 378-acre (153-hectare) conservation site protected by ungulate fence. Terrestrial predator control (cats, rodents, barn owls, feral bees) will occur in the entire ungulate fenced area for the duration of the 50-year permit term.

Pōhākea

- Predator exclusion fence (approximately 0.34 acre [0.14 hectare]) around a social attraction site (i.e., Pōhākea PF). Predators will be eradicated within the fenced area.
- Remainder of 363-acre (147-hectare) conservation site is protected by a partial pig fence. Terrestrial predator control (ungulates, cats, rodents, barn owls, feral bees) will occur in all of the conservation site outside the predator exclusion fenced area for the duration of the 50-year permit term.

Honopū

- Predator exclusion fence (approximately 3.3 acres [1.3 hectares]) around a social attraction site (i.e., Honopū PF). Predators will be eradicated within the fenced area.
- Remainder of 239-acre (97-hectare) conservation site is protected by a partial pig fence. Terrestrial predator control (ungulates, cats, rodents, barn owls, feral bees) will occur in all of the conservation site outside the predator exclusion fenced area for the duration of the 50-year permit term.

Pihea

- Partial pig fence at this conservation site.
- Terrestrial predator control (ungulates, cats, rodents, barn owls, feral bees) will occur throughout the entire 515-acre (208-hectare) conservation site for the duration of the 50-year permit term.

Hanakoa

- No fencing on any kind at this conservation site.
- Terrestrial predator control (ungulates, cats, rodents, barn owls, feral bees) will occur throughout the entire 186-acre (75-hectare) conservation site for the duration of the 50-year permit term.

Hanakāpi'ai

- No fencing on any kind at this conservation site.
- Terrestrial predator control (ungulates, cats, rodents, barn owls, feral bees) will occur throughout the entire 187-acre (76-hectare) conservation site for the duration of the 50-year permit term.

Conservation Site 10

- Predator exclusion fence of unknown size around a social attraction site. Predators will be eradicated within the fenced area.
- Remainder of the conservation site will have no fencing. Terrestrial predator control (ungulates, cats, rodents, barn owls, feral bees) will occur in the unfenced conservation site for the duration of the 50-year permit term.

Barn Owl Control

Barn owls are the only introduced owl in the state of Hawai'i. Barn owls are known to be significant predators of Newell's shearwater ('a'o), Hawaiian petrel ('ua'u), and band-rumped storm-petrel ('akē'akē) on Kaua'i (Raine et al. 2017c, 2019b). Barn owls can have multiple clutches in a year and produce large broods (del Hoyo et al. 1999), far outpacing the number of fledglings produced by the covered seabird species annually. In addition, barn owls are difficult to control because they have large home ranges and the capacity to kill large numbers of seabirds in a short period of time (Raine et al. 2019b). In a study by Raine et al. (2019b) where barn owl depredations were recorded between January 2011 and October 2018 across nine study sites, barn owls depredated 379 seabirds, of which 13 were Newell's shearwaters ('a'o) and eight were Hawaiian petrels ('ua'u). These numbers are likely an underestimate of the actual amount of barn owl depredation given that barn owls often transport their prey to other locations before feeding (Raine et al. 2019b).

The Raine et al. (2019b) study also found that barn owl control measures, when implemented in a concentrated and systematic fashion, can significantly decrease seabird depredations. Barn owl control will occur at all of the conservation sites to reduce further predation of the covered seabird species and increase reproductive success. This will be particularly important in areas where social attraction will be performed because playing a recording of a seabird call will not only attract the target seabird but will also attract hunting barn owls.

Barn owl control methods will include targeted trapping and hunting and will occur in areas where barn owls or sign of barn owls (e.g., pellets, feathers) have been observed either incidentally or through the monitoring program (Chapter 6, *Monitoring and Adaptive Management Program*). All field crew members will be trained to identify a barn owl to prevent adverse effects on the only other owl on Kaua'i, a Hawaiian endemic subspecies of the short-eared owl (pueo) (*Asio flammeus sandwichensis*) that co-occurs with barn owl.[17] Barn owl control will reduce predation of covered seabirds within the conservation sites as well as outside of the conservation sites. Barn owl control is already well established at the conservation sites: Upper Limahuli, North Bog, Pihea, Hanakāpi'ai, Hanakoa, and Pōhākea (Kaua'i Island Utility Cooperative 2019).

Invasive Bee Control

Feral European honeybees (*Apis mellifera*) have been found to be a conservation issue for endangered seabirds breeding in the Hawaiian Islands (Raine and McFarland. 2015). Feral European honeybees (feral bees) are often defined as descendants of domesticated European honeybees that have escaped managed colonies and establish self-sustaining wild colonies. Feral bees have been responsible for the takeover of active breeding burrows of both Newell's shearwater ('a'o) and Hawaiian petrel ('ua'u) at most of the management sites on Kaua'i, as well as on Lāna'i, resulting in abandonment of the burrow, and even mortality of adults and chicks due to bee sting (Raine pers. comm. [b]).

Whenever a burrow is found with an active beehive, the feral bees will be vacuumed out using specialized equipment and the honeycomb inside extracted. Every effort will be made to do this soon after the takeover is discovered, to increase the chance that the burrow will not fail, reduce the chances of mortality of visiting adults, and reduce the chance of more burrows being taken over nearby once the beehive splits. Furthermore, feral beehives that are located incidentally during other management and monitoring activities will also be actively removed using the same technique, to protect the birds as well as fieldworkers in the area.

Predator Exclusion Fencing

Predator exclusion fencing for the purposes of this HCP is defined as constructing fences that are impenetrable to most introduced terrestrial predators including feral cats (*Felis catus*), rats (*Rattus* spp.), pigs [*Sus scrofa*], and goats [*Capra hircus*]). Deer (*Odocoileus hemionus*) can jump over these fences but will be managed if they are documented in the conservation sites. Predator exclusion fencing supplements terrestrial predator control, which can be highly effective in and of itself, further reducing predation events. Predator exclusion fencing has proven to be an effective means of multi-species predator control for seabird colonies in Hawai'i (Day and MacGibbon 2002; Young et al. 2012, 2013; VanderWerf and Young 2014; Tanentzap and Lloyd 2017). Once a predator exclusion fence is built, all target predators must be eradicated within the fence. After predator eradication, traps will be placed along the boundary of the fence to further limit the potential for predators to reenter the fenced area. Barn owl control would continue within the predator exclusion fenced area.

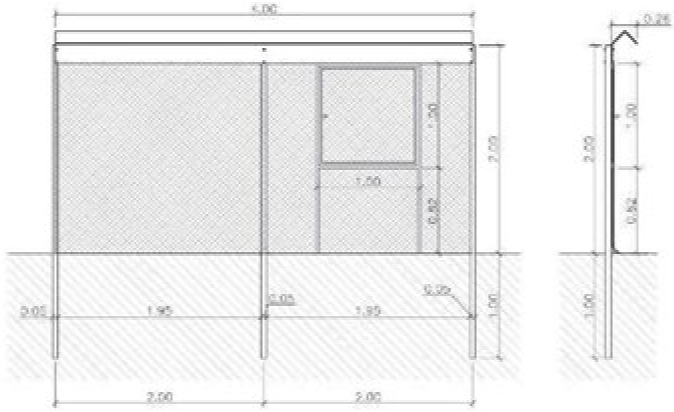
[17] Although barn owl and short-eared owl (pueo) occur in the same habitat, barn owls are nocturnal while short-eared owls (pueo) are diurnal, minimizing the potential for both species to be active at the same time.

There will be four predator exclusion fences included as part of the conservation strategy for the KIUC HCP. Two small predator exclusion fences will be in place before the start of the permit term in the Pōhākea and Honopū conservation sites. KIUC will eradicate all predators and initiate social attraction by no later than the end of Year 1 of the permit term. Both fences were constructed by DOFAW and DOFAW's partners and KIUC will take control of management and maintenance of these fences during the first year of the permit term (2023). KIUC will construct two additional predator exclusion fences within the Upper Limahuli Preserve and Conservation Site 10 conservation sites by 2025.

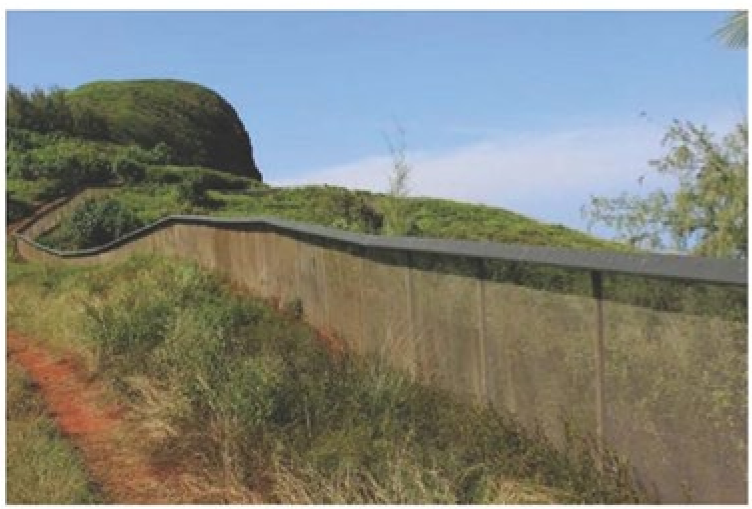
As described above under *Predator Control*, other types of predator fences are present in the conservation sites, constructed and maintained by other entities, that either partially or entirely surrounds those conservation sites. Although KIUC did not construct these fences and will not be responsible for their maintenance, they will benefit the covered seabird species within those six HCP conservation sites.

Fencing Specifications

For a fence to be capable of excluding all terrestrial predators, it must meet the following four biosecurity criteria: (1) be sufficiently high that animals cannot jump over it; (2) have a V-shaped hood on top to prevent animals from climbing over it; (3) use small-aperture mesh to prevent animals from squeezing through; and (4) include an underground skirt to prevent animals from digging underneath it (Figure 4-7). Once the fence is constructed and predators are eradicated within the fence, the protected seabird colonies will be inaccessible to terrestrial predators. This will eliminate the threat of terrestrial predator reinvasion into the protected seabird colonies, as long as the fencing remains in good condition.



SOURCE: Pacific Rim Conservation 2017



SOURCE: Young and Eric VanderWerf 2016

Figure 4-7. Predator Exclusion Fencing Design

To achieve these four biosecurity criteria, all predator exclusion fencing will conform to the following specifications (Young and VanderWerf 2014).

- Height[18] of 6.6 feet (2 m) with a 6.6-foot (2-m) buffer immediately on either side of the fence clear of rocks, structures, or trees. These fences will be the same height as other DOFAW-constructed predator exclusion fences on Kauaʻi.
- Fence base or frame constructed using 8.8-foot-long (2.7-m) posts spaced at approximately 6.6-foot (2-m) intervals along the fence length. Spacing in areas of high winds along ridge lines should be closer together.
- Single-strand wires tensioned to 330 pounds (150 kilograms) horizontally between the posts of poles.
- No fence corner should turn more sharply than 45 degrees.
- No gaps greater than 0.3 inch (7 millimeters [mm]), including the mesh.
- A 1-foot-long (30-centimeter [cm]) taut mesh skirt will be secured to the ground with pins or cement and buried to a depth of approximately 4 inches (10 cm).
- All fence materials will be made of marine-grade "316" stainless steel to minimize rusting and corrosion. The face of the fence and the horizontal skirt would have an aperture no larger than 0.5 inch by 0.5 inch (13 mm by 13 mm).
- A V-shaped, cat-proof hood will be installed on top and on the outside of the fence to allow animals to jump out of the enclosure but not to jump inside.
- Single half-door design lockable pedestrian access gates will be located along the fence edge that do not extend to ground level. Pedestrian gates will be installed every 1,640–3,281 feet (500–1,000 m). Gates will be constructed so they can be padlocked to prevent trespass.
- Fences will be continuous except across streams, rivers, pools, and other drainageways.[19] Where there is a fencing gap due to a drainage, two parallel fences will be installed to create a containment zone on both sides of the gap. The fence sections immediately above the drainage will be constructed as break-away panels that are not as tightly fastened to the rest of the fence so that in the event a large flood damages the fence, it would only damage these small, replaceable sections.
- Cliff-face tie-ins may be necessary to secure fencing to cliffs.[20]
- To the extent practicable, fences will avoid the need for culverts by using waterfalls and other topographic features for closure instead. In the event that culverts become necessary, all culverts, drainage pipes, and other water channels should pass under the fence in a pest-proof manner and would have the outside entrance to the culvert sealed with a pest-proof culvert screen.

[18] Height is measured from a point 3.3 feet (1 m) out from the base of the fence, representing the likely jumping position of a cat, vertically to the top of the fence (i.e., the highest point of the hood).

[19] Generally, this means a small gap at the top of a high (greater than 20 feet [6.1 m]) waterfall and/or a small gap at a pool immediately above the waterfall.

[20] If cliff-face tie-ins are deemed necessary, that portion of the fence line will be constructed outside the nesting season (i.e., from December to April) to avoid adverse impacts on occupied burrows.

- Earthwork will be kept to a minimum. Fence post holes will be roughly 3.3 feet (1 m) deep and soil or fill will be used to form a gentle mound along the fence alignment so that stormwater will not pass through the fence.
- Fencing must be constructed in locations where extensive vegetation does not overhang the fence or where vegetation can be controlled to prevent encroachment and overhanging.
- Fence construction must not damage or destroy threatened or endangered plants or habitat for any listed species (Appendix 1A, *Evaluation of Species Considered for Coverage*, Attachment 1 for required avoidance measures for Hawaiian hoary bat [‘ōpe‘ape‘a] [*Lasiurus cinereus semotus*], Attachment 2 for avoidance measures for listed plants).
- Fencing must be constructed in locations where human access is possible on both sides of the fence for patrols, monitoring, and fence repair.
- Fencing must be constructed in locations accessible by helicopter to ferry staff, equipment, and materials.

Each predator exclusion fence will be constructed in the following stages: (1) vegetation removal from a 13-foot-wide (4-m-wide) swath along the fence alignment; (2) necessary earthwork; (3) base fence erection; (4) attachment of mesh; (5) attachment of a cat-proof hood; and (6) installation of access components. The fencing crew and fencing materials will be transported to the site either by vehicle, helicopter, or both, which typically takes between 90 and 120 days. Construction of the predator exclusion fences at the Upper Limahuli Preserve and Conservation Site 10 conservation sites is expected to be completed by 2024 to 2025 (Young pers. comm.) (*Interim Management Actions* provides more details on construction schedule).

Replacement of the predator exclusion fence is not expected in its entirety during the 50-year permit term. However, segments of the fence may need to be replaced (especially after large storm events that knock down trees or cause landslides). Replacement of fencing segments would entail the same activities as are required for the initial installation as well as the removal and disposal of damaged fencing materials. The replaced segments would be built to meet the same four biosecurity criteria and with the same specifications as the original fence.

There are a number of factors that can constrain the construction of predator exclusion fences within a conservation site. Large sites with steep valleys, dense vegetation, drainages, or crumbling/friable substrate can make predator exclusion fencing very challenging or impracticable. In combination with the high level of infrastructure required for a fence to completely exclude terrestrial predators, these factors may physically prohibit achieving total terrestrial predator exclusion.

To minimize the likelihood of rats stowing away in materials transported into the fenced predator exclusion areas by helicopter, all gear that is to be transported to a conservation site will be packed in an area free of rodents and inspected prior to loading into the helicopter. In addition, traps will be placed in two concentric rings of four traps approximately 33 feet (10 m) and 66 feet (20 m) from each other around helicopter landing zones.

Fence Condition

KIUC will maintain the condition of the terrestrial predator exclusion fencing over the 50-year permit term. KIUC will be responsible for assessing the condition of each predator exclusion fence throughout the permit term according to the following schedule to avoid fence breaches. Acts of nature, accidents, and vandalism are likely to damage the fence over time. Therefore, it is essential to have an effective assessment, maintenance, and repair program to minimize and address fence damage as soon as practicable. If breaches occur, rapid response will be targeted to specific species that have invaded the site. Cat and rodent traps will be purchased in year one of the permit term and kept in reserve for rapid response in the event of a breach.

The following fence assessment schedule is designed to: (1) detect damage quickly after it occurs; (2) ensure that people and resources are available so that emergency repairs can be made in a timely fashion; and (3) that if any predators permeate the fence boundary, they are limited to a small area and removed as quickly as practicable.

- Opportunistic observations of the fence during every trip into and out of a conservation site on helicopters.
- Opportunistic observations of the fence condition when working within the conservation site on other tasks.
- Once a month, in the course of accessing a conservation site via helicopter, fly along the fence alignment and record observations concerning fence condition. This will be done during flights when the weather conditions allow and as soon as practicable after significant storm events (i.e., tropical storms or hurricanes for which the National Weather Service issues warnings for Kauaʻi). If any issues are noted from the air, the fence section in question will be inspected by the ground crew as soon as practicable following the observation.
- Every 3 months, personnel will walk the entire length of the fence on both sides and inspect it for breaches or deterioration.
- Inspections in high-risk areas (e.g., near cliffs, large trees, or streams) as soon as reasonably and safely practicable, following storm events.
- In the event of a predator incursion from an unidentified breach, the fence will also be inspected.

KIUC will have people and resources in place to make emergency repairs, thereby reducing the likelihood of predator expansion if a breach occurs. This will be achieved as follows.

- A single individual designated as the primary point of contact and made responsible for scheduling maintenance and monitoring visits and receiving/acting on reports of a breach or any other relevant observations on the fence.
- An annual risk analysis to identify possible areas of weakness.
- Signs placed at high-risk areas and access points that provide contact information for whom to call in the event that a breach is noticed.
- Fence repair supplies stored near high-risk areas to facilitate efficient repairs.

Social Attraction

More than 95 percent of seabirds are colonial (including the covered seabird species), which means they are attracted to breeding sites by the presence of individuals of the same species and other seabird species (Jones and Kress 2012). Social attraction is a technique that uses attractive social stimuli, generally the sight and sound of the same species, to promote nest initiation by colonial seabirds. Social attraction is used on sites that currently lack social cues but otherwise the location is suitable for nesting (Jones and Kress 2012). Because of their nocturnal flight behavior, acoustical rather than visual techniques are considered to be the most successful means of attracting the covered seabirds as they fly over or near suitable habitat (Miskelly et al. 2009; Young et al. 2019; Raine et al. 2019a). If successful, the strategy can result in relatively high productivity within a small area (Young et al. 2019).

Social attraction using acoustical playbacks in combination with artificial burrows and invasive plant species removal, is a proven method to establish new or enhance existing colonies of burrow-nesting seabirds (Gummer 2003; Sawyer and Fogle 2010; McIver et al. 2016; U.S. Fish and Wildlife Service 2016). For example, Newell's shearwater ('a'o) have nested at the Kīlauea Point National Wildlife Refuge on Kaua'i for over 10 years, due to a combination of an egg swap project coupled with social attraction (Byrd et al. 1984; Raine et al. 2021). Artificial burrows are used to increase nesting density and to eliminate the time a seabird would normally spend digging a burrow to accelerate breeding (Raine et al. 2021b).

Social attraction will only be implemented within predator exclusion fencing (at four conservation sites) because the fencing will eliminate the threat of predation, increasing the site's carrying capacity and potential for colony expansion or creation (i.e., successful social attraction). Social attraction techniques will be used to expand existing colonies and establish new colonies in the conservation sites within otherwise suitable breeding habitat. The methods for social attraction include vegetation clearing, broadcast calls, and artificial burrows using the following three steps.

- **Step 1. Restore targeted habitat to be suitable for nesting.** This step involves removing unsuitable vegetation (e.g., guinea grass [*Megathyrsus maximum*]) from an area at least 1 acre (0.4 hectare) in size and planting suitable native species such as false staghorn fern (uluhe) (*Dicranopteris linearis*). Selected locations should be large enough that they can be incrementally restored and expanded over time to increase the colonies' productivity.
- **Step 2. Install artificial burrows.** Artificial seabird burrows consist of wooden boxes with open bottoms, removable lids, and plastic tunnels for burrow entrances. They are very durable and strong enough to resist warping or physical damage from trampling, tree-fall, and rock-fall in most circumstances, especially when buried in soil substrate. The lids provide easy access and the modular tunnel component can be cut to any length and include turns to keep out light. The artificial burrows are placed in holes dug to half the height of the burrow (if the site does not allow holes to be dug to the desired depth, then the burrow is covered with sand). Burrows are then painted with reflective paint and the lid weighed down with a sand bag—this, coupled with planting native shade plants around the burrows, minimizes the threat of overheating in the burrow chamber.
- **Step 3. Install social attraction equipment.** A solar-powered sound system is installed in the social attraction site to broadcast calls over the restored habitat with the artificial burrows.

As stated in *Predator Exclusion Fencing*, there will be four predator exclusion fences in place in the conservation sites by 2025 at the Upper Limahuli Preserve, Conservation Site 10, Pōhākea PF, and Honopū PF conservation sites. Upper Limahuli Preserve, Conservation Site 10, and Pōhākea PF are social attraction sites for Newell's shearwater ('a'o), while the Honopū social attraction site will primarily target Newell's shearwater ('a'o) and band-rumped storm-petrel ('akē'akē) due to its location adjacent to the cliffs of Honopū Valley.

Invasive Plant Species Management

Invasive plant species can degrade covered seabird nesting habitat across the state (Young et al. 2018). Invasive plant species displace and out-compete native vegetation, which alters vegetation composition and structure (Simberloff et al. 2013; VanZandt et al. 2014) and can make nesting burrows inaccessible by the covered seabirds (Raine pers. comm (a).). Significant colony reduction has been recorded in several historical colonies on Kauaʻi due to multiple reasons, including the rapid spread of invasive plant species (e.g., at Kalāheo, Makaleha, Wailua; based on Kauaʻi Endangered Seabird Recovery Project unpublished data).

The following list of species are those on Kauaʻi that have been identified as the chief invasive plant species to remove from the Upper Limahuli Preserve because of their rapid growth and capability to significantly alter forest structure and understory and thus degrade covered seabird habitat (Raine pers. comm.). Appendix 4C, *Invasive Plant Species Control Methods*, provides a full list of species.

- Australian tree fern (*Sphaeropteris cooperi*)
- Strawberry guava (*Psidium cattleianum*)
- Himalayan ginger (kāhili ginger) (*Hedychium garderianum*)
- Octopus tree (*Schefflera actinophylla*)
- Pink melastome (*Melastoma candidum*)
- African tulip (*Spathodea campanulata*)
- Passion fruit (*Passiflora* spp.)

KIUC will fund continual invasive plant species management focused on the list of species in Appendix 4C, *Invasive Plant Species Control Methods*, within the Upper Limahuli Preserve and the four social attraction sites (including a 30-foot perimeter around the outside of the predator exclusion fences). Invasive plant species control will occur in the other conservation sites on an as-needed basis, when observed and documented during monitoring and determined to be spreading or otherwise problematic (Chapter 6, *Monitoring and Adaptive Management Program*). Invasive plant species control methods will include cutting, digging, and herbicide application consistent with best management practices developed by the National Tropical Botanical Garden and others involved in the control of these species in the wet upland forests of Kauaʻi (Appendix 4C, *Invasive Plant Species Control Methods*). The methods will be updated as deemed necessary to allow the use of more cost-effective techniques and products if they become available. Invasive plant species control must not damage or destroy threatened or endangered plants or habitat for any listed species (Appendix 1A, *Evaluation of Species Considered for Coverage*, Attachment 1 for required avoidance measures for Hawaiian hoary bat [ʻōpeʻapeʻa]; Attachment 2 for avoidance measures for listed plants).

Interim Management Actions

KIUC has been conducting some of the management actions included under this conservation measure within some of the conservation sites. These management actions occurred both during implementation of the Short-Term HCP (counted as 2011–2019) and since then (counted as 2020–2022) to prepare for implementation of this HCP. KIUC has been funding extensive predator control within the Upper Limahuli, North Bog, Pihea, and Pōhākea conservation sites since 2011. Invasive plant species control has been partially funded by KIUC since 2011 in the Upper Limahuli Preserve conservation site. KIUC's ongoing management (and, in some cases, long history of management) illustrates the practicability of these conservation measures and the fact that the protocols and specifications described in this conservation measure have been applied, tested, and refined for many years.

In addition, KIUC has been planning and preparing (e.g., surveys, design, permitting) for installation of the predator exclusion fence at the Upper Limahuli Preserve conservation site. KIUC expects construction of the Upper Limahuli Preserve and Conservation Site 10 conservation site fences will be completed by 2024–2025. Regular monitoring and maintenance will be conducted to maintain the condition of the terrestrial predator exclusion fencing over the 50-year permit term (Chapter 6, *Monitoring and Adaptive Management Program*).

Management Timing to Minimize Effects on Covered Seabirds

KIUC and its contractors will implement all management actions (i.e., predator control, construction of predator exclusion fences, invasive bee control, social attraction, and invasive plant species management) within protected conservation sites that contain nesting colonies of the covered seabird species (Table 4-5, Figure 4-6) in ways that minimize effects on the covered seabirds. Certain management actions that could disturb nesting seabirds (e.g., construction of predator exclusion fences) can be implemented from December to March, which is outside of the nesting season (April to mid-December) while the covered seabirds are at sea. In other cases, actions such as social attraction will be performed during the nesting season with protocols in place to limit disturbance as much as practicable.

Other activities such as infrastructure maintenance and inspections and site preparations (e.g., weatherport or fence maintenance) will also be performed outside of the nesting season, whenever practicable. Certain predator control activities can likely occur outside of the nesting season to minimize impacts on the covered seabird species; however, the primary predator control activities must occur within an active colony in order to be effective in protecting seabirds from ongoing threat of depredation in areas where predator exclusion fencing is not present.

KIUC and its contractors will decide on a case-by-case basis if the location where the conservation measure will be implemented is close enough to a breeding colony to disturb it. Some fencing segments may be far enough from the breeding colony within the conservation site that it can be completed at any time of year.

4.4.5 Conservation Measure 5. Implement a Green Sea Turtle Nest Detection and Temporary Shielding Program

This conservation measure describes the nest detection and shielding program that KIUC will implement to minimize and offset the effects of light attraction from KIUC streetlights. This action will meet the green sea turtle (honu) biological goals and objectives. The nest detection and shielding program will be implemented throughout the entire 50-year permit term at locations visually affected by KIUC streetlights. However, if KIUC demonstrates to the satisfaction of USFWS, DOFAW, and DAR that they have avoided take of green sea turtle (honu) through permanent modification of existing target streetlights, then KIUC would no longer need to implement nest shielding (Section 4.4.5.4, *Program Duration*).

4.4.5.1 Nest Detection

Protecting green sea turtle (honu) hatchlings from light disorientation first requires determining which KIUC streetlights are visible from suitable nesting habitat and then locating active nests (i.e., nests at which eggs are present or thought to be present) on those beaches before hatching occurs. There is currently no formal program on Kauaʻi to detect, mark,[21] and protect sea turtle nests.

To detect all green sea turtle (honu) nests at risk of light disorientation from KIUC streetlights, KIUC will establish a nest detection program using drone surveys and/or a network of volunteers led by a project coordinator. Monitoring may occur with or without the use of drones, depending on what method is determined most suitable during implementation.

On an annual basis, KIUC will first survey all beaches in the Plan Area with suitable green sea turtle (honu) nesting habitat and KIUC streetlights between March 1 and April 30 to identify locations where KIUC streetlights are visible from the surface of the beach. Once identified, nest detection surveys are required in those locations between May 15 and December 15. Surveys will include all sandy areas visually affected by KIUC streetlights to look for evidence of nesting (e.g., turtle tracks, digging, presence of turtles). Surveys should be completed at least once per week during peak nesting season (May through July) and bi-weekly for the remainder of the nesting season (August to December).

The following sections provide an overview of the green sea turtle (honu) nest detection program; further details are provided in Chapter 6, *Monitoring and Adaptive Management Program*.

Drone Surveys

Drones may be utilized to monitor all accessible Plan Area beaches with suitable nesting habitat for green sea turtle (honu) that may be visually affected by KIUC streetlights on an annual basis (May 15 through December 15). The drone surveys may occur at all accessible Plan Area beaches and the data will be included with island-wide data on the timing, extent, and trends of green sea turtle (honu) nesting.

There are multiple steps required for drone operations, including the following.

- Identify drone no-fly zones on Kauaʻi.
- Conduct required training and licensing for drone operators.
- Purchase equipment (primary and backup) and procure storage space for equipment/supplies, and drone footage.
- Identify safe and accessible drone launch areas for maximum beach coverage that also avoid no-fly zones.
- Finalize data and information transfer protocols from drone flights to project coordinator to inform subsequent site visits (ground truthing) by field volunteers.

If drones are utilized, KIUC's funding will be used to purchase the materials (e.g., drones, vehicle) necessary for the drone surveys. The drone surveys would require two field staff; one staff member

[21] Marking nests may not be appropriate in all situations because it may draw attention to the nest and lead to vandalism. Nest marking will be determined on a case-by-case basis depending on nest location.

to set up, manage data, and serve as a back-up operator, and the second staff member to operate the drone during the green sea turtle (honu) nesting season.

Volunteer Monitoring Program

A volunteer monitoring program will also operate between May 15 and December 15 to supplement the drone surveys. This program will be modeled after Kauaʻi's Hawaiian monk seal (ʻilio holo i ka uaua) (*Neomonachus schauinslandi*) volunteer network that is organized and managed by the DLNR DAR Protected Species biologist on the island. The purposes of the volunteer monitoring program will be to do the following.

- Conduct monitoring surveys in areas where drone surveys are not permitted or not practicable to detect possible active nests of green sea turtle (honu).
- Visit all nesting sites identified during drone surveys to field verify them and determine if the nests are active.
- Nightly, monitor active nests that are in view of KIUC streetlights starting within 15 days of estimated emergence.

The volunteer monitoring program is expected to require one full-time project coordinator. Network set-up, training, scheduling, and oversight will be provided by the project coordinator.

Once an active nest is confirmed through the volunteer monitoring program, the volunteer coordinator will work with KIUC to determine if the nest is within view of any KIUC streetlights. Each nest will be visited after dark (as soon as possible following its discovery) when the streetlights are illuminated to determine whether any KIUC streetlight can be observed near the surface of the nest location. The monitor will stand behind the nest at the sand surface to see if KIUC streetlights are visible. If they are not visible, the monitor will note the reason why (e.g., vegetation or buildings blocking the light, light too far away or at an angle where it cannot be seen). The monitor will note if the luminaire face (i.e., the portion of the head from which light emanates—the very bright point-source of the light) itself is directly visible from the nest location. Photographs will be taken from the nest location facing the streetlights and from the streetlights facing the nesting location for inclusion in the annual report.

For active nests that require shielding, volunteers will estimate the age of the nest. KIUC will submit this information to USFWS, DOFAW, and DAR within 30 days of nest discovery for their review.

4.4.5.2 Shield Active Nests from Streetlights

Program staff will shield all active green sea turtle (honu) nests that have any potential to be at risk of light impacts from KIUC streetlights using the protocols described in this section. The monitor will be conservative in their streetlight assessment and assume that any nest with even a low potential to be affected by a KIUC streetlight will require shielding.

In 2020, KIUC conducted a field assessment of all its coastal streetlights and identified 29 streetlights that are visible from the following seven beaches (Figures 4-8a through 4-8g).

- Two streetlights at Keālia Beach (Figure 4-8a)
- Four streetlights at Kapaʻa Shoreline (Figure 4-8b)

- Seven streetlights at Wailua Beach[22] (Figure 4-8c)
- Three streetlights at Poʻipū Shoreline (two on Figure 4-8d and one on Figure 4-8e)
- Three streetlights at Kukuiʻula Harbor (Figure 4-8e)
- Three streetlights at Waimea Shoreline (Figure 4-8f)
- Seven streetlights at Kekaha Shoreline (Figure 4-8g)

Program staff will, at a minimum, install nest shielding on these seven beaches when active green sea turtle (honu) nests are detected (see Section 4.4.5.1, *Nest Detection*). However, nest shielding is expected to be necessary at additional Plan Area beaches during the 50-year permit term if changes in environmental conditions[23] expose nesting habitat to light from additional existing streetlights or from new streetlights installed in coastal areas. In contrast, some beaches at which green sea turtle (honu) nests are shielded may be removed from the program if conditions change to eliminate light attraction risk (e.g., vegetation growth, new structures, beach erosion). As stated above under Section 4.4.5.1, *Nest Detection*, KIUC will survey all suitable habitat within the Plan Area on an annual basis to identify these environmental changes and expand or decrease nest shielding as necessary to respond to the changes. Changes to monitored beach locations require consultation with USFWS, DOFAW, and DAR, as described in Section 6.2.2, *Adaptive Management*.

Program staff will install light-proof fencing (Witherington et al. 2014; Witherington and Martin 2003), which is a small, removable light-proof silt fence made of wooden stakes and opaque black silt fence fabric. The light-proof fence will be erected around the nest after approximately 45 days of incubation to minimize the potential for vandalism. The following barrier technique is recommended wherever light visibility from the nests, as visible from the sand surface, cannot be eliminated or shielded at the light source.

1. The fence must be tall enough to shield the active nest site from lights from nearby streetlights.
2. Photographs and GPS coordinates of each green sea turtle (honu) nest will be documented.
3. The fence will be placed approximately 15 days prior to the expected emergence date, or when a sandy depression is visible within the defined nest area, to indicate hatchlings are in the process of emerging. Placement must be approved by a qualified biologist (e.g., DAR, National Marine Fisheries Service, DOFAW, USFWS, biological consultant).
4. Photographs of lights at night from the nest surface before and after the fence installation will be taken to confirm the effectiveness of the fence shield.
5. The fence will be in place and maintained daily prior to hatchling emergence to be effective. Adjustments to the fence may be made with approval of a qualified biologist.
6. If hatchlings move beyond the barrier into view of the light source and deviate from a path directly towards the ocean they will be captured and returned to the sheltered path by a permitted biologist.

[22] In 2020, beach erosion removed most of the suitable habitat for green sea turtle (honu) below the high tide line at Wailua Beach. As such, the current condition of the beach has limited suitability for nesting sea turtles but these lights are identified in the event that the habitat becomes more suitable in the future.

[23] Changes that may affect which green sea turtle (honu) nesting habitat is exposed to lights from streetlights may include vegetation clearing, vegetation damage from storms, construction of structures, demolition of structures, beach erosion, or beach accretion.

After the green sea turtle (honu) hatchlings have emerged and entered the ocean, a permitted biologist will remove the fence. The permitted biologist will then be responsible for nest excavation following the *Standard Research Protocols for Nesting and Basking Marine Turtles in the Pacific Region* (U.S. Fish and Wildlife Service and National Oceanic and Atmospheric Administration 2019) (or another accepted protocol during the 50-year permit term) to confirm the species and determine hatching and emergent success. The permitted biologist will also send any remaining unhatched eggs, deceased hatchlings, or samples (training required) of eggs or deceased hatchlings to the National Oceanic and Atmospheric Administration for DNA analysis.

Figure 4-8a. Streetlights Visible from Green Sea Turtle Nesting Habitat at Keālia Beach in 2020

Figure 4-8b. Streetlights Visible from Green Sea Turtle (honu) Nesting Habitat at Kapaʻa Shoreline in 2020

Figure 4-8c. Streetlights Visible from Green Sea Turtle (honu) Nesting Habitat at Wailua Beach in 2020

Figure 4-8d. Streetlights Visible from Green Sea Turtle (honu) Nesting Habitat at Po'ipū Shoreline in 2020

Figure 4-8e. Streetlights Visible from Green Sea Turtle (honu) Nesting Habitat at Kukuiʻula Harbor and Poʻipū Shoreline in 2020

Figure 4-8f. Streetlights Visible from Green Sea Turtle (honu) Nesting Habitat at Waimea Shoreline in 2020

Figure 4-8g. Streetlights Visible from Green Sea Turtle (honu) Nesting Habitat at Kekaha Shoreline in 2020

4.4.5.3 Monitoring Schedule

The green sea turtle (honu) monitoring schedule was developed to increase the frequency of site visits as a nest approaches its estimated hatching date. The objective for increasing the monitoring frequency over time as the nest incubates is to ensure that the monitor is present at the time of hatching to record the outcome and rescue any hatchlings that head away from the shoreline. The following list outlines the monitoring schedule to ensure that monitoring starts as soon as an active nest is located and determined to be at risk of light disorientation from a KIUC streetlight.

- Initially, active nests will be visited every other day to check their status (e.g., was it washed away by a king tide, was it run over by a vehicle).
- Within 15 days of the estimated hatching date, nests will be visited daily to check for signs of emergence (at which time the temporary light shield will also be installed in anticipation of hatching).
- Within 5 days of the estimated hatching date (assuming a green sea turtle [honu] nest emerges approximately 2 months after egg laying [Seminoff et al. 2015]), monitored nests will be visited twice per day, once during the daytime and once after dark.

If the monitor is not present at the time of emergence, monitors will record (including photographs to supplement the written documentation) the direction and distance of all hatchling tracks away from the nest and search for any evidence of hatchling mortality that may have resulted from disorientation.

Evidence of emergence and take (if any occurs) will be reported to USFWS, DOFAW, and DAR within 24 hours. USFWS, DOFAW, DAR, or their designee will then be responsible for final nest excavation to determine species, proportion of eggs that hatched and to send remaining eggs to the National Oceanic and Atmospheric Administration for DNA analysis. Any take of a green sea turtle (honu) hatchlings (Chapter 5, Section 5.5, *Effects on Green Sea Turtle (honu)*) will be counted on an annual basis based on the results of that year's monitoring program.

4.4.5.4 Program Duration

KIUC will fund and implement this conservation measure throughout the 50-year permit term or until such time as KIUC modifies all the streetlights potentially affecting nesting green sea turtle (honu) habitat to eliminate these effects. If KIUC modifies all the streetlights identified as a risk to green sea turtle (honu) habitat[24] consistent with Conservation Measure 6 (Section 4.4.6, *Conservation Measure 6. Identify and Implement Practicable Streetlight Minimization Techniques for Green Sea Turtle*) to eliminate light attraction of green sea turtle (honu), and commits to continue to modify both new streetlights and additional existing streetlights that become exposed (e.g., vegetation removal) in the same manner, then KIUC will no longer be required to fund the installation of temporary light shields under this conservation measure after consultation with USFWS, DOFAW, and DAR (Chapter 6, Section 6.2.2, *Adaptive Management*). However, nest detection and nest monitoring on beaches exposed to existing streetlights will continue for a period of 5 years after the installation of the streetlight retrofits to determine their effectiveness. If nest monitoring

[24] There are 29 streetlights currently identified as a risk, but this number may go up or down depending on environmental conditions at these locations.

determines that the permanent light minimization techniques are not effective, this will be addressed through the HCP's adaptive management program.

In addition, KIUC will continue to fund the nest detection and temporary shielding program required under this conservation measure throughout the permit term to identify locations where beach conditions change, resulting in non-minimized streetlights casting light onto suitable green sea turtle (honu) habitat. These additional streetlights will either be modified to eliminate light attraction of green sea turtle (honu), or active nests will be temporarily shielded in these locations consistent with this conservation measure.

4.4.5.5 Annual Training and Reporting

All staff and volunteers will be required to complete annual training provided by USFWS, DAR, or trainers approved by USFWS and DAR. This training will allow them to recognize and differentiate green sea turtle (honu) tracks, signs of nesting, and hatchling activity from other sea turtle species, as well as the proper techniques for installing temporary light shields. The training will also discuss timing of nesting and hatching, other green sea turtle (honu) behaviors that might be observed, and law protecting green sea turtles (honu) when they are on land (State of Hawaiʻi Division of Forestry and Wildlife 2020). KIUC will provide information on the approach and protocol for the streetlight assessment and will provide staff and volunteers with data collection forms to use in the field.

KIUC will develop a data collection form for the monitoring program, which will also be included in the annual report. KIUC will develop a standardized data collection form for use during green sea turtle (honu) monitoring that will ensure that all necessary information is collected by green sea turtle (honu) monitors, so that it can be reported accurately in the annual report. The data collection forms will include the following information, which has been adapted from the Kauaʻi Seabird Habitat Conservation Plan (State of Hawaiʻi Division of Forestry and Wildlife 2020).

- Date, weather conditions, personnel surveying, time spent on survey.
- Names of beaches monitored, and length of beach surveyed.
- Number of nests found.
- Assessment of potential threats at the nest, including light visibility from nest.
- Status of light shield (i.e., if installed, for future streetlights).
- Evidence of hatchling emergence and condition of the nest area (description and photos).
- Date and time of emergence.
- Direction of tracks.
- Hatchling emergence success as determined by final nest excavation.

KIUC will report the number and location of beaches surveyed (including which were surveyed via drones or on foot), the number of active nests identified at each location, the light attraction risk assessment for each nest, the number and location of shielded nests, and the hatching success and outcome for each nest (number of hatchlings that made it out of the nest and to the ocean), including the level of shielding effectiveness. In addition, if any active nests are missed by the monitoring program and if any resulting take occurs that can be attributed to KIUC streetlights, KIUC will also report these incidents as soon as possible to USFWS, DOFAW, DAR, and in the annual report.

KIUC will also create a map for each annual report showing the locations of all of beaches surveyed and active nests detected during the green sea turtle (honu) nesting season, lights visible from the beach, and identify which nests were shielded. Nests will be mapped with a GPS unit to accurately map their locations.

4.4.6 Conservation Measure 6. Identify and Implement Practicable Streetlight Minimization Techniques for Green Sea Turtle

As described in Conservation Measure 2, in 2017 KIUC retrofitted all streetlights on Kaua'i with full-cutoff shielded fixtures to direct light toward the ground (below the 90-degree horizontal plane) to minimize light attraction of the covered seabirds. In addition, in 2019 KIUC replaced all green light bulbs with white light bulbs to further reduce light attraction. These modifications were aimed at minimizing the impact of the streetlights on the covered seabirds but do not reduce streetlight visibility from the perspective of green sea turtle (honu) hatchlings. As described in Conservation Measure 5, KIUC determined in 2020 that 29 streetlights were visible from suitable green sea turtle (honu) nesting habitat in the Plan Area.

Additional modifications are needed to reduce light attraction of green sea turtle (honu) hatchlings without compromising public health or safety. KIUC owns and operates all streetlights, but this operation is governed in part by State and County regulation and according to national standards. Both the County and the State have their own sets of limitations and regulations. As a public utility, KIUC cannot unilaterally change its operation of streetlights to protect green sea turtles (honu). Instead, changes in local regulations are needed to allow these changes to be consistent with public health and safety. For example, most counties and cities in coastal Florida have passed ordinances restricting the types and uses of lights adjacent to beaches in order to protect nesting sea turtles.[25] In Hawai'i, only Hawai'i County has a lighting ordinance, but it is not designed specifically to protect nesting sea turtles.[26]

KIUC will work with the County and State to determine the range of available practicable minimization measures and their timeline for implementation. Practicable light minimization measures are those that are: (1) practicable from an engineering standpoint (e.g., what is compatible with current streetlight equipment), (2) legal (e.g., what is allowed by State/County regulations and safety risk management), (3) financially practicable (i.e., not cost prohibitive), and (4) will benefit the species (i.e., what is known to benefit sea turtles). Light minimization may include techniques such as shielding or change in wattage. All KIUC streetlight modifications require County and State agreement prior to implementation.

4.4.6.1 Identify and Install Practicable Light Minimization Techniques

In 2020, KIUC began discussions with the County and State regarding potential light minimization measures for green sea turtle (honu) that would be practicable (i.e., not compromise public safety, be practicable from an engineering standpoint, and be affordable to KIUC). In 2021, KIUC began

[25] See https://myfwc.com/media/3150/seaturtle-lightordmap.pdf for a map of jurisdictions in Florida that have passed sea turtle lighting ordinances.

[26] See Chapter 14, Article 9 of the Hawai'i County Code: http://nenue.cfht.hawaii.edu/ObsInfo/IslandLights/ordinance.html

testing different shield designs to determine if they are effective in removing light penetration and at the same time will not increase risk to public safety.

The outcome of these discussions may be that there are no practicable light minimization measures for green sea turtle (honu) that can be agreed to between KIUC, the County, and the State. If this is the case, KIUC would not be required to implement this conservation measure further, and instead would continue to implement the temporary shielding required under Conservation Measure 5 throughout the life of the permit term.

If KIUC, the County, and the State reach agreement on practicable minimization measures that can be implemented to reduce potential light effects on green sea turtle (honu) hatchlings, the minimization techniques will be submitted to USFWS, DOFAW, and DAR for their review and approval. Once USFWS, DOFAW, and DAR concur, the agreement between KIUC, the County, and the State will be finalized. KIUC will then install the agreed-upon light minimization techniques within an agreed-upon timeframe after execution of the final agreement with the County and the State. The final agreement and timeline for its implementation will be included in the next annual report submitted to USFWS and DOFAW.

If new locations are identified where beach conditions change that expose additional green sea turtle (honu) nesting habitat to light from streetlights, KIUC will install the agreed-upon light minimization techniques on those non-minimized streetlights as soon as practicable (and if practicable based on the site-specific considerations), regardless of historic or current green sea turtle (honu) nesting activity. In addition, new streetlights installed in locations where light could be cast onto suitable green sea turtle (honu) habitat will include light minimization techniques consistent with this conservation measure during construction to the degree practicable based on the site-specific considerations. Changes to beach locations where minimization will be applied for green sea turtle (honu) requires consultation with USFWS, DOFAW, and DAR, as described in Section 6.2.2, *Adaptive Management*.

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Chapter 5
Effects

5.1 Overview

This chapter describes how the KIUC HCP covered activities would affect the covered species and presents conclusions regarding expected outcomes from implementing the conservation strategy (described in Chapter 4, *Conservation Strategy*). Those conclusions are reached through a systematic, scientific evaluation of the estimated adverse, beneficial, and net effects on the covered species because of the HCP covered activities and its effects pathways. This chapter provides the information for the U.S. Fish and Wildlife Service (USFWS) and Hawaiʻi Department of Land and Natural Resources, Division of Forestry and Wildlife (DOFAW) to evaluate whether the criteria for an incidental take permit and incidental take license, respectively, have been met. For additional details on the ecology of the covered species or threats to these species, see Appendix 3A, *Species Accounts*.

This chapter is organized into four sections. Section 5.2, *Effects Pathways*, describes the effects pathways for each effect mechanism. Section 5.3, *Effects on Covered Seabirds*, Section 5.4, *Effects on Covered Waterbirds*, and Section 5.5, *Effects on Green Sea Turtle (honu)* address effects on covered seabirds, covered waterbirds, and green sea turtle (honu) (*Chelonia mydas*), respectively. For each species or group of species, this chapter describes the analytical methods and results for estimating take, the impacts of the taking on the species, the beneficial effects of the conservation strategy, and the net effects on each species.

5.2 Effects Pathways

This section describes the mechanisms by which the covered activities affect the covered species, called effects pathways. The section characterizes factors that influence the type and extent of covered species take, thereby informing the avoidance and minimization measures and effects. Effects pathways are described for each of the two primary mechanisms of effects of KIUC's covered activities: powerlines and light attraction. Light attraction is discussed separately for covered seabirds and green sea turtle (honu) because of the distinct mechanisms of effects on these covered species.

5.2.1 Powerlines

This section describes the various factors influencing covered bird species collisions with powerlines, and the effects these collisions have on the covered bird species. The effects on covered bird species are described separately for the covered seabirds and covered waterbirds.

5.2.1.1 Variables Influencing Powerline Strikes

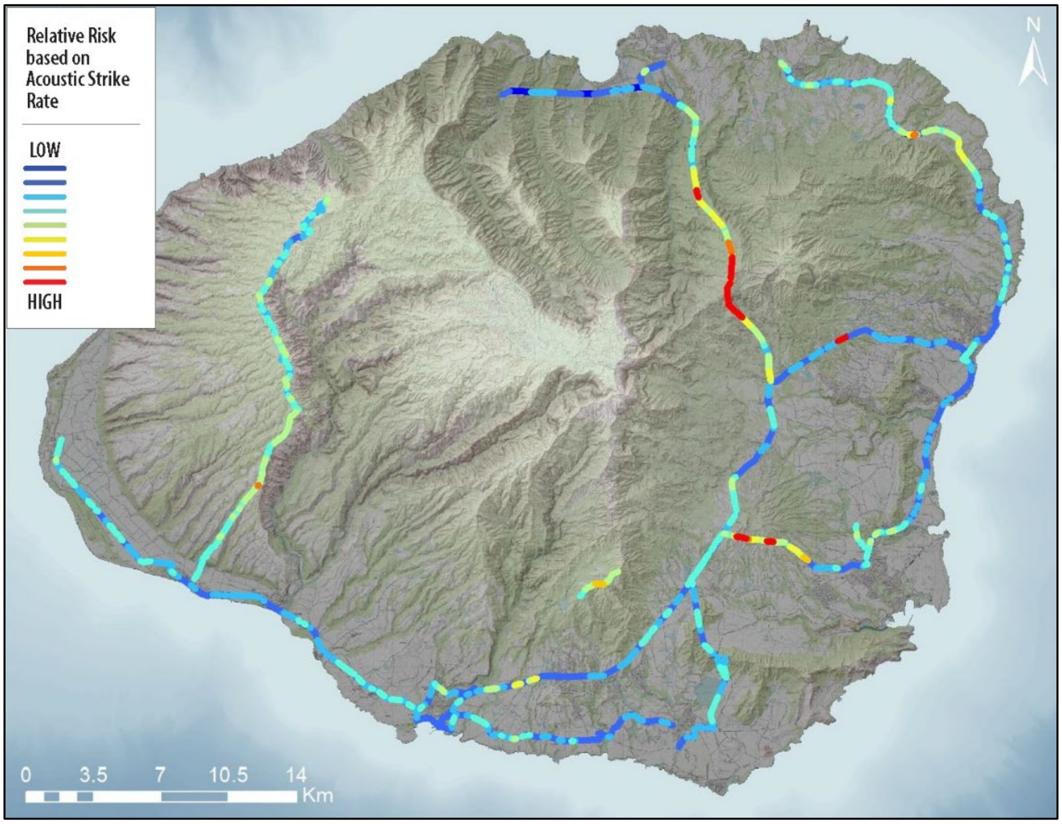
A range of variables play a role in the likelihood of the covered bird species striking powerlines. These variables include, but are not limited to, the following.

- Location of powerlines
- Seasonality
- Topography
- Height of vegetation as it relates to the powerlines and level of shielding
- Height and configuration of wires, including wire thickness, number of wires, and vertical arrangement of wires
- Flight height and speed of birds and their ability to maneuver
- Number of birds in transit in a region
- Wind speed and direction
- Flight paths relative to wind
- Ambient light levels (Travers et al. 2021)

In some areas of Kaua'i two or more of these variables contribute to increased risk, which increases the overall risk level in those areas. For example, the location of powerlines combined with flight height and speed may increase the risk level at certain spans. Powerlines that are downslope of a covered seabird nesting colony may be at a higher risk for seabird-powerline collisions due to the speed at which the birds leave their montane burrows, especially if those lines are not shielded by vegetation. Powerlines that cross a valley or drainage typically result in wires being positioned higher above the ground at mid-span compared to powerlines traversing flat terrain. Increased aboveground wire height places the wires into higher airspace, where a greater proportion of the local seabird passages occur. Powerlines located near or between wetlands and other water features present a relatively high risk to covered waterbirds because of their proximity to high-use habitat areas. Each of the variables influencing powerline strikes, with an emphasis on seabirds, is described in greater detail in Appendix 5A, *Variables Influencing Powerline Strikes.*

Newell's shearwater ('a'o) (*Puffinus auricularis newelli*) and Hawaiian petrel ('ua'u) (*Pterodroma sandwichensis*) flight paths between the ocean feeding areas and montane breeding habitats intercept powerlines, static wires, and fiber optic cables owned and operated by KIUC. Since 2011, KIUC has funded extensive powerline monitoring across most of their transmission line system on Kaua'i. The goal of this monitoring has been to better understand the amount, location, and nature of powerline interactions with the covered seabirds to inform the most effective ways to reduce collision risk. Although this program has been designed to detect seabird collisions, there have also been incidental observations of collisions by the covered waterbirds. This powerline monitoring program, formerly called the Underline Monitoring Program (UMP), and now called Infrastructure Monitoring and Minimization Project (IMMP), consists of visual observations and acoustic monitoring. Data from visual observations are used to determine species composition, passage rate, flight height, and behavior at powerlines on Kaua'i. These data are then used to estimate collision risk and how risk varies across the powerline grid. Visual observations are also used to determine the immediate fate of birds when a collision occurs (Travers et al. 2021) and validate acoustic monitoring to quantify collisions when observers are not present. Acoustic monitoring consists of strategically placing acoustic recording devices along powerlines to detect strikes and determine which powerline sections pose the greatest risk to endangered seabirds.

Based on 2013 to 2019 acoustic strike monitoring data, Figure 5-1 shows the relative collision risk in the Plan Area of Newell’s shearwaters (‘a‘o) and Hawaiian petrels (‘ua‘u) (Travers et al. 2020). Locations with higher acoustic detected collision risk are those which coincide with observed collision risk for these species. Observations indicate that the covered waterbirds are also susceptible to powerline collisions most concentrated at powerlines near wetlands (see Appendix 5B, *Rapid Waterbird Powerline Collision Assessment*).



Source: Travers et al. 2020:40

Figure 5-1. Estimated Relative Rates of Bird Strikes per Wire Span

5.2.1.2 Effect of Powerline Strikes on Covered Seabird Species

Powerlines are one of the most significant threats to Newell’s shearwater (‘a‘o) and Hawaiian petrels (‘ua‘u) on Kaua‘i. Although there have been no documented powerline strikes associated with band-rumped storm-petrels (‘akē‘akē) (*Oceanodroma castro*), observations of this species skimming over a section of powerlines in Waimea Canyon indicate that this species may also occasionally strike powerlines (Travers et al. 2021). The sections below describe the best available information on the effect of powerline collisions on these covered seabird species.

Injury or Mortality

Although numerous studies have been conducted on avian injury or mortality as a result of powerline strikes, most have been based on surveying search corridors along powerlines for grounded birds (Bernardino et al. 2018). In these studies, the number of actual line strikes is unknown, and any estimates of the number of injuries or mortalities are limited by the biases of birds flying beyond the search corridor and later succumbing to injury, birds being removed from the search corridor by scavengers, and observers missing some of the birds within the search corridor. On Kaua'i, a novel approach for monitoring powerline collisions has been employed, using acoustic monitoring devices. These devices are either deployed under the powerlines at the base of the power poles or mounted high up on the poles within the line array (depending on the scenario) and record the sound caused by a seabird striking the lines. While acoustic monitoring provides data on the number of birds colliding with lines, these data cannot provide information on the proportion of those collisions that result in injuries or mortality (Travers et al. 2021).

Understanding true survival post collision requires the colliding bird to have been previously captured and tagged with a tracking device. Due to the logistical challenges, no such study has been conducted. Travers et al. (2021) provided an alternative method in the absence of a tagging study. The authors used observations of seabird powerline collisions to determine the percentage of birds that drop immediately under or near powerlines, or lose elevation. Post-collision flight characteristics and elevation drop was used to describe the collisions impact on all other birds' flight capabilities. The authors also reported the injuries on the seabirds found grounded from powerline collisions. Overall, it was reported that 14.8 percent of seabird powerline collisions resulted in the observation of immediately grounded birds that did not regain flight within the observer's field of view, 7.4 percent had seriously compromised flight, and 6.5 percent had compromised flight but gained flight control within the observer's field of view. The birds involved in 67.6 percent of the collisions were able to regain powered flight after collision, and the remaining 3.7 percent had inconclusive post-collision flight characteristics. The immediately grounded birds were most commonly the result of a direct head-on collision with the powerlines causing head and neck injuries. Overall, the observed powerline collision outcomes, post-collision flight, grounded seabird injuries, and grounded seabird distances from powerlines indicated a probable overall grounding rate of 28.8 percent (Travers et al. 2021). Travers et al. (2021) also provided results that indicated grounded seabirds that do not die immediately from the collision injury will remain on the ground and die without human intervention. Types of injury resulting from powerline collisions include the following (Haas et al. 2003; Cooper and Day 1998; Travers et al. 2021).

- Internal injuries (e.g., bone fractures)
- Plumage damage (e.g., missing feathers; primaries and secondaries sheared off, preventing the bird from flying; head, belly, and flank feathers removed in patches, which may cause waterproofing issues, leading to hypothermia and death)
- Eye injuries
- Head injuries (physical injuries and neurological injuries that are not detectable from visual inspection)
- Skin injuries (e.g., torn open and torn off skin, open muscle, sinew, and bone tissue)

In this effects analysis, KIUC conservatively assumes all covered seabirds that become grounded (28.8 percent) experience mortality. The covered seabirds nest on steep slopes in montane areas, which gives them the necessary elevation to take off from burrow sites and clear surrounding obstacles, but they do not have this advantage at strike locations (Travers et al. 2021). These birds may occasionally climb nearby trees or rock outcrops to take flight because they have difficultly taking off from flat ground (Telfer et al. 1987; Ainley et al. 2019). They have been observed on occasion to fly away after becoming grounded when winds were strong and there were no flight path obstructions, but this is rare (Ainley et al. 1995). Grounded seabirds that survive the collision and are not able to regain flight likely succumb to mortality from other sources (if unassisted) including vehicle collision, dehydration, starvation, or predation (Rodríguez et al. 2017a; Travers et al. 2021).

Energetic Costs, Reduced Survival or Reduced Reproductive Success

As described above, a majority of the observed powerline collisions did not result in immediate grounding or altered flight indicative of an injury that would result in grounding shortly thereafter (Travers et al. 2021). However, the 71.2 percent of birds observed flying away from the powerline collision with typical/normal flight, may have injuries not detectable in the short window of time observers can track a bird post collision. These less severe injuries or subsequent behavior changes can result in reduced survival, increased energy costs or reduced reproductive success due to injuries suffered (e.g., loss of feathers or eye, head, or skin injuries). These injuries that are not observable post collision (e.g., loss of feathers, scratches to the eye, bruising, lacerations) may affect the ability of the bird to fly, gain or maintain flight, steer, balance, or slow down, leading to loss of control and increased energetic costs to maintain altitude (Croll and McLaren 1993). Most importantly, the loss of feathers may result in the loss of waterproofing, which is of particular concern for the deep-diving Newell's shearwater (ʻaʻo). This loss of feathers would then affect the ability of a bird to thermoregulate, which may be an important factor in increasing mortality (Weimerskirch et al. 2019).

If a breeding adult collides with a powerline and survives but does not return to its breeding grounds, it does not breed that year or its egg or chick will not survive, and this results in a loss of productivity. For example, to date, eight adult Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu) that collided with powerlines and were grounded have been released with a satellite tag after being rescued, rehabilitated, and released by the Save Our Shearwaters (SOS) Program. While 75 percent of these seabirds survived (only as a result of human intervention), none returned to a breeding colony that year, suggesting that all had a failed breeding season (Raine and Driskill 2020). Furthermore, if either seabird parent dies due to a powerline collision, its egg or chick is assumed to be lost because the egg/chick relies on both parents for incubation, provisioning, protection from predators, and chick rearing (see Appendix 3A, *Species Accounts*).

If a powerline collision results in death of a breeding adult, there is a loss of productivity for what would have otherwise been the remainder of that individual's lifespan. Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu) are long-lived species (30 or more years in the wild) which return to breed every year (Raine et al. 2017). The death of one individual in a breeding pair also has implications for the surviving bonded mate. The surviving bird will lose reproductive capacity until it secures a new partner. It is very unlikely that the surviving bird will find a mate and successfully breed in the year following the loss of a mate (Raine pers. comm.), so it will lose offspring for at least 1 year and possibly more (Ainley et al. 2001).

5.2.1.3 Effect of Powerline Strikes on Covered Waterbird Species

This section describes the best available information on how powerline collisions affect the covered waterbird species. There is no available scientific literature that estimates the proportion of the covered waterbirds (or any waterbird species) colliding with powerlines that are injured or killed as a result. For the purpose of assessing effects of the HCP's take on the covered waterbirds, this HCP assumes 28.8 percent of the waterbirds colliding with powerlines become grounded (Appendix 5B, *Rapid Waterbird Powerline Collision Assessment*). Because there is no reliable information on grounding rates for waterbirds, this estimate is based on the best available information on grounding rates based on observational data from seabirds as described in Section 5.2.1.2, *Effect of Powerline Strikes on Covered Seabird Species.* Unlike the covered seabirds, however, this HCP does not assume that all of the grounded covered waterbirds experience mortality, because grounded waterbirds are generally more capable of regaining flight than the covered seabirds. The covered waterbirds spend large proportions of their lives on the ground or waterbodies and are able to regain flight. Grounded waterbirds that survive and do not regain flight, however, are more vulnerable to predation and vehicle collisions, and may experience loss of productivity through energetic costs or other injury.

Linking specific mortality causes such as powerline collisions to population-level impacts is exceptionally difficult in the absence of large samples of species-specific mortality data and comprehensive population monitoring information (Loss et al. 2014; Bernardino et al. 2018). Despite the challenge of linking collision rates to population declines for the waterbirds, many authors note that some regions and bird species could experience significant population-level impacts, and that the absence of a clear link between mortality at powerlines and population impacts should not prevent mortality reduction measures from being taken, especially given imperfect understanding about how multiple mortality threats interact to cumulatively affect wildlife populations.

The life history of the covered waterbirds is substantially different than the covered seabirds, resulting in less vulnerability than the seabirds to population effects resulting from powerline collisions. That is, the covered waterbirds produce four or more offspring per year, mature much earlier in age than the covered seabirds (the covered waterbirds breed in their second year), and require much less parental care (i.e., young of the covered waterbirds leave the nest within days of hatching and become independent in several weeks); therefore, populations of the covered waterbirds are far less vulnerable to individual mortalities than the covered seabirds (see Appendix 3A, *Species Accounts*).

5.2.2 Light Attraction

5.2.2.1 Light Attraction and Fallout of Covered Seabirds

This section describes the various factors influencing fallout of the covered seabirds and its effects on these species. There is no evidence that the covered waterbirds are impacted by light attraction and the resultant fallout, so they are not discussed further in this section.

Factors Influencing Light Attraction and Fallout

Fallout of covered seabirds resulting from light attraction occurs seasonally during the autumn months in conjunction with the seabird fledging season (September 15 to December 15). Light attraction primarily affects fledgling seabirds on their first flight from their nesting colonies to the ocean (Reed et al. 1985; Telfer et al. 1987). However, adults may also be attracted to artificial lights when transiting to and from their nesting colony during the breeding period, particularly when lights are near the breeding colony (Raine et al. 2018).

KIUC operates three types of lights that potentially attract covered seabirds—streetlights, external lights at its covered facilities, and night lighting for emergency repairs. KIUC has taken steps to reduce light attraction at its streetlights and covered facilities by shielding light fixtures using full-cutoff shields and dimming covered facility lights during the seabird fledging season (see Chapter 4, Section 4.4.2, *Conservation Measure 2. Implement Measures to Minimize Light Attraction*).

Even with the streetlight modifications to reduce light output and direct all light at the ground, streetlights remain a source of light attraction. However, it is rare to be able to pinpoint which streetlight is the cause of light attraction fallout incidents because most streetlights are found in areas with many other light sources (Appendix 5C, *Light Attraction Modeling*). Additionally, for covered facilities, the covered seabirds may be attracted to non-KIUC lights in the surrounding area but land within the facility and vice-versa. Newell's shearwaters ('a'o) are regularly found under streetlights every year.

Effect of Light Attraction on Covered Seabirds

Artificial lighting often attracts the covered seabirds, and after flying around the lights, birds can tire or inadvertently hit a structure and may become grounded, an event referred to as fallout (Imber 1975; Telfer et al. 1985). Although adults can be affected by light attraction (Center for Biological Diversity 2016), fledglings are the primary age class affected. When fledglings leave their nest for the first time in the hours following sunset, they are at risk for becoming attracted to artificial lights. This attraction may also occur after young fledglings reach the ocean and are then attracted inland by coastal lights, which explains why they are frequently grounded in coastal areas that are quite distant from their colony (Troy et al. 2013; Rodríguez et al. 2015). There is also a potential for attraction to occur on their outbound journey prior to reaching the ocean (Troy et al. 2013).

Although patterns of fallout on Kaua'i are complex and result from various independent conditions (Troy et al. 2013), the primary source of attraction is bright lights. An early study on Kaua'i showed that the shielding of bright lights can reduce fallout by 40 percent (Reed et al. 1985), and recent studies continue to indicate that the reduction of lateral light spillage is beneficial to reducing light-induced fallout (Rodríguez et al. 2017a, 2017b). While efforts to shield lights can effectively reduce fallout, these efforts do not appear to eliminate it. Several studies have shown that fallout patterns are also influenced by the location and brightness of artificial lights relative to seabird colonies, the proximity of lights to the coastline, and the wavelengths emitted by different light types (Troy et al. 2011, 2013; Rodríguez et al. 2015, 2017a, 2017b, 2017c; Longcore et al. 2018). Facility lights and night lighting for repairs to restore power can also attract seabirds and result in fallout.

Injury or Mortality

When attracted to artificial lights, seabirds can become confused, disoriented, or blinded by the light. Light-attracted birds may circle repeatedly and become grounded, which involves landing on the ground in locations where they usually do not land and from which they are unable to take off due to injury, exhaustion, and confusion. Before grounding, seabirds may collide with structures (e.g., powerlines, poles, buildings) and be injured or killed (Reed et al. 1985).

If light-attracted individuals that become grounded are not rescued, they are at risk for succumbing to injury or mortality due to starvation, predation, collisions with cars, or a combination thereof. Covered seabirds have difficulty resuming flight from level ground (Telfer et al. 1987). Once grounded, covered seabirds are susceptible to dehydration, starvation, predation from introduced predators, or collision with a vehicle (Telfer et al. 1987).

Studies conducted by Travers et al. (2013) and Podolsky et al. (1998) reported mortality rates[1] of grounded Newell's shearwaters (ʻaʻo) between 40 and 43 percent. The actual rate is likely higher, since some grounded birds are removed by predators, some land on private property and may not be found or reported, and some birds hide under vegetation or structures and are not found[2] (Podolsky et al. 1998; Ainley et al. 2001; Travers et al. 2013; Raine et al. 2018).

Energetic Costs, Chick or Egg Mortality

Birds that become disoriented by lighting but do not become grounded may experience energetic costs in reorienting themselves. If either seabird parent dies due to fallout, the loss of its egg or mortality of its chick occurs because the egg/chick relies on both parents for incubation, provisioning, predator protection, and chick rearing (Ainley et al. 1997). Fallout is primarily experienced by fledglings; therefore, effects on parents and hence on eggs and chicks are expected to be relatively infrequent except in fallout events related to breeding adults such as the mass fallout event at Kōkeʻe Air Force Station in 2015 (Raine et al. 2018).

5.2.2.2 Light Attraction and Disorientation of Green Sea Turtle (honu)

Sea turtles typically arrive on beaches to nest at night and emergence occurs nocturnally (Witherington et al. 2014). Artificial lighting visible from the nesting location can disorient hatchlings as they emerge from sand nests at night, leading them to wander aimlessly or head inland (Witherington et al. 2014). Hatchlings normally orient themselves based on the brightest light sources, which is usually the moon, but can become disoriented when there is a brighter light source nearby. For additional details on the ecology of green sea turtle (honu) or threats to this species, see Appendix 3A, *Species Accounts*.

Hatchlings unable to find the ocean are likely to die due to dehydration, predation, or from vehicular collision should they enter roadways (Witherington and Martin 2000; Witherington et al. 2014). While a considerable amount of research has been conducted to identify what levels of artificial lighting may be problematic for nesting behaviors, there is no simple measure of how various light intensities affect sea turtles, or what level of light intensity may be tolerable without impact (see, for example, Witherington and Martin 2003).

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[1] Also referred to in literature and in the glossary (Chapter 10) as "crippling rate."

[2] In August and September 2015 at the Kōkeʻe Air Force Station on Kauaʻi at least 123 Newell's shearwaters (ʻaʻo) and six Hawaiian petrels (ʻuaʻu) had fallen out and were recovered. Many of these birds were found hiding under structures (Raine et al. 2018). All of the recovered seabirds were adults, the majority of which had brood patches, indicating that even experienced breeding adults, once grounded, may not be able to take off and are likely to hide in vegetation or under buildings (Raine and Banfield 2015). This situation also indicates that adults are susceptible to groundings in areas where inappropriate lighting is set up near breeding colonies (Raine et al. 2018). Once grounded, uninjured birds seek shelter, utilizing any nearby crawl spaces or dense bushes. This makes them particularly difficult to find by human searchers.

5.2.3 Conservation Strategy Implementation

The conservation strategy will result in multiple beneficial effects on covered seabirds. Powerline minimization measures will reduce seabird powerline collisions. Management and enhancement of breeding colonies will reduce the abundance and distribution of seabird predators and increase the number of chicks produced annually. The SOS Program will minimize covered seabird mortalities from various sources (KIUC and non-KIUC) through rescue and release of injured covered seabirds.

The conservation strategy may also result in a minimal amount of take of covered seabirds as individual birds may be caught in leg hold or other traps placed for predator control. The number of birds anticipated to be taken as a result of conservation measures is described in Section 5.3.3, *Species-Specific Seabird Effects.*

5.3 Effects on Covered Seabirds

This section describes the estimated effects of the covered activities on the covered seabirds over the life of the 50-year permit term. Section 5.3.1, *Methods for Quantifying Take and Assessing Effects on the Covered Seabirds*, describes the methods used to quantify these effects; Section 5.3.2, *Effects Common to All Covered Seabirds*, describes the effects of the covered activities that are common to all the covered seabirds; and Section 5.3.3, *Species-Specific Seabird Effects*, provides species-specific analyses in the context of the species abundance, distribution, and other relevant factors. The last subsection also describes the levels of take requested for each covered seabird, the impact of the taking on the population of each covered species, and the expected beneficial and net effects on each species.

5.3.1 Methods for Quantifying Take and Assessing Effects on the Covered Seabirds

This section describes the methods KIUC applied to quantify take and assess the effects of the covered activities on the covered seabirds, and includes methods used to estimate the adverse effects of powerline collision, the adverse effects of fallout from light attraction, and the beneficial effects of the conservation strategy.

5.3.1.1 Powerline Collisions—Methods

This section describes KIUC's methods for estimating take of covered seabirds associated with powerline collisions. Take of the covered seabirds can take several forms, including injury or mortality of adults or juveniles. Take could also occur in the form of the loss of chicks or fledglings as a result of the injury or mortality of a breeding adult. This section also includes the assumptions used for the purpose of estimating amounts for each of these forms of take.

Estimating Anticipated Number of Collisions (Measurable Unit of Take)

No studies of powerline strikes on the covered birds to date have been able to quantify the exact number of birds injured or killed as a result of powerline collisions. This would require not only recording all birds striking powerlines, but also tracking the outcome of all of those strikes (Travers et al. 2021; Bevanger 1998). Various estimates of injury or mortality have been made, but these have been based on untestable assumptions about data biases (Bevanger 1998). While these estimates are useful in tracking overall effects of powerline collisions on the covered seabird species, they are not estimates that can be measured in the field and verified through monitoring. Therefore, based on current technology and techniques, the exact amount of take (mortality or injury) of the covered seabirds from powerline strikes is indeterminable.

As described in the HCP Handbook, if take by number of individuals cannot be determined accurately, take limits can be expressed in a variety of ways, provided (1) there is a causal link between the surrogate unit of take and actual take of the species, and (2) a clear standard is determined for when the level of anticipated take has been exceeded (U.S. Fish and Wildlife Service and National Marine Fisheries Service 2016). Consistent with this guidance, KIUC is expressing its take request for each covered seabird as the number of powerline strikes. In other words, the number of powerline strikes serves as a reasonable and measurable surrogate for the amount of actual take of Newell’s shearwater (‘a‘o) and Hawaiian petrel (‘ua‘u).

KIUC applied the following analytical steps to estimate the number of powerline strikes anticipated for Newell’s shearwater (‘a‘o) and Hawaiian petrel (‘ua‘u) over the 50-year permit term. The method for establishing the take limit for of band-rumped storm-petrel (‘akē‘akē) is described separately in Section 5.3.3.3, *Band-Rumped Storm-Petrel (‘akē‘akē)*. Take from powerline collisions expressed as the total number of collisions (strikes) was quantified using the following steps, each of which is described below:

1. Estimated the pre-HCP annual collision rate for both species combined.
2. Used the observed passage rates, flight heights, and powerline interaction data on each 328 feet (100 meters) of powerline to determine the proportion of strikes attributable to each species. These proportions were then applied to the total annual collision rate to estimate the number of annual strikes for each species.
3. Estimated the anticipated reduction in powerline collisions that would result from powerline minimization measures described in Chapter 4, *Conservation Strategy*. This proportion was then applied to pre-HCP collision rates.
4. Calculated the annual strike number of strikes over time as a function of changing abundance.
5. Estimated the amount of additional powerline collisions expected from new powerlines built during the permit term.

Step 1: Estimate Pre-HCP Annual Collisions with Existing Powerlines

KIUC based its pre-HCP (i.e., before the HCP permit term begins) annual strike estimates on a 2020 Bayesian acoustic strike model, using data from 2013 to 2019 (Travers et al. 2020). Appendix 5D, *Bayesian Acoustic Strike Model*, outlines the methods and results for this model. In summary, the model is based on data gathered from acoustic sensors placed on power poles throughout the island to record powerline strikes, combined with data collected from more than 6,000 hours of observer monitoring to assess the initial mortality rate of seabirds hitting powerlines and species composition. A Bayesian hierarchical modeling framework was employed to estimate the annual rate of bird-powerline collisions based on the acoustic sensor data from 2013 through 2019. The cumulative mean annual number of bird strikes for all powerline spans was estimated at 16,642.[3]

[3] This number is slightly reduced from the number reported in the 2020 Bayesian model (Appendix 5D, *Bayesian Acoustic Strike Model*) due to minor errors resulting from double counting of strikes on Powerline Trail and duplicate span numbers causing doubling of strikes for those spans.

The model used data that included minimization efforts for the Short-Term HCP (Travers et al. 2020), so the annual starting point for the KIUC HCP was reduced by the number of strikes that were attributed to minimization measures implemented through the Short-Term HCP (244 strikes) (i.e., so that KIUC did not get credit for this reduction twice) to 16,398 total strikes annually. After 545 annual strikes were attributed to waterbirds based on observations at Mānā, as described in Appendix 5B, *Rapid Waterbird Powerline Collision Assessment*, the number of annual strikes attributed to Newell's shearwater ('a'o) and Hawaiian petrel ('ua'u) was reduced to 15,853.

Step 2: Determine Proportion of Powerline Strikes Attributed to Each Covered Species

The acoustic strike estimates quantify collisions of all birds combined (i.e., covered seabirds, covered waterbirds, and non-covered birds). Newell's shearwater ('a'o) and Hawaiian petrel ('ua'u) vary in their flight behavior, data about which can be used to estimate the proportion of collisions attributed to each species. Strike estimates were allocated to species by using a combination of observations of passage rate, observations of flight height, and powerline interaction data per unit length of wires by time of day and night. Additionally, an assessment of the proportional risk of powerline collisions based on powerline observations at Mānā, as described in Appendix 5B, *Rapid Waterbird Powerline Collision Assessment*, resulted in an estimated 545 of all bird strikes being attributed to waterbirds.[4]

Therefore, the total estimated annual strikes attributed to Newell's shearwater ('a'o) and Hawaiian petrel ('ua'u) is 15,853 (16,398 minus 545). Of these 15,853 birds, 70 percent are assumed to be Newell's shearwater ('a'o) and 30 percent are assumed to be Hawaiian petrel ('ua'u) (Appendix 5D, *Bayesian Acoustic Strike Model*; Appendix 5E, *Population Dynamics Model for Newell's Shearwater ('a'o) on Kaua'i*). This provides an estimated annual collision number prior to minimization of 11,097 for Newell's shearwater ('a'o) and 4,756 for Hawaiian petrel ('ua'u).

There have been no direct observations of band-rumped storm-petrel ('akē'akē) colliding with powerlines (Travers et al. 2021). In addition, band-rumped storm-petrel ('akē'akē) can be visually confused with bats. Based on the extreme rarity of strikes and the challenge of species identification, a reliable collision estimate could not be determined. Instead, a small amount of take was estimated for this species independent of the calculations above, as described in Section 5.2.1.2, *Effect of Powerline Strikes on Covered Seabird Species*. The effects analysis for band-rumped storm-petrel ('akē'akē) is based on this take limit.

Step 3: Apply Anticipated Reduction in Collisions due to Minimization Measures

As described in Chapter 4, Section 4.4.1, *Conservation Measure 1. Implement Powerline Collision Minimization Projects*, KIUC is in the process of minimizing the impacts of its powerlines on covered species by implementing physical modifications to and/or using flight diverters on all feasible spans of existing transmission and distribution lines. Travers and Raine used the 2020 Bayesian model results (Appendix 5D, *Bayesian Acoustic Strike Model*) to estimate the minimization efficacy and potential benefit of these minimization actions. Based on these results, they concluded that KIUC's powerline minimization projects range in efficacy from 42 to over 95 percent, depending on the covered species and the location and type of the minimization project (Travers et al. 2020).

[4] As described in Appendix 5B, *Rapid Waterbird Powerline Assessment*, this estimate is for all species of waterbirds potentially colliding with KIUC powerlines at Mānā, not just covered waterbirds.

To determine how much take to request, KIUC applied the minimization efficacy rates from the Bayesian model to calculate the reduction in seabird strikes for each existing powerline span, taking into account all completed and planned minimization projects from 2020 through 2023. The predicted strike reduction (i.e., number of bird strikes reduced) was estimated for all powerline spans in KIUC's system based on the type of minimization project, the length of the span, and the collision risk estimated at that location. A total of 1,682 separate calculations were made, one for each span. The estimated strike reductions for each powerline span were then summed to calculate an island-wide strike total and minimization efficacy. Minimization efficacy was calculated by dividing the number of strikes reduced, either annually or cumulatively, by the baseline annual strike total, which represents the total island-wide strike total accounting for all minimization projects completed through the end of 2019 (the final year of KIUC's Short-Term HCP). KIUC expects to complete all minimization projects by the end of 2023. At that time, KIUC commits to achieving an island-wide minimization efficacy of at least 65.3 percent (i.e., a reduction in powerline strikes of at least 65.3 percent compared to the 2019 baseline).

Assuming 2023 will be the first year of HCP implementation and minimization will not be complete until the end of 2023, KIUC assumed a 55.0 percent minimization rate the first year of HCP implementation (all of 2023), and a 65.3 percent minimization rate for each of the remaining 49 years (2024 through 2073). Table 8 of Appendix 5D provides the annual powerline minimization schedule.

Step 4: Calculate Annual Strike Numbers over Time as a Function of Changing Abundance

An important element of the conservation strategy is the management and enhancement of 10 conservation sites (see Conservation Measure 4. Manage and Enhance Seabird Breeding Habitat and Colonies at Conservation Sites). An important goal of these conservation sites is to substantially increase the population of Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu) to offset expected continued declines of these species in other parts of Kauaʻi that are not managed (i.e., no predator control) and continue to be subject to some powerline collision. As different subpopulations of Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu) fluctuate over time either up or down, amounts of powerline collisions will change even if collision risk remains constant.

- Calculating annual unminimized mortality rate for each species from powerline strikes by multiplying 2019 unminimized strikes by 28.8 percent (see *Annual Mortality and Injury from Powerline Strikes*, below, for an explanation of why 28.8 percent was used).
- Calculating changing annual mortality over time as a function of changing abundance and powerline strike minimization (see Appendix 5E, *Population Dynamics Model*, for a detailed description of this step).
- Dividing annual mortality by 28.8 percent to determine estimated annual strike numbers for each species over time.

Step 5: Estimate Strikes from New Powerlines

This HCP covers KIUC's installation of up to 360 miles (579.4 kilometers [km]) of new powerlines, or an average of 7 miles (11.3 km) of new wires per year for 50 years (see Section 2.1.2.2, *Adding New Powerlines*). As described in Chapter 4, Section 4.4.1.3, *Future Transmission and Distribution Lines*, KIUC commits in this HCP to apply the latest standards of collision minimization to all new powerlines and site new powerlines in low collision risk areas (to the maximum extent practicable) in order to minimize strikes from new powerlines. Based on estimated efficacy rates ranging from

42 percent to over 95 percent for reconfiguration, static wire removal, and bird flight diverters (Travers and Raine 2020), KIUC has estimated that powerline collisions resulting from the installation of new powerlines can be reduced by 80 percent for the covered seabirds. A total of 360 new miles (579.4 km) of powerlines would be a 34 percent increase from the 1,057 miles (1,701 km) of existing transmission and distribution (360/1,057=.34) throughout the permit area (see Chapter 2, *Covered Activities*, for more details). With 80 percent minimization of powerline strikes, a 6.8 percent increase in strikes is anticipated from the new powerlines (34 percent x 0.20 strikes remaining= 6.8 percent).

- 360 miles (579.4 km) of new powerlines divided by 1,057 miles (1,701 km) of existing transmission and distribution lines = 21.4 percent increase.
- 21.4 percent increase in miles of existing transmission and distribution lines multiplied by the percentage of strikes remaining after 80 percent minimization (i.e., 20 percent) = 6.8 percent increase in strikes from new powerlines.
- Conservatively assuming an even pace of new construction through year 50, the increase in future strikes was calculated by applying a linear increase in the strike mortality rate each year (i.e., increase by another 0.136 percent each year), such that by buildout at year 50, the strike mortality rate was equal to the estimated 6.8 percent increase in strikes.

Estimating the Form of Take

KIUC is quantifying and tracking take from powerline collisions in terms of the total number of strikes, as described above. Based on these estimates, KIUC has also estimated take by the form of take likely to occur from powerline collisions (i.e., injury, mortality, or indirect take of chicks or eggs). As described in Section 5.2.1.2, *Effect of Powerline Strikes on Covered Seabird Species*, estimating the number of avian mortalities and injuries resulting from powerline collisions is challenging because the fate of individuals is very difficult to determine after a collision in samples large enough to generate statistically valid estimates. Estimating bird mortality and injury has typically been done by conducting ground searches and then adjusting counts to account for biases related to factors such as searcher efficiency, carcass removal rate by scavengers, searchability of the habitat, and crippling bias.[5] These correction factors are often subjective and based on limited data (Bevanger 1995; Travers et al. 2021).

While relevant to some studies, these bias factors are not relevant to the KIUC HCP because powerline monitoring estimates powerline collisions directly through acoustic monitoring of wire strikes rather than individuals found during ground-level searches. The best available data to date regarding the outcome of bird collisions is a study by Travers et al. (2021) in which 206 seabird collisions with powerlines on Kaua'i were observed over a 6,000-hour observation period to evaluate post-collision elevation loss and flight characteristics. This study is described in Section 5.2.1.2, *Effect of Powerline Strikes on Covered Seabird Species*.

Annual Mortality and Injury from Powerline Strikes

As described in Section 5.2.1.2, *Effect of Powerline Strikes on Covered Seabird Species*, it is not possible to definitively know the fate of seabirds that strike powerlines unless they are found under

[5] Crippling bias is a measure used for monitoring techniques that involve estimating the number of dead or injured birds by searching under powerline corridors. It is the measure of the number of birds that hit a powerline (or any other structure) but continue to transit beyond the range of the search corridor before dying undetected.

the powerlines or tagged. Instead, KIUC used the best available data from Travers et al. (2021) to estimate these outcomes. Based on this study, 28.8 percent of the covered seabird powerline strikes are assumed to result in grounded birds (regardless of species). All grounded birds are assumed to die immediately due to impact or shortly thereafter due to starvation, dehydration, or predation.

Estimating the number of non-lethal injuries resulting from powerline collisions is even more challenging than estimating mortality, since non-lethally injured birds generally leave the search corridor under powerlines and cannot be observed. KIUC used as a proxy for non-lethal injury the proportion of birds that were observed in Travers et al. (2021) to lose elevation after striking powerlines. Based on this approach, 24.5 percent of covered seabird collisions are assumed to result in non-lethal injury (regardless of species).

Indirect Take of Eggs or Chicks

As described in Section 5.2.1.2, *Effect of Powerline Strikes on Covered Seabird Species*, an egg or chick may be lost when a parent seabird strikes a powerline. Both parents are required to care for chicks and eggs, so if one parent dies or is injured, it is likely the chick or egg will be lost. KIUC therefore assumed the loss of one egg or chick for each adult bird killed or injured as a result of powerline collisions, assuming an 80:20 proportion of subadult to adult powerline strikes (Cooper and Day 1998).

5.3.1.2 Light Attraction and Fallout—Methods

Appendix 5C, *Light Attraction Modeling*, describes the process for quantifying take of the covered seabirds from attraction to lights owned and operated by KIUC. KIUC light sources covered in the HCP include streetlights, two KIUC covered facilities covered (Port Allen Generating Station or Kapaia Power Generating Station), and night lighting for emergency repairs. These methods are summarized in the following subsections. KIUC assumed take associated with light attraction primarily for non-breeding birds (i.e., fledglings); therefore, a negligible amount of indirect take of eggs or chicks from killed or injured adults is anticipated.

Fallout from Streetlights

The streetlight assessment applied an approach developed in collaboration with USFWS and DOFAW to assign fallout documented by the SOS Program to streetlights based on the proportional contribution of those lights to the lightscape of Kaua‘i. The proportional assessment was developed using remotely sensed radiance (brightness) collected by a sensor on the Suomi National Polar-Orbiting Partnership Satellite. This sensor is designed to provide global measurements of the intensity of nocturnal visible and near-infrared light on a daily basis (Cao et al. 2020). The process used to estimate fledgling fallout due to streetlights included the following steps.

1. Partition radiance data from 2018 on Kaua‘i according to the existing spatially explicit SOS sectors that encompass all areas of the island with streetlights.[6]
2. Assess recent island-wide satellite data of the lightscape on Kaua‘i.
3. Estimate the radiance generated by a single streetlight based on a sample of remote streetlights that are isolated from other sources of nighttime light.

[6] Save Our Shearwaters (SOS) has partitioned Kaua‘i into 35 spatially explicit sectors to understand the spatial distribution of seabird injuries.

4. Estimate the proportional contribution of streetlights to radiance by sector.
5. Derive an estimate of fallout occurring due to streetlights in each sector.
6. Apply a correction factor to account for seabirds that were grounded but not detected.

KIUC compared three methods for estimating radiance per streetlight: nonparametric bootstrapping, Bayesian regression, and cross validation. All three methods produced similar estimates with overlapping confidence limits. KIUC concluded from its variance analysis that, during the months of maximal fallout (October and November), there is a predictable relationship between streetlight count per sector and the radiance of that sector, and that this relationship can be used to predict the radiance of an area given the number of streetlights. This held true regardless of whether the method used to estimate variance was derived from bootstrapping, Bayesian regression, or cross validation. Given the insensitivity of the results to the alternative analytical approaches examined, and that the bootstrapping approach relies on fewer parametric assumptions than the alternatives, the original method of bootstrapping was applied to the analysis (Appendix 5C, *Light Attraction Modeling*).

The correction factor KIUC used to account for seabirds that were grounded but not detected by citizens and turned in to SOS was based on literature that provided insight into the lower limit of detectability. Podolsky et al. (1998) evaluated two parallel seabird recovery programs searching for dead birds—one that used SOS and another that used biologists to intensively search for grounded birds. Podolsky et al. (1998) searched intensively for dead birds in proximity to powerlines in urban and suburban areas, inconspicuously marked all dead individuals, and coordinated with the SOS Program to determine if any of these dead birds were subsequently turned in by citizens. Of 50 dead birds located by biologists, 8 were found by citizens and turned in to SOS (16 percent detection). Recognizing that citizens are less likely to turn in dead birds than live ones, and based on Travers et al. (2021) reporting that 35 percent of seabirds they detected were dead, KIUC used a conservative approach by assuming all 50 birds were alive and there were an additional 26 dead birds available to be found (= (50/0.35) - 50). Thus, SOS would have found 8 birds out of 76 (50 + 26), resulting in a 10.5 percent detectability. The assumed detectability rate of 10.5 percent that KIUC used in their take estimates for the effects of streetlights is highly conservative; the actual detectability rate is expected to be higher, as described in Appendix 5C, *Light Attraction Modeling*. Fallout, whether detected or not, is assumed to result in 100% mortality in the model.

Appendix 5C provides further details on this analysis and assumptions applied. Although KIUC has applied measures to minimize light attraction and will continue to apply minimization as described in Chapter 4, Section 4.4.2, *Conservation Measure 2. Implement Measures to Minimize Light Attraction*, the extent to which these measures reduce take attributed to KIUC streetlights is not quantifiable; therefore, the assumed take is as described above and in Appendix 5C.

Fallout from Lights at KIUC Covered Facilities

For the two covered facilities, Port Allen Generating Station and Kapaia Power Generating Station (Chapter 2, *Covered Activities*), take was estimated using the average number of downed birds located at each facility as documented in KIUC monitoring logs (Kaua'i Island Utility Cooperative 2019) and the SOS database. This is a conservative estimate, since KIUC began dimming the lights in 2019 during the fallout season and drastically reduced fallout/take to zero birds in 2019 and one bird in 2020.

KIUC factored in a searcher efficiency correction of 50 percent for the data from covered facilities. A detectability factor much greater than the detectability factor for streetlights was used for a number of reasons. First, it matches the detectability rate used for similarly monitored facilities covered in the Kaua‘i Seabird HCP (State of Hawai‘i Division of Forestry and Wildlife 2020). Also, KIUC covered facilities are fenced and monitored for pests, which greatly reduces predation of downed birds prior to detection and rescue. KIUC uses traditional pest control methods such as traps and pest control services for rats and mice. Any stray cats that make it into the fenced facilities are captured using live traps and removed from the property. KIUC trains staff to identify and search for covered species and these trained staff conduct searches for downed seabirds during the seabird fallout season twice daily (Chapter 6, *Monitoring and Adaptive Management Program*). Searchers are equipped with an Oppenheimer Seabird Recovery Kit and recovered birds are transported to an SOS Aid Station (Appendix 5C, *Light Attraction Modeling*). KIUC staff have monitored and maintained inspection logs for these facilities during the seabird fallout season (September 15 through December 15) since 2011.

Fallout from Night Lighting for Restoration of Power

In rare cases when KIUC must illuminate work areas at night to restore power when equipment failure or powerline damage occurs, this may cause covered seabird fallout. As described in Chapter 2, Section 2.1.4, *Night Lighting for Restoration of Power*, an estimated 85 hours of night lighting during the seabird fallout period will be needed for repairs on an annual basis, in limited locations where repairs are needed. Because the take estimate for streetlights is conservative as described above, and fallout from lighting at temporary work areas is expected to be rare, this HCP assumes no change in take of the covered seabirds from the operation of night lighting for restoration of power.

Estimating the Form of Take

KIUC is quantifying take from light attraction in terms of the amount of fallout (i.e., number of birds that fall out of the sky), as described above. There are no data or estimates available on the fate of all birds that fall out from light attraction. For the purposes of this HCP, KIUC assumes 100 percent of fallout results in mortality. Although some of the seabirds experiencing fallout will be rehabilitated by SOS, KIUC applied an assumption of 100 percent mortality for a conservative estimate of effects. Because fallout is assumed to consist primarily of non-breeding birds (i.e., fledglings), (see Section 5.2, *Effects Pathways*), fallout is expected to result in a negligible amount of indirect take of eggs or chicks.

5.3.1.3 Take from Traps—Methods

To estimate the number of covered seabirds anticipated to be taken as a result of trapping predators at conservation sites, KIUC evaluated trapping data from 2015 through 2022 for all of KIUC's conservation sites. Based on this data, the maximum number of covered seabirds caught in a single year (2021) was eight individuals. Because this was a recent year, KIUC conservatively estimated the baseline annual number of birds caught in traps as eight individuals, or 0.013 percent of the population at all conservation sites in 2021. KIUC made a conservative assumption that all individuals caught in traps were breeding adults, then multiplied the projected annual number of breeding adults at conservation sites by 0.013 to estimate the annual number of birds trapped during the permit term and summed these annual estimates over 50 years.

Based on a 64:36 split in population numbers between Hawaiian petrel ('ua'u) and Newell's shearwater ('a'o) at the conservation sites, KIUC assigned 64 percent of the 50-year take to Hawaiian petrel ('ua'u) and 36 percent of the take to Newell's shearwater ('a'o). Based on the Hallux trapping data, all but eight of the 34 birds trapped were immediately released (of the eight, six were dead and two were taken to SOS); therefore, KIUC conservatively estimated that 23 percent (eight divided by 34) of birds trapped in the future would be killed and the remainder would be injured.

5.3.2 Impacts of the Taking—Methods

The federal Endangered Species Act requires that the HCP applicant analyze the impact of the taking on the covered species, which should be described relative to the species' reproduction, numbers, and distribution (U.S. Fish and Wildlife Service and National Marine Fisheries Service 2016). The Hawai'i Endangered Species Act has the same requirement.[7] This analysis evaluates the *impacts* of the taking on the species as a whole (or a portion of the species' range that coincides with the HCP Plan Area), and on the species' long-term survival and likelihood of recovery. Although there has been historic take of the covered seabirds from KIUC operations, the impact of the taking assessed in an HCP is based on the take authorized under the HCP's permit term.

To evaluate the impacts of the proposed (minimized) taking on Newell's shearwater ('a'o) and Hawaiian petrel ('ua'u) prior to mitigation, KIUC used a custom population dynamics model for the Kaua'i metapopulation[8] of each of the covered seabirds. Appendix 5E, *Population Dynamics Model for Newell's Shearwater ('a'o) on Kaua'i*, describes the model and results for Newell's shearwater ('a'o). Appendix 5F, *Population Dynamics Model for Hawaiian Petrel ('ua'u) on Kaua'i*, describes the model and results for Hawaiian petrel ('ua'u). Both models use the same structure for each species and only differ in some assumptions used. The model considered take resulting from KIUC activities each year over the permit term, after minimization actions were applied. Impacts of historic take are factored into the model because of the current status of the population. Using estimated trends from radar data to initialize the model also integrates the effects of powerline collisions and light fallout prior to the HCP, to the extent available data allow, because the trend estimate is based on radar survey data starting in 1993.

The model results were compared with a hypothetical *no-take scenario* in which there would be no take resulting from KIUC activities, and no mitigation.[9] Under the no-take scenario, predation and other non-KIUC-related mortalities would continue, and KIUC's mitigation measures would not be implemented. Table 5-1 describes this scenario and other scenarios used to analyze effects on the species. To evaluate the impacts of the taking on the species, the no-take scenario was compared with a proposed take scenario. The *proposed take scenario* assumes the proposed take occurs (i.e., KIUC's take is minimized according to Conservation Measure 1, *Implement Powerline Collision Minimization Projects*, and Conservation Measure 2, *Implement Measures to Minimize Light Attraction*, in Chapter 4, *Conservation Strategy*), but KIUC does not implement mitigation

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[7] Hawai'i Revised Statute Section 195D-21(b)(2)(C).

[8] A metapopulation is a group of populations that periodically interbreed. Newell's shearwater ('a'o) populations on Kaua'i are recognized as a distinct metapopulation (Vorsino 2016).

[9] Since KIUC powerlines are already in operation and their removal would be infeasible, this no-take scenario is hypothetical and used only as a basis for evaluating the impact of the taking on the species. This hypothetical no-take scenario is also helpful in isolating and separating impacts on the species from unmitigated predation versus impacts from KIUC facilities.

measures.[10] By isolating the effects of the proposed, minimized take from mitigation measures, and by comparing that scenario to the hypothetical scenario without any take or mitigation measures occurring (i.e., the no-take scenario), KIUC can quantitatively estimate the impacts of the taking on the metapopulation of Newell's shearwater (ʻaʻo) on Kauaʻi. The Kauaʻi metapopulation was chosen as the unit of analysis for Newell's shearwaters (ʻaʻo) because an estimated 90 percent of all Newell's shearwater (ʻaʻo) breed on Kauaʻi and because that metapopulation coincides with the Plan Area for this HCP. Similarly, the Kauaʻi population of Hawaiian petrel (ʻuaʻu) was chosen as the unit of analysis because a large share of the species[11] occurs on Kauaʻi.

Using this approach, KIUC determined the impacts of the taking by comparing the metapopulation trajectories of two hypothetical future scenarios that would not include mitigation measures: (1) without take from KIUC activities (the no-take scenario), and (2) with take from KIUC activities including minimization but without conservation actions (proposed take scenario).

Although not a required component of an HCP, KIUC also evaluated the extent to which the proposed minimization measures are expected to benefit the Newell's shearwater (ʻaʻo) metapopulation on Kauaʻi compared with a scenario in which this minimization did not occur. To do this, KIUC compared the proposed take scenario with a scenario in which powerlines had no minimization applied that is proposed in this HCP[12] (i.e., static wires not removed, no powerline reconfiguration, no bird flight diverters installed), called the "unminimized take" scenario (Table 5-1).

A population dynamics model could not be developed for band-rumped storm-petrel (ʻakēʻakē) due to their rarity and a lack of species-specific data. Impacts of the taking on band-rumped storm-petrel (ʻakēʻakē) were addressed qualitatively by evaluating the taking in the context of the overall distribution and abundance of this species. The impacts of the taking on this species were also evaluated relative to the estimated population on Kauaʻi.

[10] In other words, Conservation Measure 4, *Manage and Enhance Seabird Breeding Habitat and Colonies at Conservation Sites*, is not implemented.

[11] Estimates of the share of breeding individuals of Hawaiian petrel (ʻuaʻu) on Kauaʻi range from approximately 33 percent (Raine pers. comm.) upward. Recent work suggests that the number of breeding individuals on Maui, Lānaʻi, and possibly Molokaʻi are substantially greater than previously believed. For details see Section A.2.4 in the species account for Hawaiian petrel (ʻuaʻu) in Appendix 3A, *Species Accounts*.

[12] In this scenario, minimization that occurred for the Short-term HCP is still applied.

Table 5-1. Explanation of Population Dynamics Model Scenarios Used for Effects Analysis Purposes

Scenario	Take from KIUC Activities	KIUC HCP Powerline Minimization	KIUC HCP Conservation Strategy	Purpose
No-Take	No	Yes (100% Effective)	No	A hypothetical scenario in which the take proposed for authorization under the HCP does *not* occur because powerline minimization is 100% effective and there are no other sources of KIUC take for 50 years. The purpose of this scenario is to compare against the proposed take scenario, to evaluate the impacts of the take on the species. While this scenario begins with a baseline at which KIUC take has occurred in the past, comparing this scenario with the proposed take scenario isolates factors that are *not* related to the proposed take so that impacts of the proposed take can be clearly evaluated.
Unminimized Take	Yes	No	No	A scenario in which powerline minimization measures attributed to this HCP do not occur. The purpose of this scenario is to isolate the beneficial effects of KIUC's minimization measures by comparing outcomes with and without these measures (i.e., by comparing the unminimized take with the proposed take).
Proposed Take	Yes	Yes	No	A scenario in which the proposed, minimized take occurs, but with no additional measures to offset impacts. The purposes of this scenario are (1) to compare against the no take scenario for analyzing effects of the proposed take; (2) to compare against the unminimized take for analyzing the effects of minimization; and (3) to compare against the HCP to analyze the effects of compensatory mitigation.
HCP	Yes	Yes	Yes	This is the scenario proposed in the HCP, including the minimized take and the compensatory mitigation of the conservation strategy. The purposes are (1) to evaluate against the proposed take scenario to analyze the beneficial effects of compensatory mitigation, and (2) to compare against the no-take scenario to analyze the net adverse and beneficial effects of the proposed (minimized) take and the compensatory mitigation combined.

5.3.3 Benefits of the Conservation Strategy and Net Effects—Methods

For each covered seabird species, KIUC assessed the benefits of the conservation strategy and evaluated these benefits in combination with the impacts of the taking to ascertain the net effects of the HCP on the species.

To evaluate the benefits of the conservation strategy and net effects on Newell’s shearwater (‘a‘o) and Hawaiian petrel (‘ua‘u), KIUC used the population dynamics model summarized above and described in detail in Appendix 5E, *Population Dynamics Model for Newell’s Shearwater (‘a‘o) on Kaua‘i*. Using this model, KIUC compared the population trajectories between the proposed take scenario (without mitigation) and a scenario that assumes full implementation of the HCP (HCP scenario) (Section 5.3.3.1, *Newell’s Shearwater (‘a‘o)*, under the subsection *Beneficial and Net Effects*) (Table 5-1). KIUC quantified the net effect of the proposed, minimized take and all conservation measures on the species. The population dynamics model is subdivided into 14 subpopulations. Ten of these subpopulations are the proposed ten conservation sites described in Chapter 4, *Conservation Strategy* (Conservation Measure 4, *Manage and Enhance Seabird Breeding Habitat and Colonies at Conservation Sites*). The remaining four subpopulations correspond to portions of Kaua‘i with available population estimates and that share similar population characteristics. Appendix 5E, *Population Dynamics Model for Newell’s Shearwater (‘a‘o) on Kaua‘i*, provides descriptions and a map of these subpopulation locations. Benefits of the conservation strategy and net effects on Hawaiian petrel (‘ua‘u) and band-rumped storm-petrel (‘akē‘akē) were estimated qualitatively, incorporating the impacts of the taking (*Impacts of the Taking* in Section 5.3.3.2, *Hawaiian Petrel (‘ua‘u)*, and Section 5.3.3.3, *Band-Rumped Storm-Petrel (‘akē‘akē)*), and making qualitative assumptions regarding the benefits of the conservation measures on these species.

5.3.4 Effects Common to All Covered Seabirds

Tables 5-2, 5-3, and 5-4 provide the estimated take amounts for Newell’s shearwater (‘a‘o), Hawaiian petrel (‘ua‘u), and band-rumped storm-petrel (‘akē‘akē), respectively. The following subsections describe effects common to all covered seabirds.

Table 5-2. Newell's Shearwater ('a'o) Requested Take by Unit of Take, and Estimated Amount by Form of Take

		Average Annual[a]				Total Over 50 Years			
			Estimates by Form of Take[b]				Estimated Amount by Form of Take[b]		
	Unit of Take	Estimates by Unit of Take[f]	Mortality	Non-lethal Injury	Indirect Take of Eggs and Chicks	Requested Take by Unit of Take[g]	Mortality[c]	Non-lethal Injury[d]	Indirect Take of Eggs and Chicks[e]
Existing and new powerlines	Powerline strikes[f]	705	203	173	75	35,236	10,148	8,633	3,756
Existing streetlights and facilities	Fallout	72	72	-	-	3,605	3,605	-	-
New streetlights	Fallout	21	21	-	-	1,025	1,025	-	-
Conservation program	Individuals caught in traps	4	1	3	4	177	42	135	177
Total		**801**	**296**	**175**	**79**	**40,043**	**14,820**	**8,767**	**3,933**

[a] These are annual averages for the entire 50-year permit term. Actual annual numbers are expected to be highly variable. The take limit is established for the 50-year term, not annually. Additionally, the take limit applies only to the total estimate for each species, not to each type of covered activity. In other words, if the actual amount of take from one type of covered activity exceeds the estimate, that is not a permit violation as long as the total amount of take for all covered activities remains below the limit for the total amount of take for all covered activities.

[b] These are rough estimates based on the best available data, although little to no data are available for some of these estimates.

[c] For powerline strikes, uses 28% of strikes as a proxy for mortality based on proportion of birds grounded from Travers et al. (2021). For fallout, assumes 100% of fallout results in mortality. Although some of birds experiencing fallout will be rehabilitated by SOS, KIUC applied an assumption of 100% mortality for a conservative estimate of effects. For individuals caught in traps, estimated based on trapping data that 24% birds caught would be killed and the remainder would result in non-lethal injury.

[d] For powerline strikes, uses 24.5% of powerline strikes as a proxy for non-lethal injury based on proportion of birds that lose elevation but are not grounded from Travers et al. (2021). For fallout, assumes 100% of fallout results in mortality . Although some of birds experiencing fallout will be rehabilitated by SOS, KIUC applied an assumption of 100% mortality for a conservative estimate of effects.

[e] For powerline strikes, assumed 20% of injuries and mortalities are breeding adults and one egg or chick is taken for every breeding adult injured or killed. For lights, assumed primarily fledglings are affected and therefore a negligible number of eggs or chicks are indirectly lost. For traps, assumed conservatively that all trapped birds are breeding adults.

[f] For powerline strikes, the number of strikes are a surrogate metric for take. KIUC requests take of covered seabirds in all forms (mortality, injury, and indirect take of eggs and chicks) associated with the requested take as measured by number of powerline strikes.

Table 5-3. Hawaiian Petrel (ʻuaʻu) Requested Take by Unit of Take, and Estimated Amount by Form of Take

		Average Annual[a]				Total Over 50 Years			
	Unit of Take	Estimates by Unit of Take	Estimated Amount by Form of Take[b]: Mortality	Estimated Amount by Form of Take[b]: Non-lethal Injury	Estimated Amount by Form of Take[b]: Indirect Take of Eggs and Chicks	Requested Take by Unit of Take	Estimated Amount by Form of Take[b]: Mortality[c]	Estimated Amount by Form of Take[b]: Non-lethal Injury[d]	Estimated Amount by Form of Take[b]: Indirect Take of Eggs and Chicks[e]
Existing and new powerlines	Powerline strikes[f]	424	122	104	45	21,196	6,104	5,193	2,259
Existing streetlights and facilities	Fallout	4	4	0	-	205	205	-	-
New streetlights	Fallout	1	1	-	-	60	60	-	-
Conservation Program	Individuals caught in traps	6	2	5	6	315	76	239	315
		436	128	109	51	**21,776**	**6,445**	**5,433**	**2,574**

[a] These are annual averages for the entire 50-year permit term. Actual annual numbers are expected to be highly variable. The take limit is established for the 50-year term, not annually. Additionally, the take limit applies only to the total estimate for each species, not to each type of covered activity. In other words, if the actual amount of take from one type of covered activity exceeds the estimate, that is not a permit violation as long as the total amount of take for all covered activities remains below the limit for the total amount of take for all covered activities.

[b] These are rough estimates based on the best available data, although little to no data are available for some of these estimates, and it is not possible to track how many birds are injured or killed or how many eggs or chicks are lost due to powerline strikes and fallout.

[c] For powerline strikes, uses 28% of strikes as a proxy for mortality based on proportion of birds grounded from Travers et al. (2021). The HCP assumes that 100% of fallout due to light attraction results in mortality. Although some of the seabirds experiencing fallout will be rehabilitated by SOS, KIUC applied an assumption of 100% mortality for a conservative estimate of effects. For individuals caught in traps, estimated 24% birds caught would be killed and the remainder would result in non-lethal injury based on trapping data.

[d] For powerline strikes, uses 24.5% of powerline strikes as a proxy for non-lethal injury based on proportion of birds that lose elevation but are not grounded from Travers et al. (2021). For fallout due to light attraction, assumes 100% of fallout results in mortality. Although some of the seabirds experiencing fallout will be rehabilitated by SOS, KIUC applied an assumption of 100% mortality for a conservative estimate of effects.

[e] For powerline strikes, assumed 20% of injuries and mortalities are breeding adults and one egg or chick is taken or every breeding adult injured or killed. For lights, assumed negligible amount of breeding adults (primarily fledglings). For traps, assumed all trapped birds are breeding adults.

[f] For powerline strikes, the number of strikes are a surrogate metric for take. KIUC requests take of covered seabirds in all forms (mortality, injury, and indirect take of eggs and chicks) associated with the requested take as measured by number of powerline strikes.

Table 5-4. Band-Rumped Storm-Petrel ('akē'akē) Requested Take and Estimated Amount by Form of Take

		Average Annual[a]				Total Over 50 Years			
			Estimated Amount by Form of Take[b]				Estimated Amount by Form of Take[b]		
	Unit of Take	Estimated Take by Unit of Take	Mortality	Non-lethal Injury	Indirect Take of Eggs and Chicks	Requested Take by Unit of Take	Mortality[c]	Non-lethal Injury[d]	Indirect Take of Eggs and Chicks[e]
Existing and new powerlines	Powerline strikes[f]	<1	<1	<1	<1	22	6	5	2
Existing streetlights and facilities	Fallout	<1	<1	<1	0	40	20	20	-
New streetlights	Fallout	<1	<1	<1	0	46	46	0	-
Conservation Program	Individuals caught in traps	0	0	0	0	0	0	-	-
		<1	<1	<1	<1	**108**	**92**	**5**	**2**

[a] These are annual averages for the entire 50-year permit term. Actual annual numbers are expected to be highly variable. The take limit is established for the 50-year term, not annually. Additionally, the take limit applies only to the total estimate for each species, not to each type of covered activity. In other words, if the actual amount of take from one type of covered activity exceeds the estimate, that is not a permit violation as long as the total amount of take for all covered activities remains below the limit for the total amount of take for all covered activities.

[b] These are rough estimates based on the best available data, although little to no data are available for some of these estimates, and it is not possible to track how many birds are injured or killed or how many eggs or chicks are lost due to powerline strikes and fallout.

[c] For powerline strikes, uses 28% of strikes as a proxy for mortality based on proportion of birds grounded from Travers et al. (2021). For fallout, the HCP assumes 100% of fallout results in mortality. Although some of the seabirds experiencing fallout will be rehabilitated by SOS, KIUC applied an assumption of 100% mortality for a conservative estimate of effects. For individuals caught in traps, estimated 24% birds caught would be killed and the remainder would result in non-lethal injury based on trapping data.

[d] For powerline strikes, uses 24.5% of powerline strikes as a proxy for non-lethal injury based on proportion of birds that lose elevation but are not grounded from Travers et al. (2021). For fallout, the HCP assumes 100% of fallout results in mortality. Although some of the seabirds experiencing fallout will be rehabilitated by SOS, KIUC applied an assumption of 100% mortality for a conservative estimate of effects.

[e] For powerline strikes, assumed 20% of injuries and mortalities are breeding adults and one egg or chick is taken or every breeding adult injured or killed. For lights, assumed negligible amount of breeding adults (primarily fledglings). For traps, assumed all trapped birds are breeding adults.

[f] For powerline strikes, the number of strikes are a surrogate metric for take. KIUC requests take of covered seabirds in all forms (mortality, injury, and indirect take of eggs and chicks) associated with the requested take as measured by number of powerline strikes.

5.3.4.1 Powerline Effects

Requested Take from Powerline Collisions

KIUC is seeking state and federal authorization for the take from powerline collisions that would remain after it implements the minimization measures detailed in Chapter 4, Section 4.4, *Conservation Measures*. The total annual number of projected strikes varies by year but the HCP will cover take associated with no more than 35,236 Newell's shearwater (ʻaʻo) strikes, 21,196 Hawaiian petrel (ʻuaʻu) strikes, and 22 band-rumped storm-petrel (ʻakēʻakē) strikes over the 50-year permit term (Tables 5-2, 5-3, and 5-4).

Monitoring conducted since 2013 indicates there are natural annual variations that affect the number of covered seabirds visiting Kauaʻi, the flight patterns of those that do visit, and other factors affecting the number of collisions that occur in any given year. Such variation makes it difficult to set specific annual limits; therefore, take limits are defined as the total number of birds taken during the permit term. A 5-year rolling average of the annual take amounts will be monitored against annual performance standards for the purpose of adaptive management (see Chapter 6, *Monitoring and Adaptive Management Program*), but no annual take limits are established. Therefore, if the 5-year rolling average of annual take exceeds the amount projected based on the model (Appendix 6A, Table 6A) adaptive management is triggered but it is not a violation of the incidental take permit/incidental take license. The overall requested take from powerlines is established based on the assumption that KIUC can achieve a 65.3 percent reduction in powerline collisions by the end of year one. The take limit also takes into account local increases in collision risk that may result from exposing powerlines as a result of vegetation maintenance or raising the height of powerlines (i.e., KIUC will be held to the same take limit even with modifications such as exposing or raising powerlines). Additionally, the take limit applies only to the total estimate for each species, not to each type of covered activity. In other words, if the actual amount of take from one type of covered activity exceeds the estimate, that is not a permit violation as long as the total amount of take for all covered activities remains below the limit for the total amount of take for all covered activities.

5.3.4.2 Light Attraction Effects

Requested Take from Light Attraction

As described in Chapter 4, Section 4.4.2, *Conservation Measure 2. Implement Measures to Minimize Light Attraction*, KIUC has minimized and will continue to minimize its light-related impacts on the covered seabirds throughout the life of the permit term.

- Using full-cutoff shields for streetlights and covered facility lights
- Using white light-emitting diode (LED) lights on outdoor lights at its covered facilities.
- Managing the use of facility lighting so that lights are dimmed during the fledgling fallout season (September 15 to December 15).

These measures have reduced the risk of take from light attraction of the covered seabirds to the maximum extent practicable. Despite these efforts, some risk of light attraction and fallout remains. Table 5-5 provides the estimated take of the covered seabirds resulting from light attraction with the existing minimization in place throughout the permit term. These estimates are based on the analysis and calculations described in detail in Appendix 5C, *Light Attraction Modeling*. The requested take authorization is considered a conservative estimate for the following reasons.

- Streetlight take estimates are based on remotely sensed radiance data in October 2018. This precedes KIUC's minimization of light attraction at KIUC's facilities through light dimming.
- KIUC included all streetlights for which ownership was uncertain in Appendix 5C, *Light Attraction Modeling*. This approach assumes that some non-KIUC streetlights are included in the take estimate.
- KIUC used a constant annual rate of light attraction, with the maximum amount of annual take from full buildout of streetlights assumed in Year 1 of plan implementation, when in fact full buildout will occur gradually through the permit term.

KIUC may implement additional minimization measures to further reduce take through the monitoring and adaptive management strategies described in Chapter 6, *Monitoring and Adaptive Management Program*.

Table 5-5. Estimated Take of Covered Seabirds from Light Attraction After Minimization[a]

	Estimated Average Annual Mortality				
	Existing Streetlights[b]	Future Streetlights	Covered Facility Lights[b, c]	Total Average Annual	50-Year Take[d]
Newell's shearwater (ʻaʻo)	66.9	20.5	5.2	92.6	4,630
Hawaiian petrel (ʻuaʻu)	4.0	1.2	0.1	5.3	265
Band-rumped storm-petrel (ʻakēʻakē)	0.7	0.1	0	0.9	46

[a] Based on analysis provided in Appendix 5C, *Light Attraction Modeling*. Assumes constant annual rate. The take limit for light attraction is only for the 50-year permit term. Average annual mortality is expected to vary considerably; estimates provided for average annual mortality are not take limits.

[b] With continued full implementation of minimization measures in Chapter 4, Section 4.4.2, *Conservation Measure 2. Implement Measures to Minimize Light Attraction*.

[c] Midpoint between long-term average and average considering data in 2019 and 2020 after KIUC began dimming facility lights during the fallout season, which would continue throughout the permit term (Appendix 5C, *Light Attraction Modeling*).

[d] Take estimates assume a stable metapopulation on Kauaʻi. Take estimates would be an overestimate if the metapopulation on Kauaʻi declines, or an underestimate if the Kauaʻi metapopulation increases over the permit term. These estimates are considered conservative because the metapopulation is not expected to increase to the extent that take would exceed the estimated amounts (Appendix 5E, *Population Dynamics Model for Newell's Shearwater (ʻaʻo) on Kauaʻi*).

5.3.4.3 Conservation Measure Effects

Requested Take from Conservation Measure Implementation

Section 5.3.1.3, *Take from Traps—Methods*, describes how KIUC estimated the amount of take that may occur because of covered seabirds being caught in traps. Tables 5-2 and 5-3 provide the resulting take estimates for Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu), respectively.

Management of Conservation Sites

As described in Chapter 4, *Conservation Strategy*, KIUC will offset the requested take of Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu) by managing and enhancing breeding colonies of these species, and reducing the abundance and distribution of seabird predators in northwestern Kauaʻi. Through these measures, KIUC will increase the number of chicks produced annually to reverse the historic downward trend of the Kauaʻi metapopulations of this species as determined by radar and acoustic call rates.

Management actions with proven success at improving the reproductive success of Newell's shearwater (ʻaʻo) breeding colonies are ongoing and would continue and be expanded by the HCP for the duration of the permit term. Expanding the scale and types of these conservation actions (e.g., installing predator-proof fencing at feasible sites) is expected to further reduce predation and increase the survivorship of chicks produced each year. Social attraction within the fenced conservation sites is also expected to accelerate colony recruitment.

Predator control at the conservation sites is expected to significantly increase the reproductive success rate of Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu). Predator control that either establishes predator-free breeding habitat or substantially reduced predation is required to successfully restore productive seabird colonies (Buxton et al. 2014; Jones and Kress 2012; Raine et al. 2020). Given the length of time necessary to produce one chick (5–6 years of age) (Ainley et al. 2020), adult mortality is particularly harmful to the species. Predation by introduced species have depressed seabird populations to a level where they are extremely vulnerable to extirpation (U.S. Fish and Wildlife Service 2018). Terrestrial predator control has been proven to increase seabird nesting productivity on Kauaʻi. Raine et al. (2020) found that between 2011 and 2017, Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu) reproductive success rates increased by a mean of approximately 36 percent and 48 percent, respectively, following predator control operations within managed breeding sites. Additionally, Raine et al. (2020) found that barn owl (*Tyto alba*) control measures, when implemented in a concentrated and systematic fashion, can significantly decrease seabird depredations. Without predator control, Raine et al. found that modeled population trajectories within all management sites declined rapidly over a 50-year period. The conservation measures to offset take are designed to result in early improvements in the viability of the Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu) metapopulation on Kauaʻi by focusing conservation efforts in areas expected to have the greatest benefit to the species. Substantial metapopulation increases at the conservation sites and improved survival at the monitoring sites, in combination with minimizing take, are expected to reverse the current island-wide population decline and establish a viable metapopulation of each species on Kauaʻi (as defined by meeting the HCP biological objectives associated with biological goals 1 and 2).[13]

Save Our Shearwaters Program

The HCP includes a $300,000 annual funding commitment to continue to the SOS Program, which is a sufficient level of funding to support KIUC's HCP commitments. The benefit of continuing this program to the covered seabirds is quantified in Table 5-6. Chapter 6, Table 6-3, outlines an

[13] No population viability analysis has been conducted for the covered seabirds. However, USFWS and DOFAW (Nagatani 2022) estimate that for the Kauaʻi metapopulation of Newell's shearwater (ʻaʻo), 10,000 individuals (and 2,500 breeding pairs) represent a minimum viable level viable for the Plan Area.

adaptive management trigger to further ensure this funding is sufficient throughout the entire permit term.

The SOS Program has been active since 1979. However, in the early years of the program it operated with a limited budget and inconsistent staffing levels; it also lacked the systematic protocols for bird rescue, rehabilitation, and release that exist today. As a consequence, data from the program's early years provide an inaccurate estimate of bird rescues expected during the permit term. To estimate benefits to the covered seabirds during the permit term, more recent and reliable SOS Program data was used from 2009 to the present. This range captures the period over which the SOS Program has used consistent, systematic protocols and staffing levels that are expected to continue throughout the permit term given the funding commitment by KIUC.

Table 5-6 provides the number of covered seabirds recovered or rehabilitated and released by the SOS Program from 2009 to 2019 (the last full year from which data are available), and the estimated annual and 50-year recovery, rehabilitation, and release based on projections into the future of this historical data.

Table 5-6. Covered Seabirds Expected to be Rehabilitated and Released through the SOS Program, by Species

Covered Seabird Species	No. of Individuals Recovered and Released 2009–2019	Average Annual Historic Rate of Recovery and Release	Estimated 50-Year Recovery and Release[a]
Newell's shearwater (ʻaʻo)	1,600	160.0	8,000
Hawaiian petrel (ʻuaʻu)	64	6.4	320
Band-rumped storm-petrel (ʻakēʻakē)	4	0.4	20
Total	**1,668**	**166.8**	**,8,340**

[a] Assumes the average historic rate of recovery and release from 2009 to 2019 would continue throughout the 50-year permit term. This table makes no assertions about rate of survival for recovered and released birds. SOS recoveries are an assumed benefit to the species but these benefits were not quantified and were not factored into the population dynamics model to calculate effects and offsets to the Kauaʻi metapopulation.

The SOS Program recovered and released 1,668 of the covered seabirds from 2009 through 2019 (Table 5-6). Approximately 60 percent of the covered species that are handled by the SOS Program are rehabilitated and released back into the wild[14] (Bache 2019), with the expectation that they will successfully reproduce in future nesting seasons. There is evidence that rehabilitated and released fledglings of covered seabirds have reduced survivorship compared with wild fledglings, but a substantial proportion of rehabilitated fledglings have been documented to successfully migrate to their wintering grounds (Raine et al. 2020). Using satellite tags, Raine et al. (2020) found that 21 days after release that 28.9 percent of 38 SOS-rehabilitated fledglings were still transmitting in comparison with 50 percent of a similar sample of 12 wild fledglings. It is assumed that all of the rehabilitated seabirds would have died as a result of collision or grounding injuries, starvation, dehydration, predation, vehicle interactions, or other sources of mortality, if not retrieved, treated, and released by the SOS Program. Consequently, the SOS Program plays an important role in improving populations of the covered species on Kauaʻi.

[14] The remaining 40 percent are dead on arrival or their injuries are so severe they must be euthanized.

Because there is evidence that rehabilitated and released birds have reduced survivorship, the population dynamics model takes a conservative approach and does not reduce mortality to account for birds recovered and released. That is, the effects of rehabilitating and releasing covered seabirds is not factored into the population dynamics model. Table 5-6 provides the anticipated number of birds to be rehabilitated and released during the 50-year permit term, rather than number of birds expected to survive after rehabilitation, because this is a quantifiable amount that can be tracked during HCP implementation.

5.3.5 Species-Specific Seabird Effects

5.3.5.1 Newell's Shearwater (ʻaʻo)

Effects and Level of Take

Table 5-2 provides the requested take amounts for Newell's shearwater (ʻaʻo) and estimated amounts for each form of take. KIUC requests all forms of take of Newell's shearwater (ʻaʻo) that result from the following.

- Up to 35,236 strikes over 50 years from existing and new powerlines.
- Fallout of up to 3,605 individuals over 50 years from light attraction of existing KIUC-operated streetlights and facilities.
- Fallout of up to 1,025 individuals over 50 years from light attraction of new KIUC-operated streetlights.
- Injury or mortality of up to 177 individuals (injury of 135 and mortality of 42) over 50 years as a result of traps used for the conservation program.

The estimates for amount of take associated with each form of take (Table 5-2) is a rough approximation based on the best available data. Because each form of take resulting from powerline collisions and fallout cannot be measured in the field (see explanation in Section 5.3.1, *Methods for Quantifying Take and Assessing Effects on the Covered Seabirds*), take from these sources will not be tracked according to each form of take (i.e., injury, mortality, or indirect take of eggs or young).

Impacts of the Taking

The range-wide breeding population of the Newell's shearwater (ʻaʻo) occurs mostly on Kauaʻi (Appendix 3A, *Species Accounts*). Breeding populations of Newell's shearwater (ʻaʻo) on Kauaʻi declined by an estimated 94 percent over a 20-year period from 1993 to 2013 (Raine et al. 2017).

Because the Newell's shearwater (ʻaʻo) reproductive strategy has evolved to have high adult survivorship with a relatively low number of offspring, adult mortality is particularly detrimental to the species. Left unchecked, low adult survivorship (i.e., high adult mortality), along with reduced reproductive success and chick survivorship, will depress the population to a level where they can become vulnerable to extirpation. Small population sizes can result in poor colony recruitment, which further decreases the species population viability. The historic decline of the Newell's shearwater's (ʻaʻo) metapopulation on Kauaʻi is the result of a variety of factors including powerline strikes, light attraction fallout, predation by introduced species, stochastic events such as hurricanes that damage breeding habitat, and climate shifts altering shearwater food availability.

Operation of KIUC infrastructure has had substantial adverse effects on the Kauaʻi metapopulation of this species. The current rate of seabird powerline collision is affecting the age structure of the population by removing large portions of subadult and adult individuals annually from the population. Collectively, the long-term effects of powerline collisions and fallout from attraction to streetlights, combined with severe predation, are likely a primary reasons the metapopulation is at historically low levels. Because at least 90 percent of the range-wide individuals of Newell's shearwater (ʻaʻo) occur on Kauaʻi, a viable metapopulation in the Plan Area is critical to species recovery.

Reduction of annual Newell's shearwater (ʻaʻo) collisions with existing powerlines consistent with Objective 1.1 is a significant step toward reducing the decline of this species on Kauaʻi. The minimization measures will result in substantial ongoing reduction in take throughout the permit term. Take limits have been established for the HCP based on this expected take minimization, and Chapter 6, Section 6.4.1.2, *Take Monitoring*, describes how take will be monitored and minimization measures will be adaptively managed to ensure the take limit is not exceeded. As shown by comparing the unminimized take (red line) and proposed take (grey line) scenarios on Figure 5-2 (see Table 5-1 for description of each scenario), this reduction in collisions is expected to improve the population rate of change. This is the anticipated result of retaining more adults and subadults, thereby improving demography, age class structure, and population size.

As described in Section 5.3.1.4, *Impacts of the Taking—Methods*, KIUC evaluated the impacts of the taking by comparing a hypothetical no-take scenario with the proposed take scenario (and no mitigation measures). The difference between the no-take (purple line) and proposed take (grey line) scenarios in Figure 5-2 reflects the impact of KIUC's requested take on the species throughout the permit term in the absence of mitigation measures. As described in Appendix 5E, *Population Dynamics Model for Newell's Shearwater (ʻaʻo) on Kauaʻi*, in the hypothetical absence of take related to KIUC operations,[15] the Kauaʻi metapopulation would continue to decline at an estimated annual rate of 1.8 percent per year (Lambda = 0.982[16]; Figure 5-2, purple line). This is the modeled rate of decline that results from setting powerline and fallout mortality rates to zero and applying the predation mortality and reproductive success rates estimated at conservation sites prior to implementation of KIUC's predator control measures. This assessment suggests that the effects of predation and other threats to the species remain substantial even without the adverse effects of KIUC covered activities.

As shown by the grey line on Figure 5-2, even with minimization, the continued loss of Newell's shearwaters (ʻaʻo) as a result of KIUC covered activities could have an appreciable negative effect on the metapopulation of Newell's shearwaters (ʻaʻo) in the absence of mitigation measures to offset these effects. The net effects of the KIUC HCP on the species, considering both the adverse effects of the proposed take and the beneficial effects of the proposed mitigation measures, are described below.

[15] Since KIUC powerlines are already in operation and their removal would be infeasible, this no-take scenario is hypothetical and used only as a basis for evaluating the impact of the taking on the species.

[16] Lambda (λ) represents the annual population multiplier. A lambda of 1.0 indicates a population that is replacing itself but not growing or declining (i.e., a stable population). A lambda above 1.0 indicates a growing population. A lambda below 1.0 indicates a declining population.

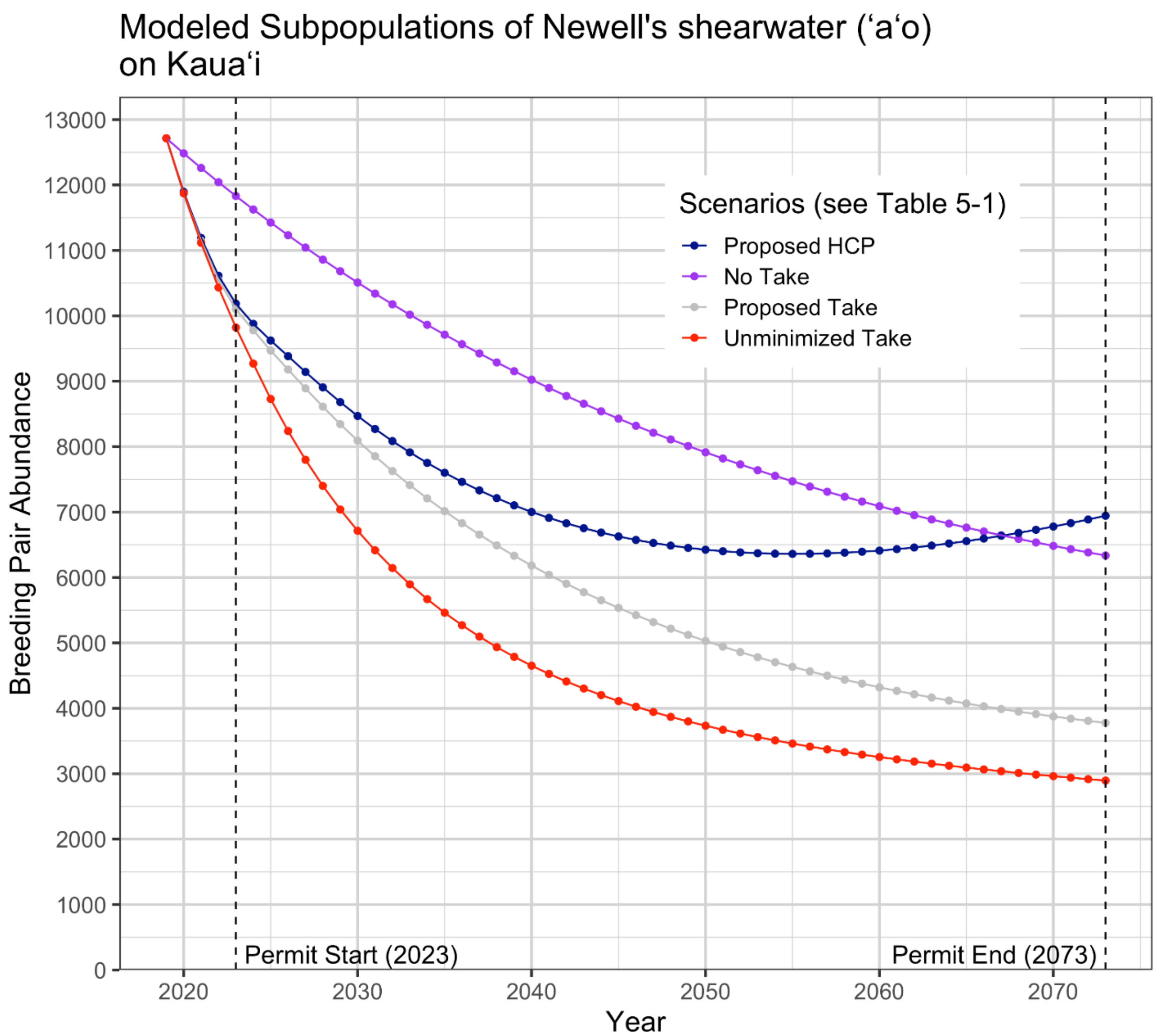

Figure 5-2. Newell's Shearwater (ʻaʻo) Population Dynamics Model: Island-wide Outcomes for All Scenarios[17]

[17] See Table 5-1 for a description of each scenario evaluated to assess effects of the take and the conservation strategy. See Appendix 5E, *Population Dynamics Model for Newell's Shearwater (ʻaʻo) on Kauaʻi* for details on the model structure and assumptions.

Beneficial and Net Effects

The measure described in Chapter 4, Section 4.4.4, *Conservation Measure 4. Manage and Enhance Seabird Breeding Habitat and Colonies at Conservation Sites,* is expected to mitigate the impact of Newell's shearwaters (ʻaʻo) mortalities resulting from KIUC covered activities. KIUC will offset the impact of the requested take of Newell's shearwaters (ʻaʻo) by implementing management actions with proven success at improving the reproductive success of Newell's shearwater (ʻaʻo) breeding colonies by reducing predation and increasing the survivorship of chicks produced each year. Social attraction within the fenced conservation sites is also expected to accelerate colony recruitment. The conservation measures to offset take are designed to result in early improvements in the viability of the Newell's shearwater (ʻaʻo) metapopulation on Kauaʻi by focusing conservation efforts in areas expected to have the greatest benefit to the species.

Metapopulation Viability

Substantial population increases at the conservation sites and improved survival of the species on Kauaʻi outside the conservation sites, in combination with minimizing take, are expected to reverse the current island-wide population decline and establish a viable metapopulation of Newell's shearwater (ʻaʻo) on Kauaʻi consistent with Goal 1 in Chapter 4, *Conservation Strategy* (Figure 5-2). Chapter 4, Section 4.3.1, *Newell's Shearwater (ʻaʻo)*, describes how *viable* is defined in the context of population dynamics modeling. The population dynamics model indicates that the KIUC HCP would achieve Goal 1 for Newell's shearwater (ʻaʻo), resulting in a viable metapopulation on Kauaʻi as represented by the following characteristics.

- Number of breeding pairs
- Population growth rate
- Age structure and demography
- Distribution

Each of these characteristics is described below in relation to the output of the population dynamics model.

Number of breeding pairs. Consistent with Objective 1.3, KIUC will (1) maintain an annual minimum of 1,264 breeding pairs of Newell's shearwater (ʻaʻo) in the conservation sites throughout the permit term, (2) reach a target of 2,371 breeding pairs by year 25 of the permit term, and (3) reach a target of 4,313 breeding pairs on the conservation sites by the end of the permit term. As described in Chapter 6, Section 6.4.4, *Conservation Site Monitoring and Adaptive Management*, and Table 6-2, KIUC will monitor the conservation sites and adaptively manage them to ensure these commitments are met.

The population dynamics model is consistent with a metapopulation size for Newell's shearwater (ʻaʻo) on Kauaʻi of over 6,300 breeding pairs at the lowest point of forecasted abundance during the 50-year permit term (Appendix 5E, *Population Dynamics Model for Newell's Shearwater (ʻaʻo) on Kauaʻi*). A metapopulation size at this abundance level is well within the range of what has been suggested in meta-analyses of minimum viable population sizes integrating a wide range of case studies for birds and other taxa (Trail et al. 2007; Reed 2003). These estimates take into account the roles of age structure, catastrophes, random demographic and environmental fluctuations (stochasticity), and inbreeding depression. The model projects that the population size will consist of an estimated 6,958 breeding pairs by the end of the permit term, with the population continuing to increase beyond the permit term. This is well above estimates by USFWS and DOFAW (2022) that for the Kaua'i metapopulation of Newell's shearwater ('a'o), 10,000 individuals and 2,500 breeding pairs represent a minimum viable abundance level for the Plan Area. As shown in Figure 5-2, no other scenario except the proposed HCP reaches this level of abundance or produces a positive growth trajectory of the island-wide metapopulation by the end of the permit term.

Population growth rate. Consistent with Objective 1.3, KIUC will maintain an annual growth rate for breeding pairs of at least 1 percent as measured by a 5-year rolling average, and maintain a 5-year rolling average of 87.2 percent reproductive success rate at reference burrows. As described in Chapter 6, Section 6.4.4., *Conservation Site Monitoring and Adaptive Management* and Appendix 6A, *Adaptive Management Comparison Tables*, KIUC will monitor the conservation sites and adaptively manage them to ensure these commitments are met.

The results of KIUC's population dynamics model indicates that after a period of decline in the metapopulation size on Kaua'i, the conservation actions included in the HCP would result in a reversal of the modeled initial downward trend that would begin at approximately Year 33 of the permit (2056) (Figure 5-2). This upward population growth trend is expected to continue for the remainder of the permit term, approximately 17 years. This positive growth for 17 years would result in population growth island-wide (Figure 5-2, dark blue line) that would also continue after the permit term if the same conservation measures remained in place. This positive rate of change in metapopulation size before the end of the permit term is a key result of the population dynamics model that is consistent with metapopulation viability on Kaua'i under the HCP.

Age structure and demography. Modeled metapopulation numbers for Newell's shearwater ('a'o) that are increasing are, by definition, consistent with viability because an increase in the modeled metapopulation size occurs when the total annual number of fledglings produced is greater than the number of deaths on an island-wide basis. This positive productivity by approximately Year 33 of the HCP will result in a net benefit to the modeled metapopulation of Newell's shearwater ('a'o). This modeled metapopulation on Kaua'i by approximately Year 33 is expected to overcome the reductions in survival and reproductive success resulting from future predicted levels of powerline strikes, light fallout from KIUC streetlights and covered facilities, and reduced levels of introduced predators in and near the conservation sites.

Distribution. As described in Chapter 4, *Conservation Strategy*, there are practical limitations precluding conservation efforts in areas of Kaua'i outside the conservation sites; therefore, future populations are likely to become spatially concentrated in remote locations with rugged terrain that are distant from most powerlines and lights, and where conservation efforts from this HCP, other HCPs, and other conservation and mitigation actions are focused. Figures 5-3 and 5-4 show the projected population trajectories for subpopulations inside and outside the 10 conservation sites proposed by this HCP, respectively.

The results of the population dynamics model are consistent with the future breeding distribution of Newell's shearwater ('a'o) on Kaua'i becoming spatially more concentrated towards the conservation sites, the Wainiha and Lumaha'i Valleys, and the Nā Pali Coast in the future (i.e., areas close to the conservation sites). Although the population dynamics model results suggest that some subpopulations outside of the conservation sites would not be considered viable, the conservative biological assumptions underlying the results for these subpopulations result in modeled rates of decline that are consistent with the largest estimated rate of decline observed across individual radar monitoring sites. That is, prior to the HCP, is the model assumes that the Hanalei to Kekaha area has been experiencing a -10.7 percent annual rate of decline, corresponding to the estimated trend at the Hanelei radar site. Of the 13 radar sites that have been systematically monitored since 1993, Hanalei produced the largest rate of decline that has been observed at any of the individual radar monitoring sites between Hanalei and Kekaha. By comparison, the average rate of decline when averaged across the 13 radar sites during the same 1993–2020 time period is -6.9 percent per year (Raine and Rossiter 2020). Furthermore, during the last decade (2010–2020), the overall trend across radar sites has been stable (Raine and Rossiter 2020). If the actual population trend in this area (and other areas included in the most recent analyses of the radar survey data) has been stable over the last decade, the results of the HCP population dynamics model would substantially *overestimate* the extent to which the future spatial distribution of breeding Newell's shearwaters ('a'o) on Kaua'i might be decreased by KIUC's take. Nevertheless, as stated above, modeled metapopulation numbers that are increasing by approximately Year 33 of the permit term are consistent with a viable metapopulation, despite a shift in distribution to concentrate populations in areas with high long-term conservation value.

Beneficial Effects of the Conservation Strategy

KIUC compared a scenario without the proposed conservation strategy (i.e., the unminimized take scenario) with the HCP scenario to evaluate the beneficial effects of the conservation strategy. Appendix 5E, *Population Dynamics Model for Newell's Shearwater ('a'o) on Kaua'i*, and Figures 5-2 through 5-5 provide relevant results from the population dynamics model. The red lines on each figure indicate the estimated population trajectory of the unminimized take scenario based on the following assumptions.

- Predation rates measured at monitored colonies prior to dedicated predator control are applied to every subpopulation.
- No predator control occurs at any of the HCP conservation sites.
- Powerline strikes and light attraction continue, but no powerline minimization occurs, other than what previously occurred as part of the Short-Term HCP.

The section below titled *Addressing Uncertainty* explains why the initial rate of population decline of -7.4 percent for the scenario in which take is neither minimized nor mitigated (unminimized take scenario) is conservative. Under this unminimized take scenario, all subpopulations are projected to decline rapidly until approximately 2060 and then begin to level off, but with a continuing decline (Figures 5-2, red line).

Figure 5-3 demonstrates that the conservation measures implemented at four of the conservation sites will substantially benefit Newell's shearwater ('a'o) and do so relatively quickly. The three conservation sites that see only moderate levels of benefit for Newell's shearwater ('a'o) are Hanakāpi'ai, Hanakoa, and North Bog, which are designed primarily to benefit Hawaiian petrel ('ua'u). HCP benefits are greatest at the four conservation sites with predator exclusion fencing and social attraction, as expected. Figure 5-4 illustrates that subpopulations outside the conservation sites show little to no benefits compared to a scenario with unminimized take and no mitigation.

Continued predator control of the remaining six conservation sites by the HCP, combined with powerline collision minimization, will prevent substantial declines of existing subpopulations of Newell's shearwater ('a'o) and likely prevent local extirpation (red lines). Four of these conservation sites with predator control (Pōhākea, Hanakāpi'ai, Hanakoa, and Honopū) collectively contribute substantial numbers of new breeding pairs to the Kauaʻi metapopulation of Newell's shearwater (ʻaʻo) with the proposed HCP (dark blue lines; Figure 5-3).

The population trajectory for Newell's shearwater (ʻaʻo) at all conservation sites combined is shown in Figure 5-5 and demonstrates substantial benefits resulting from the conservation strategy. According to the model, the total population size of Newell's shearwater (ʻaʻo) at all of the conservation sites combined is expected to increase immediately with the rate increasing gradually through approximately 2035. After that, the population increases steadily and more substantially due to the contributions of the four social attraction sites (Site 10, Upper Limahuli, Pōhākea PF,[18] and Honopū PF[19]). Of these four sites, Upper Limahuli contributes by far the greatest number of new birds because of its much larger starting population. It is possible that the social attraction sites will attract new breeding pairs to their sites sooner than expected; if this happens, the population growth within the conservation sites will likely occur even faster.

The increase in subpopulations of Newell's shearwater (ʻaʻo) within the conservation sites is expected to overcome the substantial declines projected in the largest subpopulation (Hanalei to Kekaha; see black line in Figure 5-4). The increases in subpopulations of the four conservation sites combined is therefore expected to provide a substantial benefit to Newell's shearwater (ʻaʻo) on Kauaʻi, with a reverse in the species' downward population trend and with increasing species abundance by approximately Year 33 of the permit term.

[18] PF stands for predator exclusion fence.

[19] Honopū PF awaits final approval from the landowner.

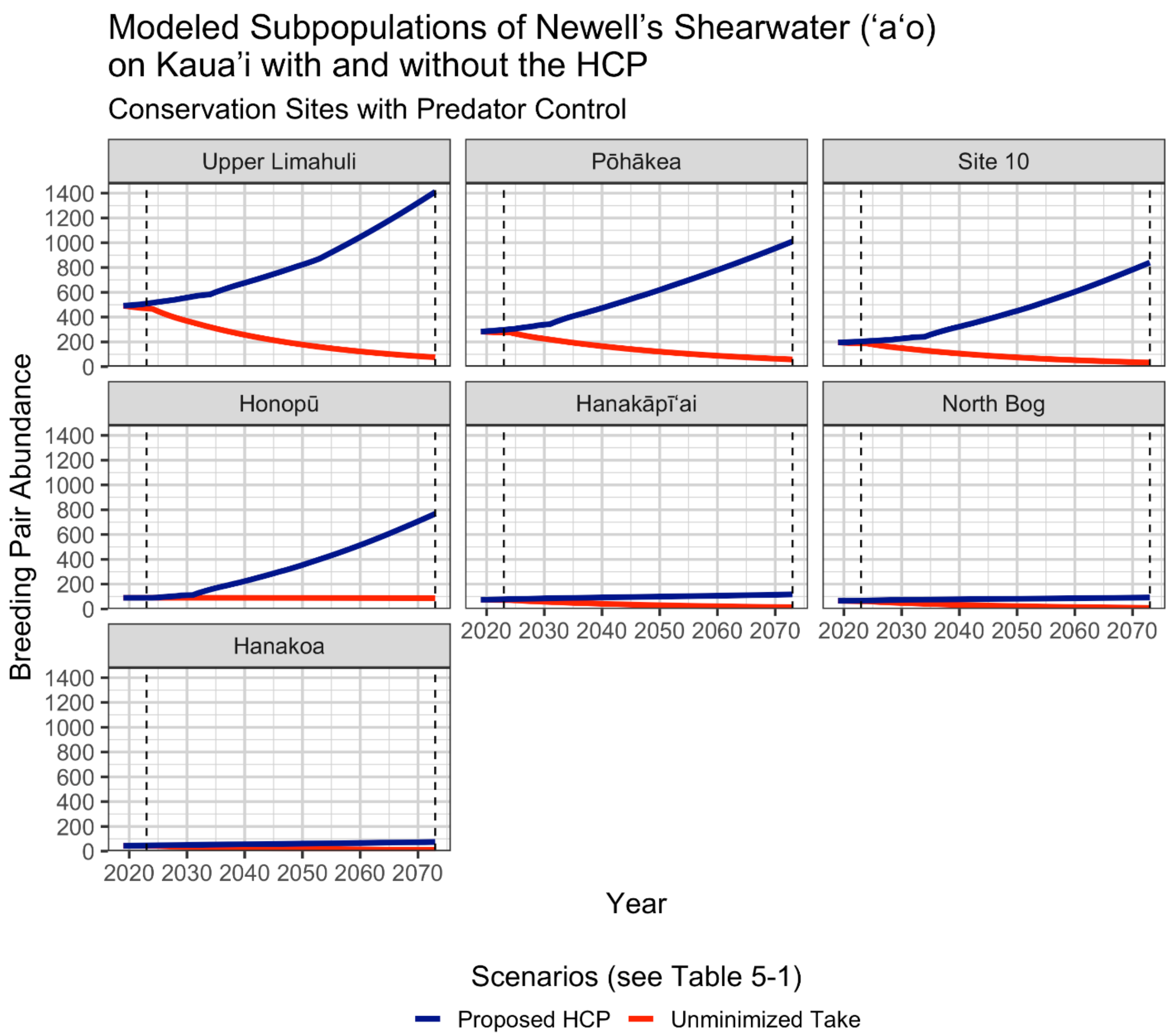

Figure 5-3. Population Dynamics Model Results for Newell's Shearwater ('a'o) for Each Conservation Site

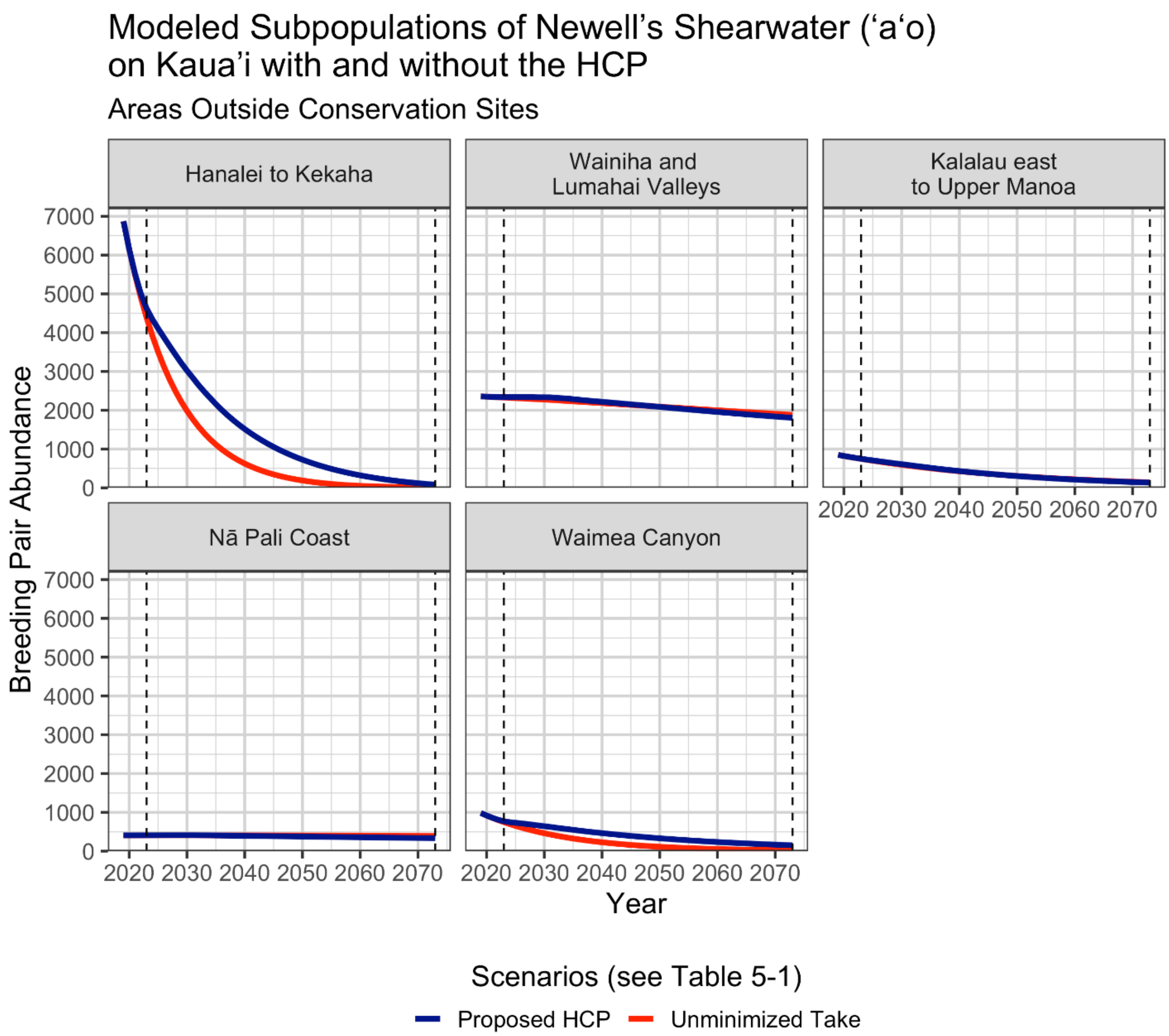

Figure 5-4. Population Dynamics Model Results for Newell's Shearwater (ʻaʻo) for Subpopulation Outside Conservation Sites

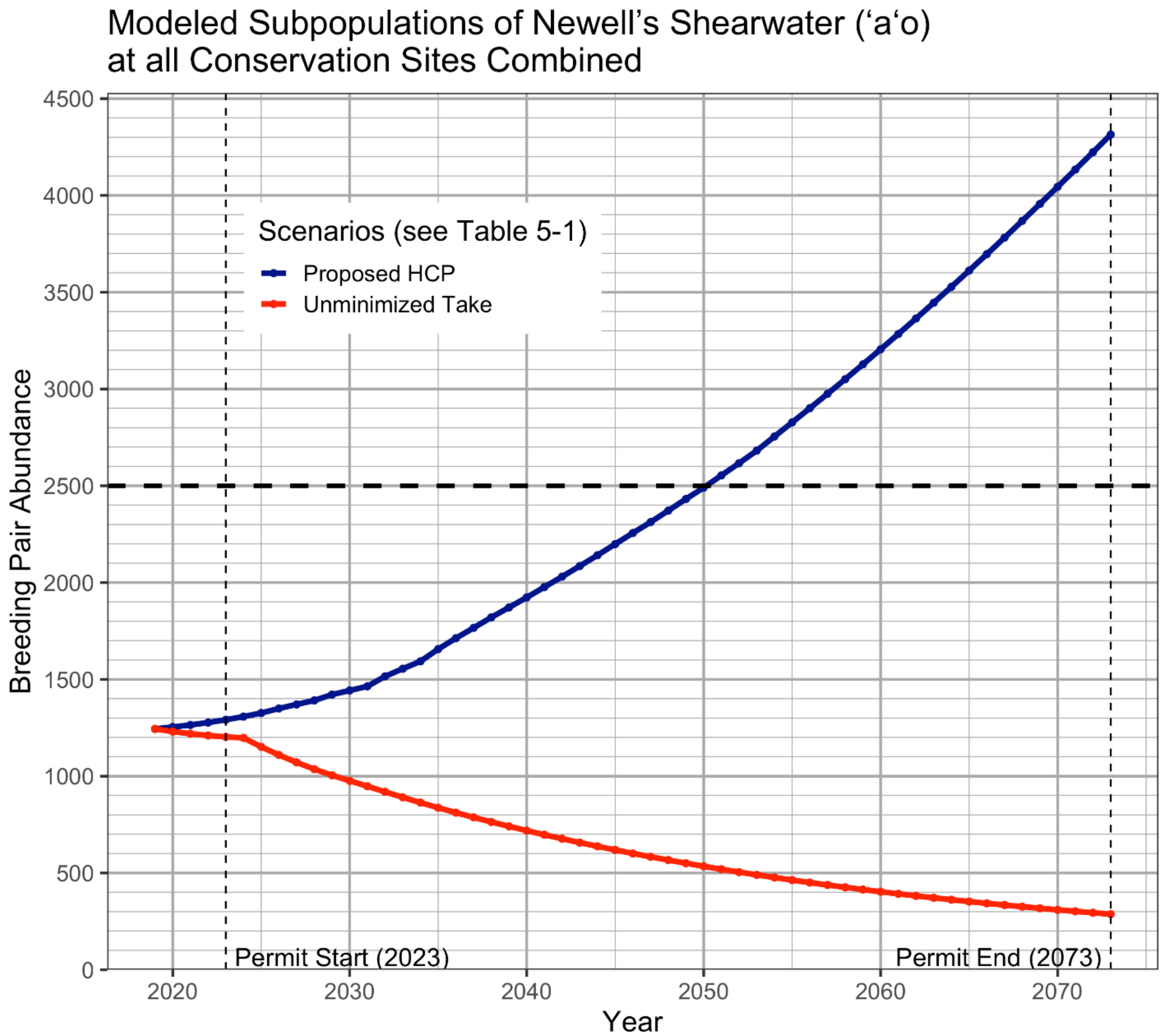

Figure 5-5. Population Dynamics Model Results for Newell's Shearwater ('a'o) for all Conservation Sites Combined

Net Effects

As described in Section 5.3.1.5, *Benefits of the Conservation Strategy and Net Effects—Methods*, the difference between the no-take scenario and the proposed HCP scenario (with its proposed conservation strategy) represents the net effects. These net effects include both the adverse effects of the proposed take and the beneficial effects of the proposed conservation strategy. The hypothetical scenario of no KIUC take during the 50-year permit term (Figure 5-2, purple line) shows a downward species decline resulting from factors other than KIUC's proposed take. In other words, even if KIUC was able to eliminate all take associated with its current and future facilities (i.e., 100 percent minimization), the Newell's shearwater ('a'o) metapopulation on Kaua'i is predicted to decline substantially and continue declining well after the 50-year permit term.[20]

In contrast, the HCP conservation measures including minimization and mitigation are projected by approximately Year 33 of the permit term to begin to reverse this decline and result in a net benefit to the Kaua'i metapopulation for 17 years of the permit and until the end of the permit term (Figure 5-3, dark blue line) compared to a scenario with no take and no KIUC conservation (Figure 5-3, purple line). HCP conservation measures are projected to slow the decline considerably between 2040 and 2050 and stabilize the island-wide metapopulation. After approximately 2056, the metapopulation is projected to increase gradually until the end of the permit term, with a net increase in numbers of breeding pairs (dark blue line) compared with a hypothetical scenario in which the proposed take did not occur (purple line). Hence, the HCP provides a net benefit to Newell's shearwaters ('a'o).

Addressing Uncertainty

The modeling used to estimate adverse, beneficial, and net effects on Newell's shearwaters ('a'o) required the application of assumptions that in some cases have a high level of uncertainty.[21] KIUC addressed this uncertainty by using conservative assumptions that err on the side of the species. In other words, the assumptions would tend to overestimate impacts, underestimate benefits, or both. For example, the initial modeled rate of decline without conservation measures represents an island-wide metappopulation that is decreasing at -7.4 percent per year, which is faster than the long-term trend in radar data across monitoring sites during 1993–2020 (radar lambda = 0.931, or a -6.9 percent decline per year; Raine and Rossiter 2020). Also, the model only takes into account the benefits to the species of one other conservation action on Kaua'i, the Kaua'i Seabird HCP conservation site. Other conservation actions implemented by others or expected in the future by others are not included in the model.

As noted above, an example of a conservative model assumption is the initial rate of metapopulation decline. The model assumes an initial rate of metapopulation decline under the unminimized take scenario of -7.4 percent per year. This estimate is conservative because it is greater than the -6.9 percent per year population decline from radar data (1993–2020). The radar trend, unlike the modeled metapopulation trend, only covers those areas of the island with breeding colonies most affected by powerlines and fallout. The radar survey estimate does not incorporate trends from breeding colonies in northwestern Kaua'i, including the conservation sites. Trends in abundance at the conservation sites have been positive since 2014–2015, as estimated through acoustic call rate monitoring data (Raine et al. 2022). Therefore, the modeled trend for the metapopulation is conservative, because it includes areas which are increasing in abundance, yet matches the long-term average radar site trend which only covers those areas of Kaua'i that have been most affected by powerline collisions and fallout. Moreover, trend data from independent data sources suggest that current trends may be less negative than they have been historically, and that abundance levels may have stabilized during the last decade for those areas of the island most affected by powerline collisions and fallout. SOS rescue data in recent years is consistent with a population at a stable level, on average. Additionally, Raine and Rossiter (2020) showed that the trends in radar estimates of

[20] Additional modeling would be needed to determine whether a future stable state of the metapopulation of Newell's shearwater ('a'o) on Kaua'i without take from KIUC covered activities would be viable or not.

[21] Appendix 5E, *Population Dynamics Model for Newell's Shearwater ('a'o) on Kaua'i*, provides a description of these sources of uncertainty.

population size have leveled out since about 2009, indicating that after a very large population decline before 2009, the population trend may now be relatively stable (a regression of radar data for the last decade [2010–2020] was flat with no significant change). Given the recent radar data that suggests a relatively consistent (albeit low) population of Newell's shearwater ('a'o), projections for the unminimized take scenario (red lines) are likely overestimating potential population declines in the future in the absence of predator control or powerline minimization. For a description of these assumption and additional examples of how the model is likely conservative, see Appendix 5E, *Population Dynamics Model for Newell's Shearwater ('a'o) on Kaua'i*.

The monitoring and adaptive management strategy described in Chapter 6, *Monitoring and Adaptive Management Program*, is designed to monitor the success of KIUC's minimization and conservation measures throughout the permit term and adjust measures as needed. This will provide additional safeguards around the uncertainties associated with the population dynamics model because ongoing monitoring data gathered during implementation will be compared against model projections, and conservation measures will be adaptively managed to ensure the species' biological goals and objectives are met.

5.3.5.2 Hawaiian Petrel ('ua'u)

Effects and Level of Take

Table 5-3 provides the requested take for Hawaiian petrel ('ua'u) and estimated amounts for each form of take. KIUC requests all forms of take of Hawaiian petrel ('ua'u) that result from the following.

- Up to 21,196 strikes over 50 years from existing and new powerlines.
- Fallout of up to 205 individuals over 50 years from light attraction of existing KIUC-operated streetlights and facilities.
- Fallout of up to 60 individuals over 50 years from light attraction of new KIUC-operated streetlights.
- Injury or mortality of up to 315 individuals (injury of 76 and mortality of 239) over 50 years as a result of traps used for the conservation program.

The estimates for amount of take associated with each form of take (Table 5-3) is a rough approximation based on the best available data. Because each form of take resulting from powerline collisions and fallout cannot be measured in the field (see explanation in Section 5.3.1, *Methods for Quantifying Take and Assessing Effects on the Covered Seabirds*), take from these sources will not be tracked according to each form of take (i.e., injury, mortality, or indirect take of eggs or young).

Impacts of the Taking

Breeding populations of the endangered Hawaiian petrel ('ua'u) on Kaua'i declined by an estimated 78 percent over a 20-year period from 1993 to 2013 (Raine et al. 2017). This decline is the result of a variety of factors including powerline strikes, light attraction fallout, predation by introduced species, and stochastic events such as hurricanes that damage breeding habitat, and climate shifts altering shearwater food availability. As with Newell's shearwater ('a'o) (Section 5.3.3.1, *Newell's Shearwater ('a'o)*), the Hawaiian petrel's ('ua'u) reproductive strategy renders adult mortality particularly harmful to the species; high adult mortality may depress the population to a level that is vulnerable to extirpation.

Reduction of annual Hawaiian petrel ('ua'u) collisions from existing powerlines consistent with Objective 2.1 is a significant step toward reducing the decline of this species on Kaua'i. The minimization measures will result in substantial ongoing reduction in take throughout the permit term, and take limits have been established for the HCP based on this expected take minimization. Chapter 6, Section 6.4, *Take and Effectiveness Monitoring and Adaptive Management Triggers*, describes how take will be monitored and minimization measures will be adaptively managed to ensure the take limit is not exceeded. As shown by comparing the unminimized take (red line) and proposed take (grey line) scenarios on Figure 5-6 (see Table 5-1 for description of each scenario), this reduction in collisions is expected to improve the population rate of change. This is the anticipated result of retaining more adults and subadults, thereby improving demography, age class structure, and population size.

As described in Section 5.3.1.4, *Impacts of the Taking—Methods*, KIUC evaluated the impacts of the taking by comparing a hypothetical no-take scenario with the proposed take scenario (and no mitigation measures). The difference between the no-take (purple line) and proposed take (grey line) scenarios in Figure 5-6 reflects the impact of KIUC's requested take on the species throughout the permit term in the absence of mitigation measures. As described in Appendix 5F, *Population Dynamics Model for Hawaiian Petrel ('ua'u) on Kaua'i*, in the hypothetical absence of take related to KIUC operations during the 50-year analysis period,[22] the Kaua'i metapopulation would continue to decline at an estimated annual rate of 4.7 percent per year (Lambda = 0.963[23]; Figure 5-6, grey line). This is the modeled rate of decline that results from setting powerline and fallout mortality rates to zero and applying the predation mortality and reproductive success rates estimated at conservation sites prior to implementation of KIUC's predator control measures. The purple line on Figure 5-6 suggests that the effects of predation and other threats to the species remain substantial even without the adverse effects of KIUC covered activities. The difference between no take (purple line) and minimized, proposed take (grey line) scenarios in the absence of mitigation reflects the impact of KIUC's requested take on the species throughout the permit term. Even with minimization, the continued loss of Hawaiian petrel ('ua'u) as a result of KIUC covered activities could have an appreciable negative effect on the metapopulation of Hawaiian petrel ('ua'u) in the absence of mitigation measures to offset these effects. The net effects of the KIUC HCP on the species, considering both the adverse effects of the requested take and the beneficial effects of mitigation measures, are described below.

[22] Since KIUC powerlines are already in operation and their removal would be infeasible, this no-take scenario is hypothetical and used only as a basis for evaluating the impact of the taking on the species.

[23] Lambda (λ) represents the annual population multiplier. A lambda of 1.0 indicates a population that is replacing itself but not growing or declining (i.e., a stable population). A lambda above 1.0 indicates a growing population. A lambda below 1.0 indicates a declining population.

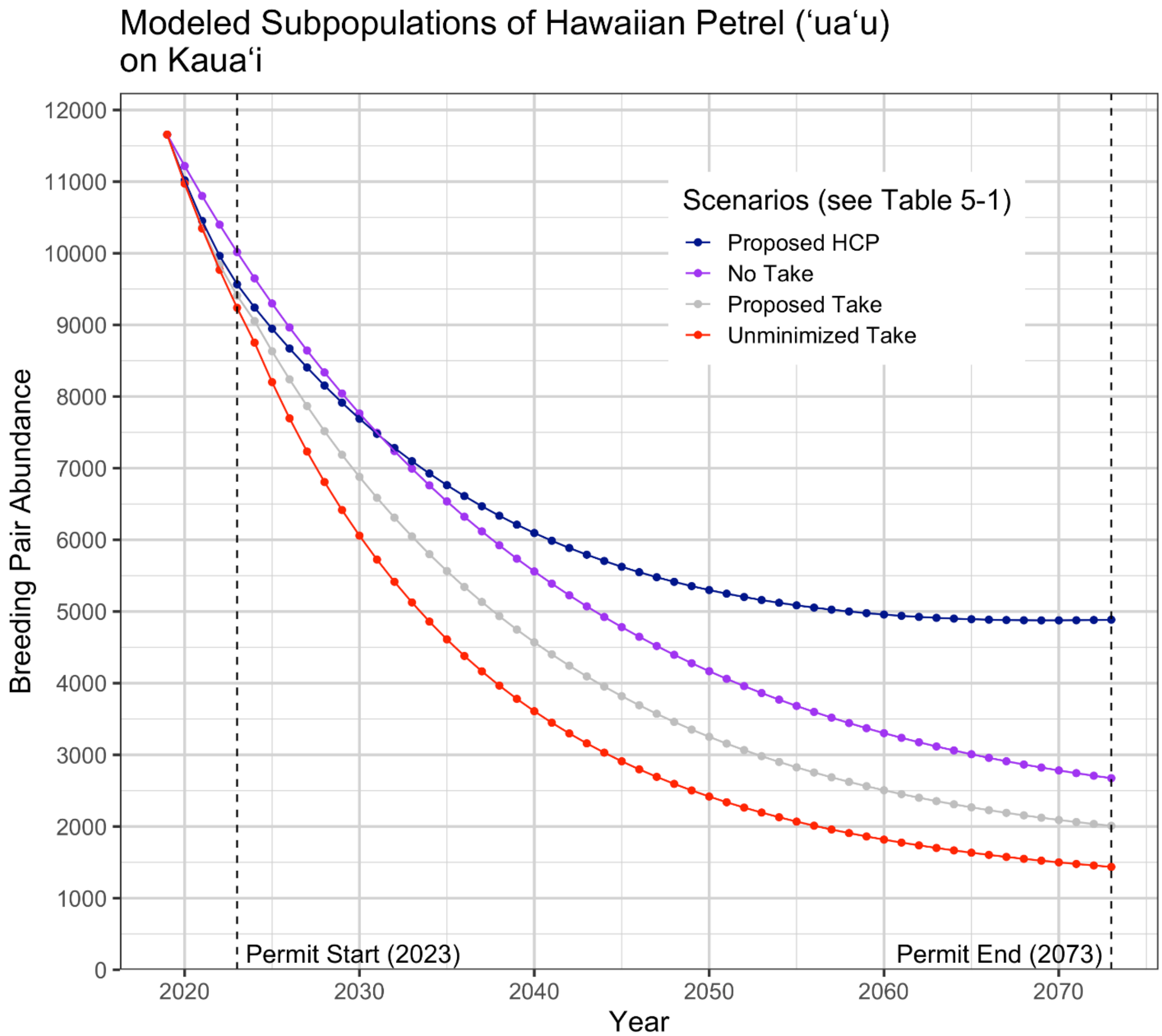

Figure 5-6. Population Dynamics Model Results for Hawaiian Petrel (ʻuaʻu) Island-wide for All Four Scenarios

Beneficial and Net Effects

The measure described in Chapter 4, Section 4.4.4, *Conservation Measure 4. Manage and Enhance Seabird Breeding Habitat and Colonies at Conservation Sites,* is expected to mitigate Hawaiian petrel (ʻuaʻu) mortalities resulting from KIUC covered activities through management and enhancement of breeding colonies and reduction of predators (the same as Newell's shearwater [ʻaʻo] described in Section 5.3.3.1, *Newell's Shearwater (ʻaʻo)*, subsection *Beneficial and Net Effects*).

Metapopulation Viability

Substantial population increases at the conservation sites and improved survival outside the conservation sites, in combination with minimizing take, are expected to eventually reverse the current island-wide population decline and establish a stable, viable metapopulation of Hawaiian petrel (ʻuaʻu) on Kauaʻi consistent with Goal 2 in Chapter 4, *Conservation Strategy*. Chapter 4, Section

4.3.2, *Newell's Shearwater (ʻaʻo)*, describes how *viable* is defined in the context of population dynamics modeling. The population dynamics model indicates that the KIUC HCP would meet Goal 2 for Hawaiian petrel (ʻuaʻu), resulting in a viable metapopulation on Kauaʻi as represented by the following characteristics.

- Number of breeding pairs
- Population growth rate
- Age structure and demography
- Distribution

Each of these characteristics is described below in relation to the output of the population dynamics model.

Number of breeding pairs. Consistent with Objective 2.3, KIUC will maintain an annual minimum of 2,257 breeding pairs on the conservation sites throughout the permit term, reach a target of 5,851 breeding pairs by year 25 of the permit term, and reach a target of 7,429 breeding pairs on the conservation sites by the end of the permit term. As described in Chapter 6, Section 6.4.4, *Conservation Site Monitoring and Adaptive Management*, and Appendix 6A, *Adaptive Management Comparison Tables*, KIUC will monitor the conservation sites and adaptively manage them to ensure these commitments are met.

The model predicts that the population size consists of an estimated 5,288 breeding pairs by the end of the permit term, with the population stabilizing and slightly increasing beyond the permit term. This is well above estimates by USFWS and DOFAW (2022) that for the Kauaʻi metapopulation of Hawaiian petrel (ʻuaʻu), 10,000 individuals (and 2,500 breeding pairs) represent a minimum viable level viable for the Plan Area.

Population growth rate. Consistent with Objective 2.3, KIUC will maintain an annual growth rate for breeding pairs of at least 1 percent at all conservation sites combined as measured by a 5-year rolling average, and maintain a 5-year rolling average of 78.6 percent reproductive success rate at reference burrows. As described in Chapter 6, Section 6.4.4, *Conservation Site Monitoring and Adaptive Management*, and Appendix 6A, *Adaptive Management Comparison Tables*, KIUC will monitor the conservation sites and adaptively manage them to ensure these commitments are met. As shown on Figure 5-9, the population growth rate at all conservation sites combined is expected to be between 1.008 and 1.011 throughout the permit term (a number greater than 1.0 indicates a growing population). As shown in Table 5-6, by the end of the permit term the metapopulation of Hawaiian petrel on Kauaʻi is modeled to be stable. Although difficult to see in the graph, the modeled metapopulation of Hawaiian petrel (ʻuaʻu) begins to grow slightly starting in Year 47 of the permit term (2075). All else being equal (i.e., the HCP conservation measures remaining in place), this positive growth trajectory would continue after the permit term and continue to increase, similar to the result for Newell's shearwater (ʻaʻo) (see Figure 5-2).

Demography and age structure. Modeled metapopulation numbers that are stable or increasing are consistent with viability because a stable or increasing modeled metapopulation size occurs when the total annual number of fledglings produced is equal to or greater than the number of deaths on an island-wide basis. This stable or slightly positive productivity at the end of the HCP will result from achieving the biological objectives, resulting in a net benefit to the modeled metapopulation that overcomes the reductions in survival and reproductive success resulting from future levels of powerline strikes, light fallout, and introduced predators. As shown on Figure 5-9, the combined conservation sites are expected to demonstrate a relatively high rate of population growth reflecting an age structure and demography consistent with a viable population.

Spatial distribution. As described in Chapter 4, *Conservation Strategy*, there are practical limitations precluding conservation efforts in areas of Kauaʻi outside the conservation sites; therefore, future populations are likely to become spatially concentrated in remote locations with rugged terrain that are distant from powerlines and lights, where conservation efforts are focused. The results of the population dynamics model are consistent with the future breeding distribution of Hawaiian petrel (ʻuaʻu) on Kauaʻi becoming spatially more concentrated towards the conservation sites and Wainiha and Lumahaʻi Valleys in the future.

Although the population dynamics model results suggest that some subpopulations outside of the conservation sites would not be considered viable, the conservative biological assumptions underlying the results for these subpopulations follow modeled rates of decline that are based on the largest estimated rate of decline observed across individual radar monitoring sites. That is, prior to the HCP, it is assumed the Hanalei to Kekaha area has been experiencing a -8.1 percent annual rate of decline, corresponding to the estimated trend at the Waiakalua Stream radar site. Of the 13 radar sites that have been systematically monitored since 1993, this is the most drastic rate of decline that has been observed at any of the individual radar monitoring sites between Hanalei and Kekaha. By comparison, the average rate of decline when averaged across the 13 radar sites during the same 1993–2020 time period is -4.6 percent per year (Raine and Rossiter 2020). Furthermore, during the last decade (2010–2020), the overall trend across radar sites has been stable (Raine and Rossiter 2020).

If the actual population trend in this area, and other areas included in the most recent analyses of the radar survey data has been stable during the last decade, the results of the population dynamics model would substantially *overestimate* the extent to which the future spatial distribution of breeding Hawaiian petrel (ʻuaʻu) on Kauaʻi might be decreased by take of KIUC covered activities. Nevertheless, as noted above, a stable population well above the abundance threshold is consistent with a viable metapopulation, despite a shift in distribution to concentrate populations in areas with higher long-term conservation value.

Beneficial Effects of the Conservation Strategy

KIUC compared a scenario without the proposed conservation strategy (i.e., the unminimized, proposed take scenario) with the proposed HCP scenario to illustrate the beneficial effects of the proposed conservation strategy. Appendix 5F, *Population Dynamics Model for Hawaiian Petrel (ʻuaʻu) on Kauaʻi*, and Figures 5-6 through 5-9, provide relevant results from the population dynamics model. The red line on Figure 5-6 indicates the estimated population trajectory of a scenario with ongoing take and no minimization or other conservation measures, based on the same assumptions described above for Newell's shearwater (ʻaʻo).

When all subpopulations are combined for Kauaʻi (Figure 5-6), the Hawaiian petrel (ʻuaʻu) metapopulation is projected to continue to decline with ongoing take and no minimization or other KIUC conservation measures (red line). By the end of the analysis period (2073), the Kauaʻi metapopulation would be close to extirpation. Depending on the age structure and spatial distribution of the species at that time, it may be functionally extinct due to its slow reproductive rate. In contrast, the HCP conservation measures are to slow the decline considerably between 2040 and 2060 and stabilize the island-wide metapopulation (Figure 5-6, dark blue line).

With an initial rate of population decline under the unminimized take scenario at -5.4 percent per year, nearly all subpopulations are projected to be extirpated by approximately 2050 or soon afterwards (Figure 5-6). The population dynamics results in Figure 5-7 demonstrate that the conservation measures at all the conservation sites will benefit Hawaiian petrel (ʻuaʻu), with substantial benefits at North Bog and Pihea. HCP benefits are greatest at the four conservation sites with predator exclusion fencing and social attraction, with slight to substantial population declines outside conservation sites as shown on Figure 5-8. The population trajectory for Hawaiian petrel (ʻuaʻu) at all conservation sites combined shown in Figure 5-9 shows that the total population size of Hawaiian petrel (ʻuaʻu) at all of the conservation sites is expected to increase steadily.

Net Effects

The difference between the no-take scenario and the HCP with its proposed conservation strategy represents the net effect resulting from the proposed take combined with the proposed conservation. The hypothetical scenario of no KIUC take during the 50-year permit term (Figure 5-6, grey line) shows a downward species decline resulting from factors other than KIUC's proposed take. In contrast, the HCP conservation measures including minimization and mitigation are projected by the end of the permit term to provide net benefits to the species by year 10 and these net benefits increase through the remainder of the permit term, as shown by comparing the grey and dark blue lines on Figure 5-6. There is projected to be a net increase in numbers of breeding pairs (dark blue line) compared with a hypothetical scenario in which the proposed take did not occur (grey line). Hence, the HCP provides a substantial net benefit to Hawaiian petrel (ʻuaʻu).

Addressing Uncertainty

Uncertainties around the modeling used to estimate adverse, beneficial, and net effects on Hawaiian petrel (ʻuaʻu) are addressed in the same manner as described above for Newell's shearwater (ʻaʻo). That is, conservative estimates were used in the model, and model projections will be compared against monitoring data during implementation to adjust the conservation strategy as needed and ensure the biological goals and objectives are met for the species.

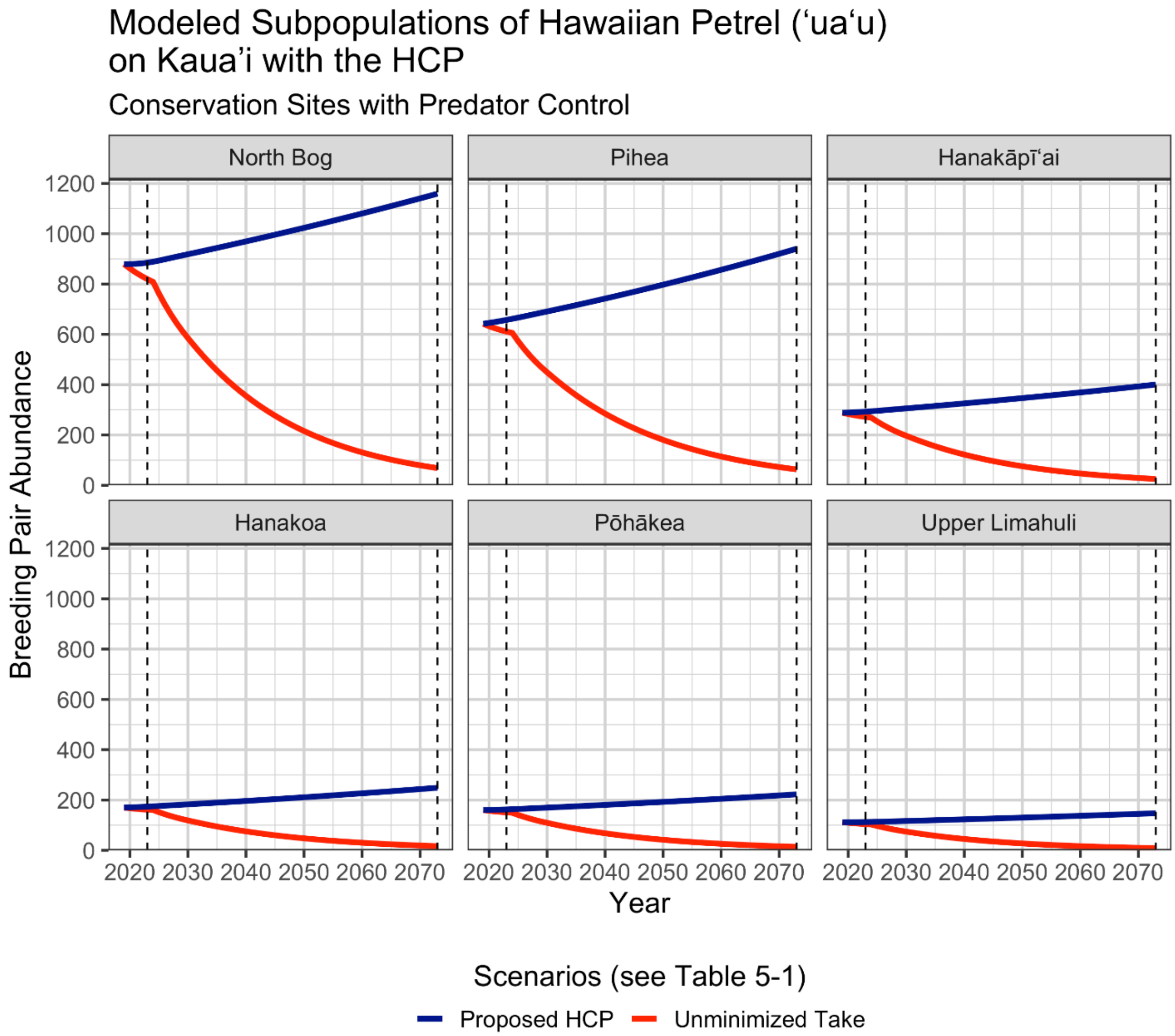

Figure 5-7. Population Dynamics Model Results for Hawaiian Petrel (ʻuaʻu) for Each Conservation Site

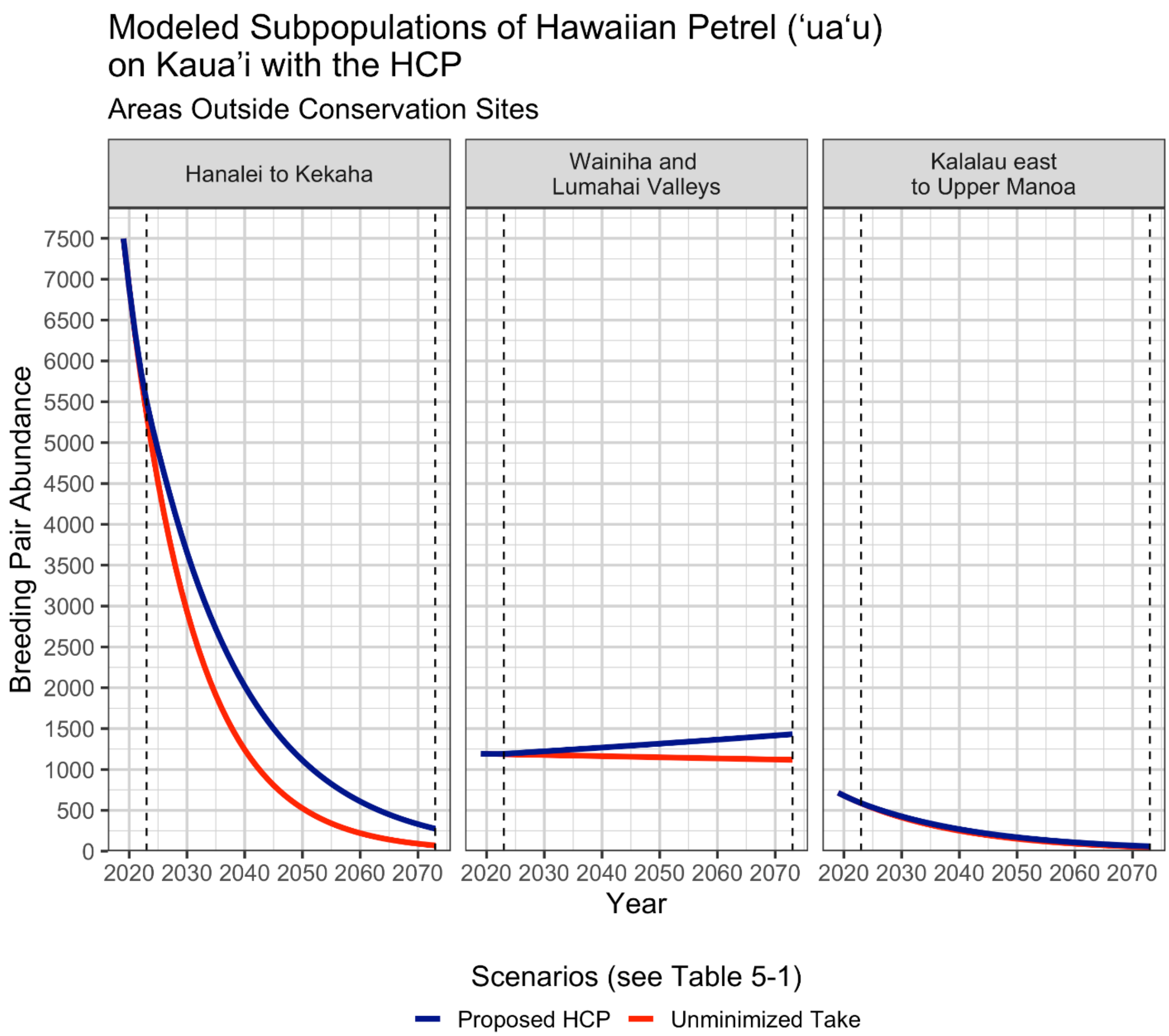

Figure 5-8. Population Dynamics Model Results for Hawaiian Petrel (ʻuaʻu) for Unmanaged Sites

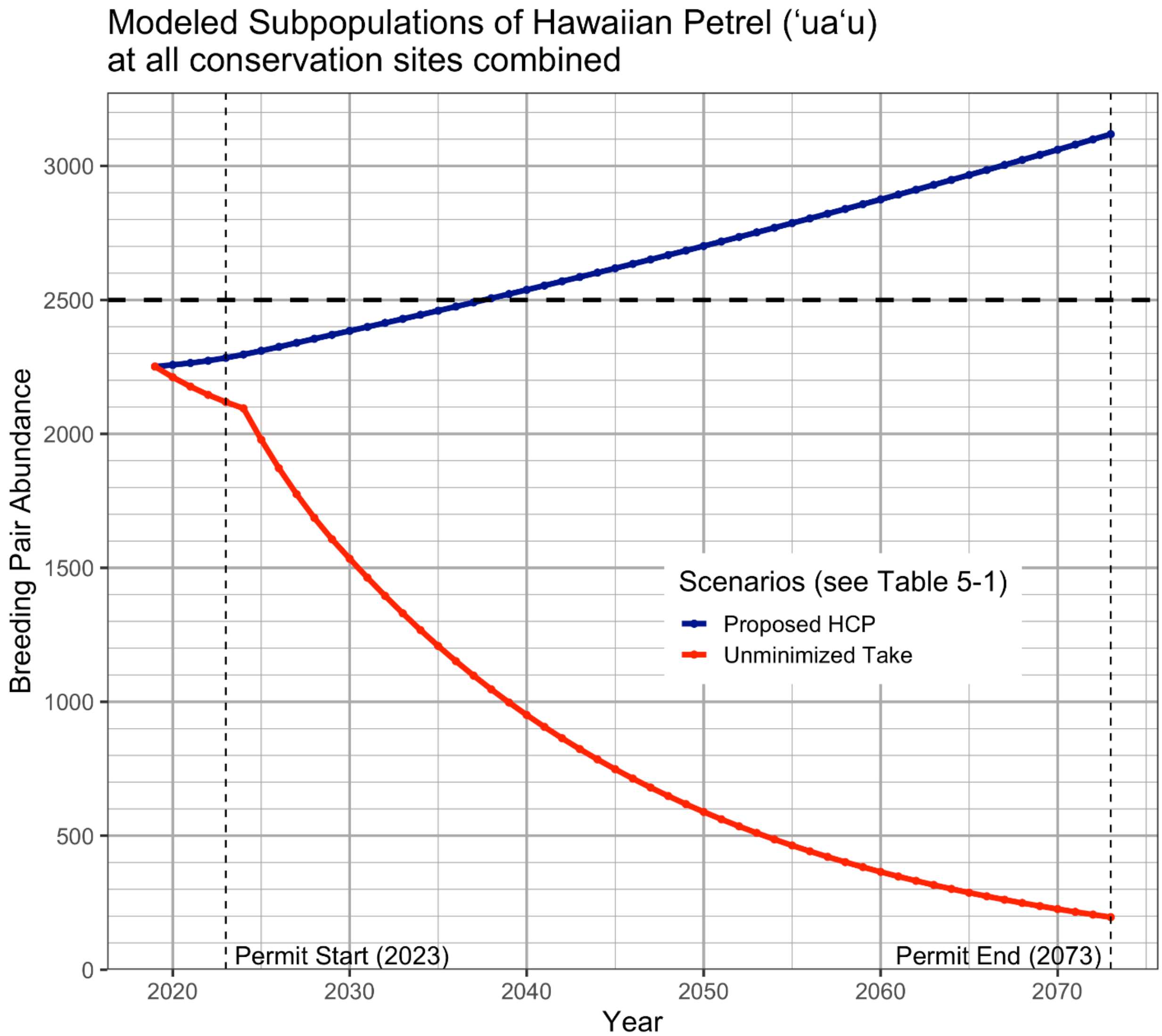

Figure 5-9. Population Dynamics Model Results for Hawaiian Petrel ('ua'u) for all Conservation Sites Combined

5.3.5.3 Band-Rumped Storm-Petrel ('akē'akē)

Effects and Level of Take

Table 5-4 provides the requested take for band-rumped storm-petrel ('akē'akē) and estimated amounts for each form of take.

There are no reliable estimates for take of band-rumped storm-petrel ('akē'akē) resulting from powerline collisions because the species is relatively rare on Kaua'i and powerline strikes are thought to be very rare (even relative to their low abundance). For the purpose of this analysis, KIUC assumed a total mortality of 16 band-rumped storm-petrels ('akē'akē) from existing powerlines and 6 from new powerlines over the 50-year permit term. Ongoing research and monitoring will evaluate the levels of take during implementation and provide measures to ensure the effects on the species do not exceed those limits, as described in Chapter 6, *Monitoring and Adaptive Management Program*.

Impacts on band-rumped storm-petrel (ʻakēʻakē) from light attraction are difficult to estimate because it is a very small and cryptic seabird that is difficult to find once grounded. Work in remote colonies of band-rumped storm-petrels (ʻakēʻakē) indicate this species is extremely susceptible to light attraction (Raine in litt.). Thus, light attraction of this species is likely underreported (Raine et al. 2017). The estimated annual band-rumped storm-petrel (ʻakēʻakē) mortality resulting from fallout is an average of 0.8 bird from streetlights and no birds from covered facility lighting (Appendix 5C, *Light Attraction Modeling*), resulting in total take estimate from fallout of 40 birds over the 50-year permit term.

The estimates for amount of take associated with each form of take (Table 5-4) is a rough approximation based on the best available data. Because each form of take resulting from powerline collisions and fallout cannot be measured in the field (see explanation in Section 5.3.1, *Methods for Quantifying Take and Assessing Effects on the Covered Seabirds*), take from these sources will not be tracked according to each form of take (i.e., injury, mortality, or indirect take of eggs or young).

Impacts of the Taking

The worldwide population size of the band-rumped storm-petrel (ʻakēʻakē) is uncertain, but is most likely around 150,000 birds (Appendix 3A, *Species Accounts*). The Hawaiʻi distinct population segment (DPS) of the band-rumped storm-petrel (ʻakēʻakē) represents a small, remnant population of possibly 400–500 birds (Appendix 3A, *Species Accounts*) or an estimated 221 breeding pairs (U.S. Fish and Wildlife Service 2020). Based on the scarcity of known breeding sites in Hawaiʻi, the remote and inaccessible locations where they are suspected to occur today, and compared to prehistoric population levels and distribution, the Hawaiʻi DPS of band-rumped storm-petrel (ʻakēʻakē) appears to be significantly reduced in numbers and range following human occupation of the Hawaiian Islands (Appendix 3A, *Species Accounts*). The mortality of an estimated 0.51 adult band-rumped storm-petrel (ʻakēʻakē) per year due to powerline strikes represents 0.15 percent of the estimated Hawaiʻi DPS (0.4300/400=0.0015 or 0.15 percent). Additionally, the mortality of 1.0 fledgling band-rumped storm-petrel (ʻakēʻakē) per year (Table 5-7) represents 0.38 percent of the estimated total fledglings produced annually by this species (221 breeding pairs; 1.0/211 = 0.0047 = 0.47 percent). The loss of 108 band-rumped storm-petrels (ʻakēʻakē) over the 50-year permit term, as described in the previous section, is not likely to have an appreciable effect on the survival and recovery of the Hawaiʻi DPS of band-rumped storm-petrel (ʻakēʻakē). The net effects of the KIUC HCP on the band-rumped storm-petrel (ʻakēʻakē), taking both the adverse and beneficial effects into account, are described below.

Beneficial and Net Effects

The measure described in Chapter 4, Section 4.4.3, *Conservation Measure 3. Provide Funding for the Save Our Shearwaters Program*, is expected to minimize and partially offset effects of powerline strikes for band-rumped storm-petrel (ʻakēʻakē). Based on SOS data from 2009 through 2019, an estimated 20 band-rumped storm-petrels (ʻakēʻakē) will be rescued and released over the 50-year permit term (Table 5-6), minimizing and partially offsetting the 44 mortalities from KIUC covered activities conservatively estimated for this species over the permit term. Management of the conservation sites are not expected to directly benefit this species because no band-rumped storm-petrels (ʻakēʻakē) have been observed at these sites to date. However, the species is likely to benefit from predator control at the Honopū conservation site because of its proximity to the Nā Pali Coast where most band-rumped storm-petrel (ʻakēʻakē) are thought to occur on Kauaʻi. Barn owl control at all conservation sites is likely to benefit band-rumped storm-petrel (ʻakēʻakē)by reducing predation at their breeding sites from these wide-ranging predators. KIUC expects funding of the SOS Program, in addition to the conservation measures for the other two covered species, are sufficient to offset the impact of the taking on band-rumped storm-petrel (ʻakēʻakē). Considering both the take associated with KIUC activities and the effects of SOS recoveries and regional predator control, the KIUC HCP will have a net benefit on band-rumped storm-petrels (ʻakēʻakē) on Kauaʻi.

5.4 Effects on Covered Waterbirds

5.4.1 Methods for Assessing Effects on Waterbirds

The covered waterbirds are susceptible to powerline strikes but not susceptible to light attraction, so the analysis focuses only on estimating the effects of powerline strikes. The effects analysis for covered waterbirds is based on an assessment provided as Appendix 5B, *Rapid Waterbird Powerline Collision Assessment,* completed by Marc Travers and André Raine in 2020. This section summarizes the methods of this assessment.

A combination of acoustic data of recorded strikes and observations of waterbird behavior around powerlines were used to estimate powerline collisions for three of the covered waterbirds: Hawaiian stilt (aeʻo) (*Himantopus mexicanus knudseni*), Hawaiian duck (koloa maoli) (*Anas wyvilliana*), and Hawaiian goose (nēnē) (*Branta sandvicensis*). Observational and acoustic data were not available for the other two covered waterbirds, Hawaiian common gallinule (ʻalae ʻula) (*Gallinula galeata sandvicensis*) and Hawaiian coot (ʻalae keʻokeʻo) (*Fulica alai*), so strike estimates were not developed for these species. Rather, analysis of grounded bird detections was used to estimate the number of powerline mortalities (not strikes) for these two species.

All waterbird collisions were assigned to one of three geographic areas: (i) Mānā, (ii) Hanalei wetlands, and (iii) all other areas (Figure 4-1). Mānā is the only area with a full range of monitoring data including observation data, acoustic detections of strikes, and modeling of acoustic strike patterns across a season. Hanalei wetlands (east of the town of Hanalei) includes the Hanalei National Wildlife Refuge; this area has a large concentration of suitable breeding and foraging habitat for all of the covered waterbirds, is known to support a large share of the island's population of each species and overlaps with powerlines. However, no monitoring data is available for this area.

All other sites on Kauaʻi where covered waterbirds occur have (1) relatively low densities of occurrences, (2) are far from powerlines and therefore have low risks of collisions, or (3) both; for these reasons, all other sites on the island were combined into a single category. Because of the lack of observational or acoustic data at Hanalei wetlands and all other areas, observational and acoustic data from Mānā was used as the basis for the determination of waterbird powerline collisions in the other two areas.

To partition the total number of powerline collisions by species, a collision risk score was developed that ranked each species' (covered and noncovered) relative collision risk at Mānā. The collision risk score for each species was based on a combination of observational data including the frequency of powerline crossings, the flight height of the birds crossing the wires (i.e., proximity of flight to wires), and whether the covered waterbirds tend to fly singly or in pairs or flocks (birds in pairs or flocks have a higher collision risk than single birds). Each species' proportion of risk was then calculated by dividing each species' risk score by the total risk scores for all covered waterbirds.

For Mānā, night strikes and crepuscular strikes (i.e., dawn and dusk) were estimated separately because the Bayesian acoustic strike model does not address crepuscular strikes (Appendix 5D, *Bayesian Acoustic Strike Model*). The Bayesian acoustic strike model results in an estimated 640 night strikes of all birds (covered seabirds, covered waterbirds, and non-covered birds) annually at Mānā. The total night strikes were multiplied by each species' proportion of risk to estimate annual night strikes for each species at Mānā. For crepuscular strikes, the raw crepuscular strike numbers were adjusted to a strike estimate proportionally equivalent to the Bayesian model estimate (i.e., the proportion of Bayesian night strike estimates to raw night strike estimates was applied to the crepuscular raw strike data to arrive at crepuscular night strike estimates). Night strike estimates and crepuscular strike estimates were then added together for the total annual take estimate for Mānā.

Powerline collision rates at Hanalei were estimated based on Mānā estimates and adjusted proportionately by the relative length of powerlines at each site (powerline configuration and heights are similar between the sites). The Hanalei section of powerlines is 95 percent of the length of powerlines at Mānā, so Mānā strike rates were multiplied by 0.95 to estimate the Hanalei strike rates.

To assess strike rates at all other sites, the collision risk score was calculated for each waterbird species based on island-wide observational monitoring data from all other powerlines. The proportion of all strikes that occur in monitored areas outside Mānā was then estimated by dividing the collision risk score outside Mānā by the risk score at Mānā. This proportion was multiplied by the estimated strike rate at Mānā to estimate the strike rate in other areas. Appendix 5B, *Rapid Waterbird Powerline Collision Assessment*, provides additional detail on these methods, and describes limitations to the analysis and the estimates.

Take of covered waterbirds anticipated from future powerlines was estimated using the same methods as described for covered seabirds in Section 5.3.1.1, *Powerline Collisions—Methods.* The locations for future powerlines are currently unknown, but take limits were established based on an assumed 6.8 percent increase in strikes over the permit term.

As described for covered seabirds in Section 5.3.1.1, *Powerline Collisions—Methods,* the measurable units of take for covered waterbirds are powerline strikes. Requested take limits for waterbirds were established based on the estimated proportion of injuries and mortalities along powerline spans associated with the greatest amount of waterbird habitat and movement, which is at Mānā (spans 1–113) and Hanalei (spans 462–478 and 1297–1328); these areas have had confirmed waterbird take in previous years from powerline collisions and had a total annual rate of collisions of 985 for all birds, 729 of which were for covered waterbird species.[24] Assuming 90 percent minimization during implementation, the annual total rate of collisions of the covered waterbird species would be 72.9, with a total number of collisions of 3,645 over the 50-year permit term (72.9 x 50). (Table 5-7). The proportion of total covered waterbird strikes on the affected spans during the permit term would therefore be an estimated 74 percent (3,645/4,925= 74 percent). Covered waterbird take will be tracked over the permit term as 74 percent of all collisions along these spans, and it will be assumed that the proportion of injuries and mortalities by species are as provided in

[24] These numbers came from adding up all annual strikes from Appendix 5B, *Rapid Waterbird Powerline Collision Assessment*, Tables 2, 3, and 4.

Table 5-7. Assuming a 6.8 percent increase in strikes with new powerlines, the total number of covered waterbird collisions estimated for the 50-year permit term is 3,893.

There are no published data available regarding the grounding rate of covered waterbirds (i.e., the rate at which waterbirds that collide with powerlines are grounded) on Kauaʻi or elsewhere. Similarly, no published data exist on the mortality rate of grounded waterbirds on Kauaʻi or elsewhere. In the absence of such data, for the purposes of this HCP, the same grounding rate assumption used for seabirds are used for waterbirds (28.8 percent). The analysis also assumes that 69.7 percent of grounded waterbirds die (Travers et al. 2021). While the seabird analysis assumes all grounded seabirds result in mortality, the waterbird analysis assumes that grounded waterbirds without severe injuries after an initial collision are likely to continue surviving. This is because they are primarily ground-dwelling species thus are more mobile when grounded and have greater capacity to regain flight than grounded seabirds (Section 5.2.1.3, *Effect of Powerline Strikes on Covered Waterbird Species*).

For Hawaiian common gallinule (ʻalae ʻula) and Hawaiian coot (ʻalae keʻokeʻo), data on dead bird detections were used to estimate powerline collision mortalities (not strikes), because neither of these species have supporting observational data (Appendix 5B, *Rapid Waterbird Powerline Collision Assessment*). Dead birds were classified in the field as either confirmed, probably, or possibly a result of KIUC powerline strikes based on the location of the dead bird relative to powerlines, roads, and nearby water features.[25]

For all covered waterbirds, KIUC expects to minimize strikes at powerlines where waterbirds are vulnerable by 90 percent by the end of 2023 (Shaw et al. 2021), when the HCP is expected to take effect. As such, the number of estimated strikes was multiplied by 10 percent to estimate powerline strikes post-minimization.

The limitations of the assessment are described in Appendix 5B, *Rapid Waterbird Powerline Collision Assessment.* Despite these limitations, the analysis provides the best available information to conservatively estimate the effects of powerline collisions on the covered waterbirds, as described above and in Section 5.4.2, *Effects Common to All Covered Waterbirds*, and Section 5.4.3, *Species-Specific Waterbird Effects.*

5.4.2 Effects Common to All Covered Waterbirds

Effects and Level of Take

KIUC requests take of the covered waterbirds associated with 74 percent of all KIUC powerline collisions along powerline spans in Mānā (spans 1–113) and Hanalei (spans 462–478 and 1297–1328) during the permit term. Because species identity cannot be determined using acoustic strike data, KIUC requests take authorization for all covered waterbirds combined as a constant proportion of 74 percent of all powerline strikes along these spans as determined from acoustic strike data, adjusted for minimization. KIUC will also apply this proportion to future lines associated with covered waterbirds.

[25] Appendix 5B, *Rapid Waterbird Powerline Collision Assessment*, provides details and a description of how each category was assigned. Categories of "definitive" and "probable" (not "possible") were used to estimate mortality for Hawaiian gallinule (ʻalae ʻula). For Hawaiian coot (ʻalae keʻokeʻo), there were no observations of "definitive" or "probable" category birds; to avoid a zero estimate, the "possible" category was used for this species.

There will be an estimated 98.5 annual powerline collisions along spans in Mānā (spans 1–113) and Hanalei (spans 462–478 and 1297–1328) (Travers et al. 2020) for all birds (covered and non-covered); after 90 percent minimization up to 4,925 powerline collisions may occur throughout the 50-year permit term for all bird species recorded along these spans (98.5 X 50). In these areas, 74 percent of all bird collisions are attributed to the covered waterbirds, for a total of 3,645 covered waterbird collisions over the permit term. Assuming a 6.8 percent increase in collisions with new powerlines, an estimated 3,893 covered waterbird collisions are anticipated over the permit term. Chapter 6, *Monitoring and Adaptive Management Program*, describes how KIUC will monitor powerline collisions to ensure take does not exceed this level.

Section 5.2.1.3, *Effect of Powerline Strikes on Covered Waterbird Species*, describes the ways in which powerline strikes can adversely affect the covered waterbirds. Table 5-7 provides the annual and 50-year estimates for number of powerline strikes and number of covered waterbirds injured and killed based on the methods described above in Section 5.4.1, *Methods for Assessing Effects on Waterbirds*. These estimates are for the purpose of analyzing effects on the species but not for tracking take, as described in Chapter 6, *Monitoring and Adaptive Management Program*.

Table 5-7. Estimated Effects on Covered Waterbirds from Powerline Strikes

Species	Estimated Annual Strikes without Min-imization[a]	Percent of Total Waterbird Strikes	Estimated Annual Strikes with Min-imization[b]	Est. Annual Ground-ings[c]	Est. Annual Injury[g]	Est. Annual Morta-lity[d]	50-Year Strikes without New Power-lines[b,f]	50-Year Strikes with New Powerlines (6.8% increase)	50-Year Ground-ing[c]	50-Year Injury[g]	50-Year Powerline Mortality[d,f]	50-Year Projected SOS Rescues[e,f]
Hawaiian stilt (aeʻo)	60	<1	6	2	1	1	300	320	92	28	65	69
Hawaiian duck (koloa maoli)	203	<1	20	6	2	4	1,015	1,084	312	94	219	763
Hawaiian coot (ʻalae keʻokeʻo)	N/A	N/A	N/A	1	0	1	NA	NA	60	17	42	219
Hawaiian common gallinule (ʻalae ʻula)[h]	N/A	N/A	N/A	4	1	3	NA	NA	238	67	167	175
Hawaiian goose (nēnē)[h]	466	1	47	13	4	9	2,330	2,488	717	215	502	1,106
TOTAL	729		72.9	26	8	18	3,645	3,893	1,419	420	993	2,333

[a] Estimated annual strikes prior to minimization, from Appendix 5B. Hawaiian coot (ʻalae keʻokeʻo) and Hawaiian common gallinule (ʻalae ʻula) strikes not estimated in Appendix 5B (only mortality estimated). See footnote h.

[b] Assumes 90% minimization by 2023, year 1 of the HCP.

[c] Assumes 28.8% of strikes result in grounded birds. See Section 5.4.1, *Methods for Assessing Effects on Waterbirds.*

[d] For Hawaiian stilt (aeʻo), Hawaiian duck (koloa maoli), and Hawaiian goose (nēnē), assumes 70% of groundings result in mortality, based on Travers et al. (2021) observations that 70% of seabirds found were dead and 30% were alive. This is a conservative estimate because seabird mortality is likely higher than waterbird mortality from powerline strikes. For Hawaiian common gallinule (ʻalae ʻula), based on Appendix 5B, 20.8 birds with *definitive* and *probable* powerline collision as source of mortality, multiplied by 0.15 to account for 90% minimization. For Hawaiian coot (ʻalae keʻokeʻo), based on 5.2 *possible* powerline collisions as source of mortality, since there were zero birds of this species in the *definitive* or *probable* categories.

[e] Based on average annual number of SOS rescues from 2012 through 2019 (time span within which SOS consistently collected waterbird data).

[f] Rounded up to next whole number.

[g] Grounded birds that are not killed are assumed to be injured.

[h] For Hawaiian common gallinule (ʻalae ʻula) and Hawaiian coot (ʻalae keʻokeʻo), mortality was estimated as described in footnote d. Groundings were estimated by dividing mortality by 0.7 (70% of groundings result in mortality). Strikes were estimated by dividing groundings by 0.288 (28.8% of strikes result in grounding).

Beneficial and Net Effects

As described in Chapter 4, *Conservation Strategy*, rescue and recovery efforts through the SOS Program will minimize and offset the number of mortalities from powerline strikes. In addition, the SOS Program is expected to fully offset mortalities through the rescue, recovery, and release of waterbirds back into the wild that are affected by factors unrelated to KIUC's covered activities (non-take situations such as botulism). Rescuing, treating, and releasing covered waterbirds in this situation contributes to the species recovery by increasing their survival and reproduction. Section 5.4.3, *Species-Specific Waterbird Effects*, provides an analysis of the beneficial effects of the SOS Program on each covered waterbird species.

Table 5-8 summarizes the number of individuals of each covered waterbird species recovered or released from the SOS Program from 2012 through 2019, which is when SOS consistently collected data on waterbirds (Raine pers. comm.). This cumulative amount is converted to an average annual rate of recovery and release and multiplied by 30 to estimate the total number of waterbirds expected to be recovered and released during the permit term. This estimate is likely conservative since the earlier years of the SOS Program recovered fewer birds than in later years of the program because the program was smaller and less well known than it is today, with fewer volunteers or paid staff, and less visibility to the public.

Table 5-8. Covered Waterbird Species Recovered or Rehabilitated and Released by SOS Program

Species	No. of Individuals Recovered and Released 2012–2019 [a]	Average Annual Rate of Recovery and Release (No. of Individuals)	Assumed 50-Year Recovery and Release (No. of Individuals) [b]
Hawaiian stilt (ae'o)	11	1.37	69
Hawaiian duck (koloa maoli)	122	15.25	763
Hawaiian coot ('alae ke'oke'o)	35	4.37	219
Hawaiian common gallinule ('alae 'ula)	28	3.5	175
Hawaiian goose (nēnē)	177	22.13	1,106

[a] Source: SOS Program data.

[b] Rounded up to whole number.

5.4.3 Species-Specific Waterbird Effects

The effects and level of take for the covered waterbirds are described in Section 5.4.2, *Effects Common to All Covered Waterbirds*, and Table 5-7. The sections below describe the impacts of the taking and the beneficial and net effects of the KIUC HCP on each species.

5.4.3.1 Hawaiian Stilt (ae'o)

Impacts of the Taking

Long-term census data indicate that the statewide population Hawaiian stilt (ae'o) increased from 1985 to 2004 and have been roughly stable since then with approximately 1,500 to 2,000 individuals statewide (U.S. Fish and Wildlife Service 2020; Paxton et al. 2021). Populations have been increasing on Kaua'i over the last 31 years (Paxton et al. 2022). The USFWS formally proposed downlisting the species from endangered to threatened in May 2021 (U.S. Fish and Wildlife Service 2021). Because the covered powerlines have been present throughout the census period, it is reasonable to assume that the population trajectory of Hawaiian stilt (ae'o) has been stable or slightly increasing despite ongoing powerline collisions. The stable or increasing population even with this ongoing source of mortality therefore indicates that the species' population is sustainable with current levels of powerline collision mortality (and with other sources of mortality unrelated to KIUC covered activities). Powerline collisions will be reduced by 90 percent by the minimization measures of this HCP (see Chapter 4, Section 4.4.1, *Conservation Measure 1. Implement Powerline Collision Minimization Projects*).

Beneficial and Net Effects

The measure described in Chapter 4, Section 4.4.3, *Conservation Measure 3. Provide Funding for the Save Our Shearwaters Program,* is expected to minimize and fully offset the effects of powerline strikes on Hawaiian stilts (ae'o) and contribute to the species' recovery. Based on SOS data since 2012, an estimated 69 Hawaiian stilts (ae'o) will be rescued and released over the 50-year permit term, exceeding the 65 mortalities from powerline strikes conservatively estimated for this species over the permit term (Table 5-7).

5.4.3.2 Hawaiian Duck (koloa maoli)

Impacts of the Taking

The Hawaiian duck (koloa maoli) population has been estimated by USFWS to be about 2,000 true Hawaiian ducks (koloa maoli) (i.e., not hybridized) on Kaua'i and Ni'ihau, and 200 on the Island of Hawai'i (U.S. Fish and Wildlife Service 2011, 2015). Paxton et al. (2021) estimated a 5-year average population size between 2012 and 2016 on Kaua'i of 751 to 1,185 individuals. Hawaiian duck (koloa maoli) survey counts on O'ahu, Maui, and Hawai'i are confounded by the difficulty in distinguishing in the field Hawaiian duck (koloa maoli) from mallards and hybrids of mallards and Hawaiian duck (koloa maoli). Because of these issues, there is currently no credible population estimate for Hawaiian duck (koloa maoli) at any scale (U.S. Fish and Wildlife Service 2018). The Kaua'i population of this species increased between 2006 and 2016 (Paxton et al. 2021).

Since its listing under the federal Endangered Species Act in 1967, the Hawaiian duck (koloa maoli) population has increased on Kaua'i, though it is declining on other Hawaiian Islands (U.S. Fish and Wildlife Service 2011). The Hawaiian duck (koloa maoli) population on Kaua'i is substantially larger than the populations on all other Hawaiian Islands combined. This comparatively large population size is likely due to the lack of an established population of mongooses and very low occurrence of hybridization (U.S. Fish and Wildlife Service 2011).

Because the population on Kaua'i has been increasing even with the ongoing source of powerline mortality, the species' metapopulation on Kaua'i is likely sustainable and viable into the future with substantially reduced levels of powerline collision mortality under this HCP.

Beneficial and Net Effects

The measure described in Chapter 4, Section 4.4.3, *Conservation Measure 3. Provide Funding for the Save Our Shearwaters Program*, is expected to minimize and fully offset effects of powerline strikes on Hawaiian ducks (koloa maoli) and contribute to the species' recovery. Based on SOS data since 2012, an estimated 763 Hawaiian ducks (koloa maoli) will be rescued and released over the 50-year permit term, exceeding the 219 mortalities from powerline strikes conservatively estimated for this species over the permit term (Table 5-7).

5.4.3.3 Hawaiian Coot (ʻalae keʻokeʻo)

Impacts of the Taking

The Hawaiian coot (ʻalae keʻokeʻo) population was estimated to be 1,248 to 2,577 birds across the state of Hawaiʻi as an annual average from 2012 to 2016 (Paxton et al. 2021). Survey data from biannual waterbird counts suggest that the population on Kauaʻi has been increasing from 2006 to 2016 (Paxton et al. 2021). Due to the relatively high reproductive rate of Hawaiian coot (ʻalae keʻokeʻo) and its upward population trend even with the ongoing losses from powerline strikes, ongoing but substantially reduced powerline strikes are not expected to adversely affect the long-term survival or potential for recovery of Hawaiian coots (ʻalae keʻokeʻo) on Kauaʻi.

Beneficial and Net Effects

The measure described in Chapter 4, Section 4.4.3, *Conservation Measure 3. Provide Funding for the Save Our Shearwaters Program,* is expected to mitigate and fully offset effects of powerline strikes on Hawaiian coots (ʻalae keʻokeʻo) and contribute to the species' recovery. Based on SOS data since 2012, an estimated 219 Hawaiian coots (ʻalae keʻokeʻo) will be rescued and released over the 50-year permit term, exceeding the 42 mortalities from powerline strikes conservatively estimated for this species over the permit term (Table 5-7).

5.4.3.4 Hawaiian Common Gallinule (ʻalae ʻula)

Impacts of the Taking

Hawaiian common gallinule (ʻalae ʻula) counts indicate that the statewide population is small but relatively stable with an average of 947 birds (678-1,235) over 5 years (2012–2016), on Kauaʻi (Paxton et al. 2021). Count totals, however, are extremely variable between summer and winter surveys (U.S. Fish and Wildlife Service 2011). However, the annual surveys may be flawed; actual population size is thought to be greater because of the species' secretive behavior. Thus, an accurate population estimate is not available (U.S. Fish and Wildlife Service 2011). Paxton et al. (2021) report an increasing population trend on Kauaʻi for this species over the last 11 years.

Research has shown that broadcasting calls increases the number of individuals counted by as much as 30 percent on Oʻahu and 56 percent on Kauaʻi (Desrochers et al. 2008). Based on a minimum population size of 313 birds (287 x 1.30), the loss of an average of four birds annually (1.0 percent) to powerline strikes could have a substantial adverse effect on the long-term survival and recovery of the species. However, the measured stability of the Hawaiian common gallinule (ʻalae ʻula) population, despite the historic impacts of powerline strikes and other sources of mortality (e.g., vehicle strikes, predators), suggests that ongoing but substantially reduced powerline strikes are not expected to adversely affect the long-term survival or potential for recovery of Hawaiian common gallinule (ʻalae ʻula).

Beneficial and Net Effects

The measure described in Chapter 4, Section 4.4.3, *Conservation Measure 3. Provide Funding for the Save Our Shearwaters Program,* is expected to minimize and fully offset effects of powerline strikes on Hawaiian common gallinules ('alae 'ula) and contribute to the recovery of the species. Based on SOS data since 2012, an estimated 175 Hawaiian common gallinules ('alae 'ula) will be rescued and released over the 50-year permit term, exceeding the 167 mortalities from powerline strikes conservatively estimated for this species over the permit term (Table 5-7).

5.4.3.5 Hawaiian Goose (nēnē)

Impacts of the Taking

The Hawaiian goose (nēnē) population throughout Hawai'i is estimated as 3,865 individuals: 1,099 on Hawai'i, 477 on Maui, 23 on Moloka'i, 2,266 on Kaua'i (59 percent), and 0 on O'ahu (Nēnē Recovery Action Group 2020). Hawaiian geese (nēnē) appear to be increasing on Kaua'i (U.S. Fish and Wildlife Service 2018; Nēnē Recovery Action Group 2020), partially as a result of the release of captive breeding and translocation (U.S. Fish and Wildlife Service 2018). The growing population of this species with historical and ongoing take from KIUC powerlines suggests ongoing but substantially reduced powerline strikes are not expected to adversely affect the long-term survival or potential for recovery of Hawaiian goose (nēnē) on Kaua'i.

These historic levels of collision will be reduced substantially (90 percent) by the minimization measures of this HCP (Chapter 4, Section 4.4.1, *Conservation Measure 1. Implement Powerline Collision Minimization Projects*).

Beneficial and Net Effects

The measure described in Chapter 4, Section 4.4.3, *Conservation Measure 3. Provide Funding for the Save Our Shearwaters Program,* is expected to minimize and fully offset effects of powerline strikes on Hawaiian geese (nēnē) and contribute to the species' recovery. Based on SOS data since 2012, an estimated 1,106 Hawaiian geese (nēnē) will be rescued and released over the 50-year permit term, exceeding the 502 mortalities from powerline strikes conservatively estimated for this species over the permit term (Table 5-7).

5.5 Effects on Green Sea Turtle (honu)

5.5.1 Methods for Assessing Effects

There has been no systematic monitoring to assess effects of KIUC streetlights on green sea turtles (honu). There was an incident in September 2020 on Kaua'i where green sea turtle (honu) hatchlings at night moved toward a KIUC streetlight and some of the hatchlings were crushed by vehicles before a concerned citizen collected some and called local police to assist. Other than that recent incident, there are no records of KIUC streetlights affecting green sea turtle (honu) hatchlings. However, adverse effects of lights on green sea turtle (honu) hatchlings are well documented in other areas (see Section 5.2.2.2, *Light Attraction and Disorientation of Green Sea Turtle (honu)*) and assumed to occur from KIUC streetlights near suitable green sea turtle (honu) nesting habitat.

KIUC conducted a field evaluation in 2020 to assess the extent to which KIUC streetlights might affect green sea turtles (honu), and to evaluate where additional minimization measures are needed. During the evaluation, all sandy beaches on Kaua'i with KIUC streetlights that are potentially visible from the surface of beaches where suitable green sea turtle (honu) nesting habitat was present were evaluated. Suitable nesting habitat was considered regardless of whether or not turtles had been recorded nesting in those locations. The primary criterion for determining whether streetlights could affect green sea turtles (honu) was whether the streetlights were visible from the surface of sandy beaches. Seven beaches were determined to have streetlights that were visible from potentially suitable green sea turtle (honu) nesting habitat at the time of the evaluation: Keālia Beach (2 streetlights), Kapa‘a Shoreline (4 streetlights), Wailua Beach (7 streetlights), Po‘ipū Shoreline (3 streetlights), Kukui‘ula Harbor (3 streetlights), Waimea Shoreline (3 streetlights), and Kekaha Shoreline (7 streetlights). KIUC will reevaluate all suitable habitat near KIUC streetlights on an annual basis to add or remove locations that may affect green sea turtle (honu) hatchlings as environmental conditions change (Section 4.4.5.2, *Shield Active Nests from Streetlights*).

5.5.2 Effects and Level of Take

As described in Appendix 3A, *Species Accounts*, average annual nesting density of green sea turtles (honu) at all Kaua‘i beaches are very low, ranging from less than one (i.e., one nest every several years) to one to two nests per year between 2015 and 2020 (State of Hawai‘i Division of Aquatic Resources 2020). Without minimization, the number of green sea turtle (honu) nests affected by KIUC streetlights is expected to be less than one per year due to limited extent of effects on suitable beaches. Although nesting density is low, observations of nesting have increased over the past 5 years (State of Hawai‘i Division of Aquatic Resources 2020), suggesting that effects of KIUC streetlights could increase slowly over time if no action is taken.

KIUC assumes that with the monitoring and minimization measures to be conducted under Conservation Measure 5, *Implement a Green Sea Turtle Nest Detection and Temporary Shielding Program*, in Chapter 4, *Conservation Strategy*, most or all take resulting from KIUC streetlights will be avoided. Despite this, KIUC requests take authorization of 50 green sea turtle (honu) nests over the 50-year permit term, which is equivalent to an average of one nest every year. This requested take accounts for the possibility of green sea turtle (honu) nests going undetected by monitors and not being temporarily shielded from a KIUC streetlight. Alternatively, temporary shielding may be ineffective at some nest sites due to incorrect placement or vandalism, in which case hatchlings may be affected by KIUC streetlights.

Based on the methodology and assumptions described above, KIUC requests take of 50 green sea turtle (honu) nests over the 50-year permit term (an average of one nest per year), where take in the form of disorientation, injury, or mortality of any hatchlings in a nest counts as take of that nest. This approach was selected because of the difficulty of observing all hatchlings in any one nest since hatching occurs at night and its timing is unpredictable. KIUC believes that this take request is conservative. KIUC assumes that with the monitoring and minimization measures under Conservation Measure 5, *Implement a Green Sea Turtle Nest Detection and Temporary Shielding Program* in Chapter 4, *Conservation Strategy*, most and potentially all take of green sea turtle (honu) from KIUC streetlights can be avoided.

5.5.3 Impacts of the Taking

As described in the species account (Appendix 3A, *Species Accounts*), the estimated number of female green sea turtles (honu) that nest in the Plan Area is 16, representing only 0.39 percent of the total of 3,864 breeding females estimated for the entire Central North Pacific DPS of green sea turtle (honu) (Seminoff et al. 2015). Of 20 nesting sites documented on Kaua‘i, all but two were described as having intermittent or indeterminate use (Parker and Balazs 2015). At the French Frigate Shoals, the principal nesting site for the green sea turtle (honu) where approximately 95 percent of all nesting occurs, nesting green sea turtles (honu) increased by an estimated 4.8 percent annually from 1966 to 2006 (over 40 years) (Appendix 3A, *Species Accounts*; Balazs and Chaloupka 2006). Information on at-sea abundance trends has been consistent with the increase in nesting (Balazs et al. 1996, 2005; Balazs 2000; Seminoff et al. 2015), although Hurricane Walaka in 2018 resulted in substantial loss of nesting habitat and the long-term effects of this catastrophic event have not been fully analyzed. The loss of up to 50 nests over a 50-year period resulting from KIUC streetlights, where most or all of the take is expected to consist of small fraction of the hatchlings in each nest, is not expected to adversely affect the population or appreciably reduce the likelihood of the species' survival and recovery in the wild.

5.5.4 Beneficial and Net Effects

The green sea turtle (honu) monitoring and minimization measures described in Conservation Measure 5, *Implement a Green Sea Turtle Nest Detection and Temporary Shielding Program* in Chapter 4, *Conservation Strategy*, will not only minimize take resulting from KIUC streetlights (possibly to zero), but is also expected to minimize take resulting from other proximate light sources. On six of the seven beaches identified[26] in KIUC's 2020 streetlight assessment, most of the light is from sources other than KIUC streetlights, including residential buildings, commercial buildings (e.g., restaurants, resorts, shopping centers), and beach infrastructure (e.g., restrooms, parking lot lighting, walking path lighting). As described in Chapter 4, *Conservation Strategy*, KIUC's nest shielding program will shield any nests that have even the smallest potential to be affected by KIUC streetlights. This will result in the shielding of green sea turtle (honu) nests affected by non-KIUC light sources. As such, the take of hatchlings in up to 50 nests over 50 years is expected to be fully offset through the reduction of take from non-KIUC light sources. The nest shielding program is also expected to provide a net conservation benefit to green sea turtle (honu) because over the 50-year permit term KIUC will be shielding more nests than would be affected by their own streetlights.

[26] At the Kekaha Shoreline, the primary light source is KIUC streetlights. Surrounding lights in the vicinity are sparse and therefore contribute little to the beach lightscape.

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Chapter 6
Monitoring and Adaptive Management Program

6.1 Introduction

This chapter describes the monitoring and adaptive management program for the KIUC HCP. The goal of the monitoring component of the program is to evaluate on an ongoing basis whether the HCP is meeting or is likely to achieve the biological goals and objectives. The goal of the adaptive management component of the program is to outline a system for adjusting the KIUC HCP management strategy using the monitoring results. Specifically, the purposes of the monitoring and adaptive management program are to do the following.

- Ensure that KIUC remains in compliance with the HCP, the federal incidental take permit (ITP), and the state incidental take license (ITL).
- Ensure take of the covered species does not exceed the maximum limits set by the federal ITP and state ITL.
- Evaluate the effectiveness of the conservation measures (Chapter 4, *Conservation Strategy*) on an ongoing basis and identify when adaptive management must be applied to improve their effectiveness.

Adaptive management and monitoring will be integrated into one program. This chapter begins with an overview of the monitoring and adaptive management program. The chapter then provides details on the required monitoring and adaptive management actions. Finally, the chapter provides a description of all HCP data and reporting requirements (refer to Chapter 7, *Plan Implementation*, for details regarding data management and reporting).

6.1.1 Regulatory Context

As discussed in the *Habitat Conservation Planning and Incidental Take Permit Processing Handbook* (HCP Handbook) (U.S. Fish and Wildlife Service and National Marine Fisheries Service 2016), monitoring and reporting are mandatory elements of all HCPs.[1] When properly designed and implemented, monitoring programs should provide the information needed to answer the following questions.

- Is the permittee (KIUC) in compliance with its HCP, federal ITP, and state ITL?
- Is progress being made toward meeting the HCP's biological goals and objectives by the deadlines established in the HCP?
- Is the HCP's conservation strategy effective at minimizing and mitigating impacts as defined in the HCP?
- Is there a need to adjust conservation measures through adaptive management to improve the outcomes of the conservation strategy to meet established goals and objectives?

[1] 50 Code of Federal Regulations 17.22, 17.32, and 222.307; 65 *Federal Register* 35242 (June 1, 2000).

Adaptive management programs are recommended for programmatic HCPs and those with data gaps or scientific uncertainty that could affect how species are managed during implementation. The HCP Handbook (U.S. Fish and Wildlife Service and National Marine Fisheries Service 2016) describes adaptive management as a method for addressing uncertainty in natural resource management and states that management must be linked to measurable biological goals and monitoring. Conservation measures proposed in Chapter 4, *Conservation Strategy*, could be adapted in response to new information within an adaptive management framework if the commitments defined under the HCP's regulatory assurances (Chapter 7, *Plan Implementation*) are maintained.

The Hawaiʻi Endangered Species Act has similar requirements for HCP monitoring and adaptive management programs.[2] HCP monitoring programs must do the following.

- Include monitoring of the threatened and endangered species in the HCP.
- Include periodic monitoring by representatives of the Hawaiʻi Department of Land and Natural Resources or the Endangered Species Recovery Committee (ESRC), or both.
- Provide for an adaptive management strategy that specifies the actions to be taken periodically if the plan is not achieving its goals.

6.2 Overview of Monitoring and Adaptive Management Program

6.2.1 Types of Monitoring

KIUC will oversee and implement two types of monitoring: compliance monitoring and effectiveness monitoring. A description of each of these elements is provided below.

6.2.1.1 Compliance Monitoring

Compliance monitoring tracks the status of HCP implementation and documents that HCP requirements are being met. Compliance monitoring verifies that KIUC is carrying out the terms of the HCP, the federal ITP, and the state ITL. KIUC conducted compliance monitoring during the active period of the 5-year Short-Term HCP (2011 to 2016). The goals of compliance monitoring under the Short-Term HCP included, but was not limited to, data collection to inform take levels and minimization potential that would be used to inform this HCP. Under the KIUC HCP, the goal of compliance monitoring will shift to (1) confirming implementation of the conservation measures, (2) confirming estimated strike reductions, and (3) tracking annual take over the 30-year permit term.

- Tracking implementation of the conservation measures, including commitments on location, extent, and schedule, as show in Tables 6-1 and 6-2.
- Tracking KIUC's annual funding contribution to the Save Our Shearwaters (SOS) Program, as described in Chapter 7, Section 7.5, *Funding Assurances*.

[2] Hawaiʻi Revised Statutes Sections 195D-21(b)(2)(G) and 195D-21(b)(2)(H).

- Tracking implementation of the monitoring and adaptive management program, as described in this chapter.
- Reporting implementation progress on an annual basis (see Section 7.7, *Annual Reporting*, for details).

U.S. Fish and Wildlife Service (USFWS) staff, State of Hawai'i Department of Land and Natural Resources staff (including the State of Hawai'i Division of Forestry and Wildlife [DOFAW] and the State of Hawai'i Division of Aquatic Resources [DAR]), or members of the ESRC may visit any KIUC locations associated with this HCP[3] upon request to ensure that conservation measures are being implemented in accordance with the HCP, the federal ITP, and state ITL. If, during any site visit, agency personnel note any apparent discrepancies and bring them to KIUC's attention, KIUC will investigate the apparent deviation and report its findings and recommended course of action to the agencies within 10 business days.

6.2.1.2 Take Monitoring

Take monitoring compares the actual take that occurs during implementation to the take limit authorized by the federal ITP and state ITL. KIUC will track impacts on the covered species to ensure that the take limit defined in Chapter 5, *Effects*, is not exceeded. Actual take will be estimated using the same methods that were developed to predict take by the covered activities.

6.2.1.3 Effectiveness Monitoring

Effectiveness monitoring assesses the biological performance of the HCP. Specifically, effectiveness monitoring evaluates the implementation and success of the conservation strategy described in Chapter 4, *Conservation Strategy*. Effectiveness monitoring will determine the effectiveness of KIUC's minimization and conservation actions. For example, effectiveness monitoring in the 10 conservation sites will determine whether predator control is as effective as predicted in the HCP, and whether the actions are on track to achieve the biological goals and objectives of the HCP (Chapter 4, Section 4.3, *Biological Goals and Objectives*).

6.2.2 Adaptive Management

Based on the best scientific information currently available, KIUC believes that the HCP conservation measures will achieve the biological goals and objectives described in Chapter 4, *Conservation Strategy*. Over time, however, conditions in the Plan Area or the status of the covered species may change in ways that could change the effectiveness of the conservation measures. It is also possible that new approaches or new technology will prove more effective at achieving the biological goals and objectives than what is currently described in the HCP. Finally, it may be found that conservation measures are less effective at achieving the biological goals and objectives than expected. The adaptive management process described here is intended to address all these situations.

Adaptive management is a structured approach to decision-making in the face of uncertainty that makes use of the experience of management and monitoring results in an embedded feedback loop of monitoring, evaluation, and adjustments in management strategies. The kinds of uncertainties it

[3] For example, powerline minimization project areas, covered facilities, or conservation sites.

is intended to address include a lack of biological information about the covered species or uncertainty in the effectiveness of minimization or mitigation techniques.

Adaptive management is a required component of HCPs that allows for the incorporation of new information into conservation and mitigation measures during HCP implementation. Effective implementation of this approach requires explicit and measurable objectives, and identifies what actions are to be taken and when they are to occur. Adaptive management changes do not trigger the need for an amendment of the HCP or the associated federal ITP or state ITL.

The adaptive management process is often represented as a cycle of *plan*, *do*, *monitor*, *learn, and adjust* (Webb et al. 2017). Large programs and complex situations often contain multiple cycles of adaptive management operating simultaneously at different scales, but nested within the larger adaptive management framework (Bormann and Stankey 2009).

6.2.2.1 Minor Adjustments vs. Adaptive Management

To define adaptive management, it is helpful to first describe what adaptive management is not. As the HCP operator, KIUC will be making decisions daily about the best approaches to use in implementing the HCP. HCP implementation will necessarily involve many minor adjustments to the conservation measures described in Chapter 4, *Conservation Strategy*, to remain consistent with the HCP, perform effectively, and remain cost efficient.

KIUC has complete authority over changes and adjustments that are related to day-to-day management and monitoring responsibilities. Throughout the year, KIUC will need to plan and implement simple adjustments to routine activities that are small in size or effect or need to be implemented rapidly. These types of changes are not adaptive management and therefore do not require consultation with USFWS or DOFAW.

Day-to-day activities must fit within the framework of the HCP's conservation strategy and be implemented consistent with the HCP's biological goals and objectives. Such changes will be reported in each Annual Report (Chapter 7, Section 7.7, *Annual Reporting*) and at monthly coordination meetings. The following types of actions are considered minor adjustments. However, this list cannot encapsulate all minor adjustments that may occur during HCP implementation.

- Day-to-day conservation site management and monitoring activities. Examples include the location of wildlife cameras or predator traps, predator control techniques like selection of predator traps, placement of traps, and frequency and intensity of trapping, fence repairs, debris removal, methods and timing of invasive plant removal, and methods and timing to install artificial burrows.
- Methods and equipment to install bird flight diverters on new powerlines.
- Repair or replacement of existing and future powerline collision minimization infrastructure that is included in KIUC's powerline collision minimization plan.
- Repair or replacement of existing and future light minimization infrastructure for the covered seabirds and green sea turtle (honu).

- Adjustments in green sea turtle (honu) nest monitoring methods, locations,[4] and approaches that are consistent with the conservation measure (e.g., beach shielding locations, monitoring techniques)

6.2.2.2 Adaptive Management Decisions

It may become clear from monitoring results or from external scientific information that certain conservation measures need to be adjusted in more substantial ways that go beyond the day-to-day minor adjustments. Adaptive management actions are intended to capture substantial changes to the HCP that are needed to achieve a biological objective in the event the conservation measures are not working as intended. For example, monitoring results may reveal that conservation measures, despite many minor adjustments, are not expected to meet a metric within a biological objective. Alternatively, new techniques may become available that have the potential to dramatically improve the performance of a conservation measure but are untested on Kaua'i or with the covered species. Such substantial changes to conservation measures are considered adaptive management actions that require following the adaptive management decision making process described in the next section.

Adaptive management changes may require multiple years to assess, plan, and implement. Adaptive management actions require clear objectives, success criteria, and implementation schedules. The following actions are considered adaptive management actions and require consultation with and pre-approval from USFWS and DOFAW (and DAR for green sea turtle [honu]), following the decision making process described in the next section below. Only the actions listed below are considered adaptive management for the purposes of this HCP.

- Actions to ensure an estimated strike reduction below those forecast in Chapter 4, Section 4.4.1, *Conservation Measure 1. Implement Powerline Collision Minimization Projects* (i.e., 65.5 percent by the end of 2023 for covered seabirds, and 90 percent for covered waterbirds).
- Any modifications to KIUC's streetlight or facility light minimization techniques (e.g., removing shields, changing the type of shields, changing dimming protocols).
- Any modifications to SOS Program funding, other than annual adjustments for inflation.
- Implementation of any new techniques to minimize green sea turtle (honu) hatchling disorientation.
- Adding or discontinuing conservation sites.
- Adding, removing, or changing the location of predator exclusion fences, ungulate fences, or social attraction sites.
- Changes to any of the timelines in the HCP conservation strategy that delay completion of minimization or mitigation actions.
- Reducing the monitoring frequency for any conservation action.

[4] Changes to locations within beaches do not require agency consultation (e.g., moving fences from year to year depending on nest location) because these areas have already been reviewed and approved by USFWS and DOFAW in this HCP. Only new beach locations are considered an adaptive management action.

Strong adaptive management programs include pre-defined thresholds for adaptive management actions. That is, when a threshold is crossed (or likely to be crossed) for a particular important metric, the adaptive management decision making process is triggered. This "automatic" trigger helps to ensure that appropriate assessments are conducted and, if necessary, action is taken. Thresholds can be defined as either qualitative metrics or quantitative. In either case, a threshold can be set so that it serves as an "early warning" for a conservation measure that may be off track but has not yet failed. In this way, the adaptive management process can function to improve performance well in advance of serious issues that may be difficult and expensive to address. In this HCP, these thresholds are called *adaptive management triggers*. Section 6.3, *Compliance Monitoring and Adaptive Management Triggers*, and Section 6.4, *Take and Effectiveness Monitoring and Adaptive Management Triggers*, define the adaptive management triggers and responses for this HCP.

6.2.2.3 Adaptive Management Decision-Making Process

KIUC will consult with USFWS and DOFAW (DAR will be included when addressing green sea turtle [honu]) before making any decisions regarding adaptive management actions as defined above. The adaptive management decision-making process consists of the following steps.

1. As part of their annual reporting requirements (Chapter 7, Section 7.7, *Annual Reporting*), KIUC will report the results of compliance monitoring, take monitoring, and effectiveness monitoring, including any supporting monitoring or other data necessary to determine whether the HCP is on track to meet the biological goals and objectives. As part of this assessment, KIUC will assess whether an adaptive management trigger is likely to be reached within the next reporting year, has already been reached, or has been exceeded (see the next sections for triggers).
2. If an adaptive management trigger has been reached or exceeded, this will trigger a mandatory collaborative process between KIUC, USFWS, and DOFAW[5] to define and implement an agreed-upon response. KIUC will identify a recommended approach after reviewing the appropriate adaptive management section and list of potential adaptive management changes in this chapter or will develop an approach for adaptive management if no practicable pre-defined response exists. The potential need for adaptive management may also be identified by KIUC, USFWS, DOFAW, or DAR at any time based upon sufficient evidence that an adaptive management trigger has been reached or exceeded or biological objectives are not being met or are unlikely to be met. KIUC, USFWS, DOFAW, or DAR may also identify the potential need for adaptive management if an adaptive management trigger is likely to be met.
3. KIUC will receive input from USFWS, DOFAW, and in some cases the ESRC,[6] on the recommended adaptive management action or actions. USFWS or DOFAW may approve or disapprove of the proposed changes. However, KIUC will make the final decision on adaptive management changes after discussion with and input from USFWS and DOFAW. KIUC will remain responsible for permit compliance and meeting the biological objectives of the KIUC HCP.
4. USFWS and DOFAW will decide whether an amendment to the HCP or federal ITP/state ITL is necessary, and if so, the necessary steps to follow. They will further determine whether the proposed adaptive management actions will result in physical changes to the environment that

[5] DAR will be included when the adaptive management trigger involves green sea turtle (honu).

[6] Consistent with Hawai'i Revised Statutes Chapter 195D, the ESRC will make adaptive management recommendations at their annual review meeting for this HCP.

were not addressed in the original analyses, and if so, whether there is a need for updates to the EIS, federal Endangered Species Act Section 7 Biological Opinion, or Findings documents.

5. KIUC will report to USFWS and DOFAW as soon as practicable regarding the implementation and results of any adaptive management action. The subsequent Annual Report will discuss the adaptive management action implemented by KIUC and the preliminary outcomes, if available.

Any adaptive management changes selected and implemented by KIUC will be consistent with and support the achievement of the biological goals and objectives (Chapter 4, *Conservation Strategy*) and will consider the take limit (Chapter 5, *Effects*) and the commitments of the funding strategy (Chapter 7, *Plan Implementation*), as well as the commitments of KIUC's No Surprises regulatory assurances (Chapter 7).

Most adaptive management actions are expected to either be cost neutral or funded by cost savings (e.g., reduction or cessation of ineffective conservation measures). If adaptive management actions result in additional costs, those costs will be funded through KIUC's letter of credit (Chapter 7, Section 7.5, *Funding Assurance*). KIUC, USFWS, DOFAW (and DAR when applicable for green sea turtle [honu]) will evaluate a range of adaptive management responses across a range of costs, and will, when possible, balance the action and the cost, but will ultimately select an adaptive management response based its ability to support the biological goals and objectives.

6.3 Compliance Monitoring and Adaptive Management Triggers

As described above, compliance monitoring tracks the status of HCP implementation and documents that KIUC is implementing the conservation measures as described, including required methods and timing. KIUC will closely monitor the implementation of all conservation measures to ensure that they are being implemented properly and on time. If there are delays in implementation, KIUC will report these delays in monthly coordination meetings with USFWS and DOFAW and as part of the annual report (Chapter 7, Section 7.7, *Annual Reporting*). Compliance monitoring results will be the primary tool for USFWS and DOFAW to verify that KIUC remains in compliance with the HCP requirements, the federal ITP, and state ITL. As defined by this HCP, compliance monitoring is comprised of the components listed below.

Compliance monitoring is typically not associated with adaptive management. However, because of the importance of implementing conservation measures on schedule and to the specifications of the HCP, KIUC has included two components here: (1) a compliance schedule (Table 6-1) and (2) adaptive management triggers and responses for all relevant compliance monitoring actions (Table 6-2). Adaptive management triggers are often tied to HCP deadlines to ensure that key compliance actions are implemented according to the HCP schedule and if they are not, immediate responses are implemented. If an adaptive management trigger is reached or is likely to be reached as determined by KIUC, USFWS, or DOFAW, these three agencies will first jointly perform an assessment described in the column *Adaptive Management Response Step 1*. Based on the initial assessment, KIUC may implement a response, with input from USFWS, DOFAW (and DAR, when applicable), identified in the last column as *Adaptive Management Response Step 2*. KIUC will designate or hire a compliance monitor to track and report on KIUC's compliance with the requirements identified in Table 6-1. The compliance monitor will also assist with the adaptive management process, including the assessments identified in *Adaptive Management Response Step 1*.

Compliance monitoring and adaptive management will allow KIUC to document that all the requirements of the HCP are being met and will allow USFWS and DOFAW (and DAR, when applicable) to determine, using the success metrics in Table 6-2, whether the HCP is on track both in terms of scope and schedule.

Table 6-1. Schedule for HCP Compliance

Key Task with Deadline Tied to Permit Compliance	Deadline
Key Initial Deadlines	
Complete Powerline Minimization Plan (Appendix 4B, *KIUC Minimization Projects*)	End of 2023
Eradicate predators and initiate social attraction in Pōhākea PF and Honopū PF	End of 2023
Select and approve Conservation Site 10	End of 2023
Complete installation of predator exclusion fencing at Upper Limahuli and Conservation Site 10	End of 2025
Eradicate predators and initiate social attraction in Upper Limahuli and Conservation Site 10	End of 2026
Complete strike reduction monitoring for Powerline Minimization Plan (Appendix 4B, *KIUC Minimization Projects*) to determine final reduction amount	End of 2026
Key Annual Deadlines	
Shield all new or damaged streetlights	September 15
Dim or turn off facility lights at Port Allen Generating Station	September 15
Complete training program for covered seabird facility monitoring	August 15
Complete training program for green sea turtle (honu) nest monitoring	March 1
Complete Annual Work Plan	December 31
Submit Annual Report	June 1

[a] This table is only intended to identify key deadlines. Annual monitoring activities that will occur every year are not included in this table but described below in this chapter.

Table 6-2. Compliance Monitoring Adaptative Management Triggers

Conservation Measure	Metric of Success	Adaptive Management Triggers	Monitoring Strategy	Adaptive Management Response Step 1	Adaptive Management Response Step 2
Conservation Measure 1. Implement Powerline Collision Minimization Projects	All minimization in KIUC's minimization plan (Appendix 4B, *KIUC Minimization Projects*), is complete by the end of 2023	All minimization in KIUC's minimization plan (Appendix 4B, *KIUC Minimization Projects*), is not complete by the end of 2023.	KIUC compliance monitoring. Annual reporting and annual work plan	Assess, in coordination with USFWS and DOFAW, whether the expected delay in completing powerline collision minimization will affect overall estimated annual strikes	If the expected delay is affecting overall estimated annual strikes and is likely to result in an exceedance of the 50-year take request, KIUC will, by the end of 2028, implement additional minimization (this may also include the same amount/location using a technique with a higher strike reduction) to make up the difference, where it will be implemented, and timeline for implementation and monitoring. If additional minimization cannot offset the deficit and annual strikes are exceeding what is expected (65.3% reduction in strikes), by the end of 2032 (which gives KIUC time to measure the performance of the new minimization) evaluate whether the 50-year take limit is likely to be exceeded. If the take limit is likely to be exceeded, a permit amendment may be needed.
Conservation Measure 1. Implement Powerline Collision	No more than 16% (27.2 miles [43.8 km]) of total transmission wire length will include wire height	An average of more than 4.4 miles (7.1 km) of wire height in any 5-year period results in a height increase	KIUC compliance monitoring. Annual reporting and	Assess, in coordination with USFWS and DOFAW, whether the above-average rate of wire height increases is expected to continue, is likely to exceed the metric of success by the end of	If the increased rate is affecting overall estimated annual strikes and is likely to result in an exceedance of the 50-year take request, KIUC will identify additional minimization within 1

Conservation Measure	Metric of Success	Adaptive Management Triggers	Monitoring Strategy	Adaptive Management Response Step 1	Adaptive Management Response Step 2
Minimization Projects	increases by the end of the 50-year permit term		annual work plan	the permit term. and would affect KIUC's 50-year take request.	year to make up the difference, where it will be implemented, and a timeline for implementation and monitoring. If this option is not possible, KIUC, USFWS, and DOFAW will determine if a permit amendment may be necessary.
Conservation Measure 1. Implement Powerline Collision Minimization Projects	No more than a 34% (348 miles [560 km]) increase in new powerlines within KIUC's approximate 1,000-mile (1,609-km) system over the 50-year permit term	An average of more than 34.8 miles (56 km) of new wires in any 5-year period	KIUC compliance monitoring. Annual reporting and annual work plan	Assess, in coordination with USFWS and DOFAW, whether the rate of installation of new powerlines is expected to continue, is likely to exceed the metric of success by the end of the permit term and would affect KIUC's 50-year take request.	If the increased rate is affecting overall estimated annual strikes and is likely to result in an exceedance of the 50-year take request, KIUC will identify additional minimization within 1 year to make up the difference, including where it will be implemented, and a timeline for implementation and monitoring. If this option is not possible, KIUC, USFWS, and DOFAW will determine if a permit amendment may be necessary.
Conservation Measure 1. Implement Powerline Collision Minimization Projects	KIUC determines using existing data, in areas where vegetation management has exposed wires, that minimization can be implemented to reduce the strike rate, or conducts monitoring to determine	Minimization is not installed on newly exposed wires (due to vegetation management) where data indicates it is necessary and practicable to reduce the strike rate within 1 year of determination	KIUC compliance monitoring. Annual reporting and annual work plan	Assess, in coordination with USFWS and DOFAW, whether the newly exposed area is expected to continue (e.g., vegetation may grow back) and would affect KIUC's 50-year take request.	If the area(s) will affect overall estimated annual strikes and is likely to result in an exceedance of the 50-year take request, KIUC will identify additional minimization within 1 year to make up the difference, including where it will be implemented, and a timeline for implementation and monitoring. If this option is not possible, KIUC, USFWS, and DOFAW will

Conservation Measure	Metric of Success	Adaptive Management Triggers	Monitoring Strategy	Adaptive Management Response Step 1	Adaptive Management Response Step 2
	whether minimization is needed				determine if a permit amendment may be necessary.
Conservation Measure 1. Implement Powerline Collision Minimization Projects	No static wires on new powerlines	Static wires placed on new powerlines	KIUC compliance monitoring. Annual reporting and annual work plan	KIUC compliance monitor will evaluate new powerline design prior to construction	KIUC will remove the static wire
Conservation Measure 1. Implement Powerline Collision Minimization Projects	New distribution lines will be no more than 45 feet (13.7 m) above ground	New distribution lines are more than 45 feet (13.7 m) above ground	KIUC compliance monitoring. Annual reporting and annual work plan	KIUC compliance monitor will consult with a qualified avian biologist to determine whether the spans(s) greater than 45 feet (13.7 m) above ground increases the collision risk of the covered birds and could result in an increased strike rate.	If the area(s) will affect overall estimated annual strikes and is likely to result in an exceedance of the 50-year take request, KIUC will identify additional minimization within 1 year to make up the difference, including where it will be implemented, and a timeline for implementation and monitoring. If this option is not possible, KIUC, USFWS, and DOFAW will determine if a permit amendment may be necessary.
Conservation Measure 1. Implement Powerline Collision Minimization Projects	One vertical wire level on new distribution and transmission lines where possible	More than one vertical wire level on a new distribution and transmission lines	KIUC compliance monitoring. Annual reporting and annual work plan	KIUC compliance monitor will consult with a qualified avian biologist to determine whether the new powerline design increases the collision risk of the covered birds and could result in an increased strike rate.	If the area(s) will affect overall estimated annual strikes and is likely to result in an exceedance of the 50-year take request, KIUC will identify additional minimization within 1 year to make up the difference, including where it will be implemented, and a timeline for implementation and monitoring. If this option is not possible,

Conservation Measure	Metric of Success	Adaptive Management Triggers	Monitoring Strategy	Adaptive Management Response Step 1	Adaptive Management Response Step 2
					KIUC, USFWS, and DOFAW will determine if a permit amendment may be necessary.
Conservation Measure 1. Implement Powerline Collision Minimization Projects	New powerlines located in areas that reduce and minimize collision risk, where possible	New powerlines are planned in a high-risk area, based on existing data, predictive modeling, and/or consultation with qualified avian biologist	KIUC compliance monitoring. Annual reporting and annual work plan	A qualified avian biologist will evaluate the location and all planned minimization against the strike risk using existing strike data (e.g., Bayesian Model) to determine if the location could result in exceedance of KIUC's expected take based on Appendix 6A, *Adaptive Management Comparison Tables*, Tables 6A-1 and 6A-2.	Meet and confer with USFWS and DOFAW to determine best response. Installation of additional or improved minimization may be sufficient to remedy the issue. If possible, also modify location to further minimize risk. If this is not possible, evaluate options that ensure take levels are not exceeded.
Conservation Measure 1. Implement Powerline Collision Minimization Projects	Diverters installed on new powerlines, where practicable. Reflective diverters near roads and LED diverters away from roads	Diverters cannot be installed on new powerlines	KIUC compliance monitoring. Annual reporting and annual work plan	KIUC compliance monitor will consult with a qualified avian biologist to determine if the new powerline locations without diverters could affect overall estimated annual strikes and is likely to result in an exceedance of the 50-year take request	If the area(s) will affect overall estimated annual strikes and is likely to result in an exceedance of the 50-year take request, KIUC will identify additional minimization within 1 year to make up the difference, including where it will be implemented, and a timeline for implementation and monitoring. If this option is not possible, KIUC, USFWS, and DOFAW will determine if a permit amendment may be necessary.
Conservation Measure 2. Implement Measures to Minimize Light Attraction	Streetlights: Full-cutoff shields on all KIUC streetlights, so that light does not shine above 90-	Full-cutoff shields are not installed on new streetlights (shields are installed on all existing streetlights) or	KIUC compliance monitoring. Annual reporting and annual work plan	KIUC personnel are required to report any damaged or removed shields to KIUC compliance monitor. The KIUC compliance monitor is also responsible for ensuring new lights are shielded	KIUC will replace or repair shields on existing streetlights prior to the seabird fallout season. If damage occurs during the seabird fallout season, KIUC will repair shield as soon as possible following damage.

Conservation Measure	Metric of Success	Adaptive Management Triggers	Monitoring Strategy	Adaptive Management Response Step 1	Adaptive Management Response Step 2
	degree horizontal plane	shields that are damaged or removed prior to the seabird fallout season (September 15 to December 15)		and documenting compliance in Annual Report.	Shields missing from new streetlights will be installed prior to the seabird nesting season.
Conservation Measure 2. Implement Measures to Minimize Light Attraction	Streetlights: 1,754 streetlights installed by the end of the 50-year permit	More than 175 new streetlights installed over any 5-year period (the average expected over any 5-year period).	KIUC compliance monitoring. Annual reporting and annual work plan	Assess, in coordination with USFWS and DOFAW, whether the rate of installation of new streetlights is expected to continue and would affect KIUC's 50-year take request.	If the increased rate of streetlight installation is likely to continue, is likely to affect overall estimated annual strikes, and is likely to result in an exceedance of the 50-year take request, KIUC will identify additional light minimization within one year to make up the difference, including where it will be implemented and a timeline for implementation. If this option is not possible, KIUC, USFWS and DOFAW will determine if a permit amendment may be necessary.
Conservation Measure 2. Implement Measures to Minimize Light Attraction	Port Allen Generating Station: Dim/turn off the exterior lighting during the fledgling fallout season (September 15 to December 15)	Lights are not being dimmed/turned off at night during the seabird fledgling fallout season (September 15 to December 15)	KIUC compliance monitoring. Annual reporting and annual work plan	KIUC compliance monitor is responsible for informing staff of requirement annually prior to September 15, conducting periodic spot checks, and documenting compliance in Annual Reports	Correct immediately to ensure lights are dimmed or shielded at night consistent with the HCP
Conservation Measure 2. Implement Measures to	Port Allen Generating Station and Kapia Generating	Lights are not compliant between September 15 and December 15	KIUC compliance monitoring. Annual	KIUC compliance monitor is responsible for informing staff of requirement annually prior to September 15, conducting	Correct immediately to ensure lights are dimmed at night consistent with the HCP

Conservation Measure	Metric of Success	Adaptive Management Triggers	Monitoring Strategy	Adaptive Management Response Step 1	Adaptive Management Response Step 2
Minimize Light Attraction	Station: Turn off interior lights at night, or use retractable screen or shades, during the fledgling fallout season (September 15 to December 15)		reporting and annual work plan	periodic spot checks, and documenting compliance in Annual Reports	
Conservation Measure 2. Implement Measures to Minimize Light Attraction	Port Allen Generating Station: All lights utilize full-cutoff white LED lights and shielded wall-mounted white LED box lighting (including new lights installed during the permit term)	Lights are not compliant	KIUC compliance monitoring. Annual reporting and annual work plan	KIUC compliance monitor is responsible for conducting periodic spot checks, and documenting compliance in Annual Reports	Correct immediately to ensure compliance.
Conservation Measure 2. Implement Measures to Minimize Light Attraction	Kapaia Generating Station: All lights are shielded to direct light downward, away from the sky	Lights are not compliant	KIUC compliance monitoring. Annual reporting and annual work plan	KIUC compliance monitor is responsible for conducting periodic spot checks, and documenting compliance in Annual Reports	Correct immediately to ensure compliance
Conservation Measure 2. Implement Measures to Minimize Light Attraction	85 hours of night lighting for restoration of power during the fledgling fallout season (September 15 to	An average of more than 8.5 hours of night lights during the fledgling fallout season (September 15 to December 15)	KIUC compliance monitoring. Annual reporting and annual work plan	Assess, in coordination with USFWS and DOFAW, whether the rate of nighttime lighting for construction is expected to continue and would affect KIUC's 50-year take request.	If the increased rate of streetlight installation is likely to continue, is likely to affect overall estimated annual strikes, and is likely to result in an exceedance of the 50-year take request, KIUC will identify

Conservation Measure	Metric of Success	Adaptive Management Triggers	Monitoring Strategy	Adaptive Management Response Step 1	Adaptive Management Response Step 2
	December 15) by the end of the 50-year permit term	in any 5-year period			additional light minimization within one year (on lights not owned or operated by KIUC) to make up the difference, including where it will be implemented and a timeline for implementation. If this option is not possible, KIUC will also considered changes to the SOS monitoring program to increase the numbers of covered seabirds rescued and turned in to SOS.
Conservation Measure 2. Implement Measures to Minimize Light Attraction	Annual seabird training program prior to the start of the seabird fallout period (September 15 to December 15) using Appendix 6B, *KIUC Site Monitoring Protocols and Procedures for Protected Seabirds*	Training has not occurred by August 15 of each year	KIUC compliance monitoring. Annual reporting and annual work plan	KIUC compliance monitor checks August 15 of each year to ensure training has occurred. If not, compliance monitor ensures and documents that training has occurred.	None
Conservation Measure 2. Implement Measures to Minimize Light Attraction	Predator control is occurring within KIUC's covered facilities	Predator control is not occurring within KIUC's covered facilities	KIUC compliance monitoring. Annual reporting and annual work plan	KIUC will review and evaluate why predator control was not conducted	Predator control will be implemented immediately once non-compliance is documented.
Conservation Measure 3. Provide Funding	KIUC funds SOS consistent with Section 4.4.3,	KIUC does not fund SOS consistent with Section 4.4.3,	KIUC compliance monitoring.	KIUC will work with USFWS and DOFAW to review and evaluate the reason for non-compliance	KIUC will remedy the SOS funding as determined by outcome of Step 1.

Conservation Measure	Metric of Success	Adaptive Management Triggers	Monitoring Strategy	Adaptive Management Response Step 1	Adaptive Management Response Step 2
for the Save Our Shearwaters Program	*Conservation Measure 3. Provide Funding for the Save Our Shearwaters Program*	*Conservation Measure 3. Provide Funding for the Save Our Shearwaters Program*	Annual reporting and annual work plan		
Conservation Measure 4. Manage and Enhance Seabird Breeding Habitat and Colonies at Conservation Sites	KIUC will implement predator control consistent with Section 4.4.4.2, *Management Actions*	KIUC does not implement predator control consistent with Section 4.4.4.2, *Management Actions*	KIUC compliance monitoring. Annual reporting and annual work plan	KIUC will evaluate why predator control is not consistent with Section 4.4.4.2, *Management Actions*. KIUC is permitted to make minor adjustments to the conservation strategy (Section 6.2.2.1, *Minor Adjustments vs. Adaptive Management*)	If for any reason predator control is not consistent with the HCP and is not due to a minor adjustment, meet and confer with USFWS and DOFAW to discuss cause and appropriate response to ensure Objectives 1.3, 2.3, and 3.3 are met.
Conservation Measure 4. Manage and Enhance Seabird Breeding Habitat and Colonies at Conservation Sites	KIUC will install and maintain predator exclusion fencing and implement social attraction consistent with Section 4.4.4.2, *Management Actions*	KIUC's predator exclusion fencing or social attraction is not consistent with Section 4.4.4.2, *Management Actions*	KIUC compliance monitoring. Annual reporting and annual work plan	KIUC will evaluate why predator exclusion fencing is not consistent with Section 4.4.4.2, *Management Actions*. KIUC is permitted to make minor adjustments to the conservation strategy (Section 6.2.2.1, *Minor Adjustments vs. Adaptive Management*)	If for any reason predator control or social attraction is not consistent with the HCP and is not due to a minor adjustment, meet and confer with USFWS and DOFAW to discuss cause and appropriate response to ensure Objectives 1.3 and 2.3 are met.
Conservation Measure 4. Manage and Enhance Seabird Breeding Habitat and Colonies at Conservation Sites	KIUC will eradicate all predators and initiate social attraction in Pōhākea PF and Honopū PF, consistent with Section 4.4.4.2, *Management Actions*, by no	Predators are not eradicated, or social attraction is not initiated in Pōhākea PF and Honopū PF by the end of 2023.	KIUC compliance monitoring. Annual reporting and annual work plan	Assess, in coordination with USFWS and DOFAW, whether the delay is likely to affect KIUC's ability to meet Objectives 1.3 or 2.3	If the delay will reduce KIUC's take offset, KIUC will identify additional mitigation to make up the difference to ensure Objectives 1.3 and 2.3 are met. If this option is not possible, KIUC, USFWS, and DOFAW will determine if a permit amendment may be necessary.

Conservation Measure	Metric of Success	Adaptive Management Triggers	Monitoring Strategy	Adaptive Management Response Step 1	Adaptive Management Response Step 2
	later than the end of the first year of the permit term (2023).				
Conservation Measure 4. Manage and Enhance Seabird Breeding Habitat and Colonies at Conservation Sites	KIUC will select and commit to a location and configuration for Site 10 no later than the end of 2023.	KIUC has not selected a location for Site 10 by the end of 2023	KIUC compliance monitoring. Annual reporting and annual work plan	Assess, in coordination with USFWS and DOFAW, whether the delay is likely to affect KIUC's ability to meet Objective 1.3 or 2.3	If the delay will reduce KIUC's take offset, KIUC will identify mitigation to make up the difference to ensure Objectives 1.3 and 2.3 are met. If this option is not possible, KIUC, USFWS, and DOFAW will determine if a permit amendment may be necessary.
Conservation Measure 4. Manage and Enhance Seabird Breeding Habitat and Colonies at Conservation Sites	KIUC will complete installation of predator exclusion fencing at Upper Limahuli Preserve and Conservation Site 10 by the end of 2025	Predator exclusion fencing is not complete at Upper Limahuli Preserve and Conservation Site 10 by the end of 2025	KIUC compliance monitoring. Annual reporting and annual work plan	Assess, in coordination with USFWS and DOFAW, whether the delay is likely to affect KIUC's ability to meet Objective 1.3 or 2.3	If the delay will reduce KIUC's take offset, KIUC will identify mitigation to make up the difference to ensure Objectives 1.3 and 2.3 are met. If this option is not possible, KIUC, USFWS, and DOFAW will determine if a permit amendment may be necessary.
Conservation Measure 4. Manage and Enhance Seabird Breeding Habitat and Colonies at Conservation Sites	KIUC will eradicate all predators and initiate social attraction in Upper Limahuli Preserve and Site 10, consistent with Section 4.4.4.2, *Management Actions*, no later	Predators are not eradicated, or social attraction is not initiated in Upper Limahuli Preserve and Conservation Site 10 by the end of 2026.	KIUC compliance monitoring. Annual reporting and annual work plan	Assess, in coordination with USFWS and DOFAW, whether the delay is likely to affect KIUC's ability to meet Objective 1.3 or 2.3	If the delay will reduce KIUC's take offset, KIUC will identify mitigation to make up the difference to ensure Objectives 1.3 and 2.3 are met. If this option is not possible, KIUC, USFWS, and DOFAW will determine if a permit amendment may be necessary.

Conservation Measure	Metric of Success	Adaptive Management Triggers	Monitoring Strategy	Adaptive Management Response Step 1	Adaptive Management Response Step 2
	than the end of 2026				
Conservation Measure 4. Manage and Enhance Seabird Breeding Habitat and Colonies at Conservation Sites	KIUC will implement invasive plant species management consistent with Section 4.4.4.2, *Management Actions*	Invasive plant species management not implemented consistent with Section 4.4.4.2, *Management Actions*	KIUC compliance monitoring. Annual reporting and annual work plan	KIUC will evaluate why invasive plant species control is not consistent with Section 4.4.4.2, *Management Actions*. KIUC is permitted to make minor adjustments to the conservation strategy (Section 6.2.2.1, *Minor Adjustments vs. Adaptive Management*)	If for any reason invasive plant species control is not consistent with the HCP and is not due to a minor adjustment, meet and confer with USFWS and DOFAW to discuss cause and appropriate response to ensure Objectives 1.3 and 2.3 are met.
Conservation Measure 5. Implement a Green Sea Turtle Nest Detection and Temporary Shielding Program	KIUC will implement nest detection program consistent with Section 4.4.5.1, *Nest Detection*	Nest detection program not implemented consistent with Section 4.4.5.1, *Nest Detection*	KIUC compliance monitoring. Annual reporting and annual work plan	KIUC compliance monitor tracks compliance and notifies entities responsible for implementation of nest detection program to ensure compliance. KIUC is permitted to make minor adjustments to the conservation strategy (Section 6.2.2.1, *Minor Adjustments vs. Adaptive Management*)	KIUC will correct the issue immediately to ensure compliance. If, for any reason, the nest detection program cannot be implemented consistent with specifications and the change is not due to a minor adjustment, meet and confer with USFWS, DOFAW, and DAR to discuss the cause and appropriate response to ensure Objective 5.1 is met.
Conservation Measure 5. Implement a Green Sea Turtle Nest Detection and Temporary Shielding Program	KIUC will shield active nests from streetlights consistent with Section 4.4.5.2, *Shield Active Nests from Streetlights*	Nests not shielded from streetlights consistent with Section 4.4.5.2, *Shield Active Nests from Streetlights*	KIUC compliance monitoring. Annual reporting and annual work plan	KIUC compliance monitor tracks compliance and notifies entities responsible for shielding nests to ensure compliance. KIUC is permitted to make minor adjustments to the conservation strategy (Section 6.2.2.1, *Minor Adjustments vs. Adaptive Management*)	KIUC will correct the issue immediately to ensure compliance. If, for any reason, the nest detection program cannot be implemented consistent with specifications and the change is not due to a minor adjustment, meet and confer with USFWS, DOFAW, and DAR to discuss the cause and appropriate response to ensure Objective 5.1 is met.

Conservation Measure	Metric of Success	Adaptive Management Triggers	Monitoring Strategy	Adaptive Management Response Step 1	Adaptive Management Response Step 2
Conservation Measure 5. Implement a Green Sea Turtle Nest Detection and Temporary Shielding Program	KIUC will conduct annual training and reporting consistent with Section 4.4.5.5, *Annual Training and Reporting*	Annual training not completed 1 month prior to the start of the green sea turtle (honu) nesting season or reporting is not consistent with Section 4.4.5.5, *Annual Training and Reporting*	KIUC compliance monitoring. Annual reporting and annual work plan	KIUC compliance monitor tracks compliance and notifies entities responsible for implementation of training and reporting to ensure compliance. KIUC is permitted to make minor adjustments to the conservation strategy (Section 6.2.2.1, *Minor Adjustments vs. Adaptive Management*)	KIUC will correct the issue immediately to ensure compliance.
Conservation Measure 6. Identify and Implement Practicable Streetlight Minimization Techniques for Green Sea Turtle	KIUC will install practicable light minimization techniques within a timeframe agreed upon by USFWS, DOFAW, and DAR, consistent with Section 4.4.6.1, *Identify and Install Practicable Light Minimization Techniques*, if an agreement is reached with the County and State	Light minimization techniques are installed within the agreed upon timeframe if an agreement is reached with the County and State that this minimization is practicable.	KIUC compliance monitoring. Annual reporting and annual work plan	KIUC will consult with USFWS, DOFAW, and DAR to determine reason for non-compliance.	KIUC will correct the issue immediately to ensure compliance.

km = kilometer; LED = light-emitting diode; m = meter

6.4 Take and Effectiveness Monitoring and Adaptive Management Triggers

As described above, take monitoring is a component of compliance monitoring that compares the actual take that occurs during implementation to the take limit authorized by the federal ITP and state ITL. Effectiveness monitoring assesses the biological performance of the HCP.

This section describes methods and protocols for take monitoring and effectiveness monitoring actions. The section also describes the adaptive management triggers and responses relevant to each of the six conservation measures and their associated biological goals and objective identified in Chapter 4, *Conservation Strategy*. Table 6-3 summarizes the adaptive management triggers and responses for take monitoring and effectiveness monitoring. The format for Table 6-3 is the same as for Table 6-2. The one exception is that the relevant biological goals and objectives are also include in Table 6-3 to help organize the monitoring actions. Each section after Table 6-3 describes take monitoring, effectiveness monitoring, and adaptive management associated with each conservation measure. For details of the metrics of success, the adaptive management triggers, the monitoring strategy, and the response steps, see the text following Table 6-3.

Table 6-3. Adaptive Management Triggers for Take and Effectiveness Monitoring

Conservation Measure	Metric of Success	Adaptive Management Triggers	Monitoring Strategy	Adaptive Management Response Step 1	Adaptive Management Response Step 2
Take Monitoring					
Objective 1.1 (Newell's shearwater ('a'o)), Objective 2.1 (Hawaiian petrel ('ua'u))					
Conservation Measure 1. Implement Powerline Collision Minimization Projects	No more than 553 annual powerline strikes of Newell's shearwater ('a'o) by year 25 of the permit term (2048) and no more than 203 annual strikes Newell's shearwater ('a'o) by end of permit term (2073) (based on a 5-year rolling average)	Strikes higher than predicted as shown in Appendix 6A, *Adaptive Management Comparison Tables*, Table 6A-1 based on 5-year rolling average	Annual monitoring of high-risk spans. Rover acoustic monitoring and Bayesian model. Proportion by species will be constant and assumed.	Notify USFWS and DOFAW and meet and confer to determine whether modifications to minimization or monitoring are needed. KIUC will evaluate whether the cause is due to strike reduction issues or population increases as measured by radar data or other data available at the time. If difference is likely due to strike reduction issues, see Step 2. If difference is likely due to population increase of subpopulations more susceptible to powerline collisions, coordinate with USFWS and DOFAW to assess whether permit amendment will be needed.	Reduce strikes through additional powerline minimization. KIUC will evaluate the span(s) to determine what minimization technique(s) already identified in the HCP are practicable. KIUC may also test novel minimization techniques that incorporate new technology. KIUC will identify a practicable plan of action within 6 months of annual reporting. The timeline for minimization installation will depend on the technique (i.e., reconfiguration requires more planning and permitting than diverter installation).
Conservation Measure 1. Implement Powerline Collision Minimization Projects	No more than 358 annual powerline strikes of Hawaiian petrel ('ua'u) by year 25 of the permit term (2048) and no more than 203 annual strikes of	Strikes higher than predicted as shown in Appendix 6A, *Adaptive Management Comparison Tables*, Table 6A-1 based on	Annual monitoring of high-risk spans. Rover acoustic monitoring and Bayesian model. Proportion by species will be	Notify USFWS and DOFAW and meet and confer to determine whether modifications to minimization or monitoring are needed. KIUC will evaluate whether the cause is due to strike reduction issues or population increases as	Reduce strikes through additional powerline minimization. KIUC will evaluate the span(s) to determine what minimization technique(s) already identified in the HCP are practicable. KIUC may also test novel minimization techniques that incorporate new technology.

Conservation Measure	Metric of Success	Adaptive Management Triggers	Monitoring Strategy	Adaptive Management Response Step 1	Adaptive Management Response Step 2
	Hawaiian petrel (ʻuaʻu) by end of permit term (2073) (based on a 5-year rolling average)	5-year rolling average	constant and assumed.	measured by radar data or other data available at the time. If difference is likely due to strike reduction issues, see Step 2. If difference is likely due to population increase of subpopulations more susceptible to powerline collisions, coordinate with USFWS and DOFAW to assess whether permit amendment will be needed.	KIUC will identify a practicable plan of action within 6 months of annual reporting. The timeline for minimization installation will depend on the technique (i.e., reconfiguration requires more planning and permitting than diverter installation).
Objective 4.1 (Waterbirds)					
Conservation Measure 1. Implement Powerline Collision Minimization Projects	No more than 65 Hawaiian stilt (aeʻo) mortalities, 219 Hawaiian duck (koloa maoli) mortalities, 42 Hawaiian coot (ʻalae keʻokeʻo) mortalities, 167 Hawaiian common gallinule (ʻalae ʻula) mortalities, or 502 Hawaiian goose (nēnē) mortalities by the end of permit term	More than one Hawaiian stilt (aeʻo) mortality, four Hawaiian duck (koloa maoli) mortalities, one Hawaiian coot (ʻalae keʻokeʻo) mortalities, three Hawaiian common gallinule (ʻalae ʻula) mortalities, and 10 Hawaiian goose (nēnē) mortalities in any year, based on a 5-year rolling average.	Annual monitoring of high-risk spans. Rover acoustic monitoring and Bayesian model. Proportion of strikes attributed to waterbirds will be constant and assumed.	Notify USFWS and DOFAW and meet and confer to determine whether modifications to minimization or monitoring are needed. KIUC will evaluate whether the cause is due to strike reduction issues or population increases as measured by radar data. If difference is likely due to strike reduction issues, see Step 2. If difference is likely due to population increases, coordinate with USFWS and DOFAW to assess whether permit amendment will be needed.	Reduce strikes through additional powerline minimization. KIUC will evaluate the span(s) to determine what minimization technique(s) already identified in the HCP are practicable. KIUC may also test novel minimization techniques that incorporate new technology. KIUC will identify a practicable plan of action within 6 months of annual reporting. The timeline for minimization installation will depend on the technique (i.e., reconfiguration requires more planning and permitting than diverter installation).

Conservation Measure	Metric of Success	Adaptive Management Triggers	Monitoring Strategy	Adaptive Management Response Step 1	Adaptive Management Response Step 2
Objective 1.1 (Newell's shearwater (ʻaʻo)), Objective 2.2 (Hawaiian petrel (ʻuaʻu)), Goal 3, Objective 3.1 (Band-rumped storm-petrel (ʻakēʻakē))					
Conservation Measure 2. Implement Measures to Minimize Light Attraction	No more than 260 groundings (alive or dead) of Newell's shearwater (ʻaʻo), 5 groundings of Hawaiian petrel (ʻuaʻu), and no groundings of band-rumped storm-petrel (ʻakēʻakē) by the end of the permit term at the covered facilities (Port Allen and Kapaia Generating Stations).	Groundings (alive or dead) of six or more Newell's shearwater (ʻaʻo) annually, based on a 5-year rolling average. Any incidents of Hawaiian petrel (ʻuaʻu) or band-rumped storm-petrel (ʻakēʻakē) also trigger adaptive management.	Facility monitoring (Section 6.4.2, *Light Attraction Monitoring and Adaptive Management*)	Notify USFWS and DOFAW and meet and confer to determine whether modifications to management or monitoring are needed. If needed, go to Step 2.	KIUC will investigate causes and evaluate whether further minimization is practicable to reduce fallout or if additional monitoring is needed to reduce mortality. Implement further minimization or monitoring if feasible and appropriate based on causes. See Section 6.4.2.3, *Adaptive Management*.
Conservation Measure 2. Implement Measures to Minimize Light Attraction	Predators are removed from covered facilities consistent with Section 4.4.2.5, *Predator Removal at Covered Facilities*	Any signs of predation on covered species carcass at a covered facility	KIUC compliance monitoring. Annual reporting and annual work plan	Any carcasses found are brought to SOS for examination	KIUC will assess predator source and modify predator control strategy as appropriate to remedy the issue as soon as possible following discovery of carcass.
Conservation Measure 2. Implement Measures to Minimize Light Attraction	Groundings from construction night lighting for the restoration of power is 5 or fewer Newell's shearwaters (ʻaʻo),	Groundings from construction night lighting for the restoration of power is 6 or more Newell's	KIUC compliance monitoring. Annual reporting and annual work plan	Notify USFWS and DOFAW and meet and confer to determine if the number of grounded birds due to night lighting could result in KIUC exceeding its combined take estimate for light attraction	KIUC will investigate whether additional minimization is practicable to reduce fallout or if additional monitoring is needed to reduce mortality. Implement further minimization or monitoring if feasible and

Conservation Measure	Metric of Success	Adaptive Management Triggers	Monitoring Strategy	Adaptive Management Response Step 1	Adaptive Management Response Step 2
	and 0 Hawaiian petrel (ʻuaʻu) or band-rumped storm-petrel (ʻakēʻakē), based on a 5-year rolling average	shearwater (ʻaʻo), and 1 or more Hawaiian petrel (ʻuaʻu) or band-rumped storm-petrel (ʻakēʻakē), based on a 5-year rolling average		(Chapter 5, *Effects*, Table 5-5). If the answer is yes, proceed to Step 2.	appropriate. KIUC, USFWS, and DOFAW may also consider additional powerline minimization to make up the difference if additional light attraction minimization is not practicable.
Objective 1.3 (Newell's shearwater (ʻaʻo)), Objective 2.3 (Hawaiian petrel (ʻuaʻu))					
Conservation Measure 4. Manage and Enhance Seabird Breeding Habitat and Colonies at Conservation Sites	No more than 177 Newell's shearwater (ʻaʻo)or 315 Hawaiian petrel (ʻuaʻu) injured or killed from predator traps over the permit term.	Five-year rolling average of more than 4 Newell's shearwater (ʻaʻo) or more than 6 Hawaiian petrel (ʻuaʻu) injured or killed from predator traps in any year.	Conservation site monitoring (Section 6.4.4, *Conservation Site Monitoring and Adaptive Management*)	Notify USFWS and DOFAW and meet and confer to determine whether modifications to management are needed. If needed, go to Step 2.	KIUC will investigate causes and implement modifications as needed based on the best available technology to minimize mortalities.
Objective 5.1 and 5.2 (Green sea turtle (honu))					
Conservation Measure 5. Implement a Green Sea Turtle Nest Detection and Temporary Shielding Program	No more than 50 nests taken over the permit term	Number of nests taken in any year is 2 or greater, or take of any number of hatchlings from undocumented nests	Nest monitoring (see Chapter 4, Section 4.4.5, *Conservation Measure 5. Implement a Green Sea Turtle Nest Detection and Temporary Shielding Program*).	Notify USFWS and DOFAW and meet and confer to determine whether modifications to management or monitoring are needed. If needed, go to Step 2.	KIUC will evaluate potential additional minimization and monitoring measures and implement if practicable. See Section 6.4.5.3, *Adaptive Management*

Conservation Measure	Metric of Success	Adaptive Management Triggers	Monitoring Strategy	Adaptive Management Response Step 1	Adaptive Management Response Step 2
Mitigation Efficacy Monitoring					
Objective 1.1 (Newell's shearwater ('a'o)), Goal 2, Objective 2.1 (Hawaiian petrel ('ua'u))					
Conservation Measure 1. Implement Powerline Collision Minimization Projects	65.3% reduction in seabird strikes	Island-wide seabird annual take over a 3-year average (2024, 2025, 2026) after all minimization is completed (end of 2023) is higher than expected with 65.3% reduction of strikes	Acoustic data from song meters located on powerlines as measured over 3 years after minimization is completed reduction of strikes is measured through take monitoring	Notify USFWS and DOFAW and meet and confer to determine whether modifications to management or monitoring are needed. KIUC will evaluate whether the cause is due to strike reduction issues or population increases as measured by radar data. If difference is like due to strike reduction issues, see Step 2. If difference is due to population increases, coordinate with USFWS and DOFAW to assess whether permit amendment will be needed.	If the cause is minimization not being effective and annual strikes exceed what is expected with 65.3% strike reduction, by the end of 2028 identify additional minimization (this may also include the same amount/location using a technique with a higher strike reduction) to make up the difference, where it will be implemented, and timeline for implementation. If minimization cannot make up the difference, and annual strikes are exceeding what is expected with 65.3% reduction in strikes, by the end of 2028 evaluate whether the 50-year take limit is likely to be exceeded. If so, a permit amendment may be needed.
Objective 4.2 (Waterbirds)					
Conservation Measure 1. Implement Powerline Collision Minimization Projects	90% reduction of waterbird strikes	If annual take as measured and calculated at Mānā and Hanalei spans over a 3-year average (2024, 2025, 2026) after all minimization is completed (end	Acoustic data from song meters located on powerlines as measured over 3 years after minimization is completed reduction of strikes is	Notify USFWS and DOFAW and meet and confer to determine whether modifications to management or monitoring are needed. KIUC will evaluate whether the cause is due to strike reduction issues or population increases as measured by radar data. If difference is like due to strike	If the cause is minimization not being effective and annual waterbird strikes exceed what is expected with 90% strike reduction, by the end of 2028 identify additional minimization (this may also include the same amount/location using a technique with a higher strike reduction) to make up the difference, where it will be

Conservation Measure	Metric of Success	Adaptive Management Triggers	Monitoring Strategy	Adaptive Management Response Step 1	Adaptive Management Response Step 2
		of 2023) is higher than expected with 90% reduction of waterbird strikes	measured through take monitoring	reduction issues, see Step 2. If difference is due to population increases, coordinate with USFWS and DOFAW to assess whether permit amendment will be needed.	implemented, and timeline for implementation. If minimization cannot make up the difference, and annual strikes are exceeding what is expected with 90% reduction in strikes, by the end of 2028 evaluate whether the 50-year take limit is likely to be exceeded. If so, a permit amendment may be needed.
Objective 1.1 (Newell's shearwater ('a'o)), Objective 2.2 (Hawaiian petrel ('ua'u)), Objective 3.1 (Band-rumped storm-petrel ('akē'akē))					
Conservation Measure 2. Implement Measures to Minimize Light Attraction	No more than 260 groundings (alive or dead) of Newell's shearwater ('a'o) and 5 mortalities of Hawaiian petrel ('ua'u) by the end of the permit term.	Groundings (alive or dead) exceed 5 Newell's shearwater ('a'o) annually, based on a 5-year rolling average. Any incidents of Hawaiian petrel ('ua'u) or band-rumped storm-petrel ('akē'akē) also trigger adaptive management.	Facility monitoring (Section 6.4.2, *Light Attraction Monitoring and Adaptive Management*)	Notify USFWS and DOFAW and meet and confer to determine whether modifications to management or monitoring are needed. If needed, go to Step 2.	KIUC will investigate causes and evaluate whether further minimization is practicable to reduce fallout or if additional monitoring is needed to reduce mortality. Implement further minimization or monitoring if feasible and appropriate based on causes. See Section 6.4.2.3, *Adaptive Management*.
Conservation Measure 2. Implement Measures to Minimize Light Attraction	Predators are removed from covered facilities consistent with Section 4.4.2.5, *Predator Removal*	Any signs of predation on covered species carcass at a covered facility	KIUC compliance monitoring. Annual reporting and annual work plan	Any carcasses found are brought to SOS for examination	KIUC will assess predator source and modify predator control strategy as appropriate to remedy the issue as soon as possible following discovery of carcass.

Conservation Measure	Metric of Success	Adaptive Management Triggers	Monitoring Strategy	Adaptive Management Response Step 1	Adaptive Management Response Step 2
	at Covered Facilities				
Objective 3.2 (Band-rumped storm-petrel ('akē'akē)), Objective 4.2 (Waterbirds)					
Conservation Measure 3. Provide Funding for the Save Our Shearwaters Program	Fund SOS or another rehabilitation facility at the level needed to provide rehabilitation care for covered avian species	10% or greater combined increases in covered avian species 3 years in a row	SOS tracking of data and annual reporting of numbers of birds handled for each species	Work with SOS, USFWS, and DOFAW to determine if the current level of funding is sufficient to rehabilitate the increased number of covered species. If the funding level is determined to be insufficient, see Step 2.	KIUC will increase funding by at least 50% relative to the increased covered species (10% increase in covered species turned in equals 5% increase in funding. 20% increase in covered species turned in equals 10% increase in funding, etc.)
Objective 1.3 (Newell's shearwater ('a'o)), Objective 2.3 (Hawaiian petrel ('ua'u))					
All 10 conservation sites combined Conservation Measure 4. Manage and Enhance Seabird Breeding Habitat and Colonies at Conservation Sites	Maintain an annual minimum of 1,264 Newell's shearwater ('a'o) breeding pairs	Fewer than 1,264 Newell's shearwater ('a'o) breeding pairs in any given year.	Call rates/breeding rates and modeling	Notify USFWS and DOFAW and meet and confer to determine whether modifications to management are needed. If needed, go to Step 2.	KIUC will evaluate causes and develop an appropriate approach. Options may include modifying predator control strategy or other methods based on available information and technology.
All 10 conservation sites combined Conservation Measure 4. Manage and Enhance Seabird Breeding Habitat and Colonies at Conservation Sites	Growth rate for Newell's shearwater ('a'o) breeding pairs annually of at least 1% to reach a target of 2,371 breeding pairs by Year 25 of the permit term and 4,313 breeding	Newell's shearwater ('a'o) breeding pairs in any year is lower than Appendix 6A, *Adaptive Management Comparison Tables*, Table 6A-3 based on 5-year rolling	Call rates/breeding rates and modeling.	Notify USFWS and DOFAW and meet and confer to determine whether modifications to management are needed. If needed, go to Step 2.	KIUC will evaluate causes and develop an appropriate approach. Options may include modifying predator control strategy or other methods based on available information and technology.

Conservation Measure	Metric of Success	Adaptive Management Triggers	Monitoring Strategy	Adaptive Management Response Step 1	Adaptive Management Response Step 2
	pairs by the end of the permit term.	average to account for annual variability			
All 10 conservation sites combined Conservation Measure 4. Manage and Enhance Seabird Breeding Habitat and Colonies at Conservation Sites	Maintain an 87.2% reproductive success rate for Newell's shearwater ('a'o)	Less than 87.2% reproductive success rate for Newell's shearwater ('a'o) based on a 5-year rolling average.	Annual colony monitoring at reference burrows: estimate of burrows, chicks, predation/loss, and fledgling success	Notify USFWS and DOFAW and meet and confer to determine whether modifications to management are needed. If needed, go to Step 2.	KIUC will evaluate causes and develop an appropriate approach. Options may include modifying predator control strategy or other methods based on available information and technology.
Upper Limahuli Conservation Measure 4. Manage and Enhance Seabird Breeding Habitat and Colonies at Conservation Sites	Maintain an 87% reproductive success rate for Newell's shearwater ('a'o)	Less than 87% reproductive success rate for Newell's shearwater ('a'o) based on a 5-year rolling average.	Annual colony monitoring at reference burrows: estimate of burrows, chicks, predation/loss, fledgling success	Notify USFWS and DOFAW and meet and confer to determine whether modifications to management are needed. If needed, go to Step 2.	KIUC will evaluate causes and develop an appropriate approach. Options may include modifying predator control strategy or other methods based on available information and technology.
Pōhākea Conservation Measure 4. Manage and Enhance Seabird Breeding Habitat and Colonies at Conservation Sites	Maintain a 93.7% reproductive success rate for Newell's shearwater ('a'o)	Less than 93.7% reproductive success rate for Newell's shearwater ('a'o) based on a 5-year rolling average.	Annual colony monitoring at reference burrows: estimate of burrows, chicks, predation/loss, fledgling success	Notify USFWS and DOFAW and meet and confer to determine whether modifications to management are needed. If needed, go to Step 2.	KIUC will evaluate causes and develop an appropriate approach. Options may include modifying predator control strategy or other methods based on available information and technology.
Hanakāpi'ai Conservation Measure 4. Manage and Enhance Seabird	Maintain an 86.8% reproductive success rate for Newell's shearwater ('a'o)	Less than 86.8% reproductive success rate for Newell's shearwater	Annual colony monitoring at reference burrows: estimate of burrows, chicks,	Notify USFWS and DOFAW and meet and confer to determine whether modifications to management	KIUC will evaluate causes and develop an appropriate approach. Options may include modifying predator control strategy or other methods based

Conservation Measure	Metric of Success	Adaptive Management Triggers	Monitoring Strategy	Adaptive Management Response Step 1	Adaptive Management Response Step 2
Breeding Habitat and Colonies at Conservation Sites		(ʻaʻo) based on a 5-year rolling average.	predation/loss, fledgling success	are needed. If needed, go to Step 2.	on available information and technology.
Conservation Site 10 Conservation Measure 4. Manage and Enhance Seabird Breeding Habitat and Colonies at Conservation Sites	Maintain a 81.3% reproductive success rate for Newell's shearwater (ʻaʻo)	Less than 81.3% reproductive success rate for Newell's shearwater (ʻaʻo) based on a 5-year rolling average.	Annual colony monitoring at reference burrows: estimate of burrows, chicks, predation/loss, fledgling success	Notify USFWS and DOFAW and meet and confer to determine whether modifications to management are needed. If needed, go to Step 2.	KIUC will evaluate causes and develop an appropriate approach. Options may include modifying predator control strategy or other methods based on available information and technology.
All 10 conservation sites combined Conservation Measure 4. Manage and Enhance Seabird Breeding Habitat and Colonies at Conservation Sites	Maintain an annual minimum of 2,257 Hawaiian petrel (ʻuaʻu) breeding pairs	Fewer than 2,257 Hawaiian petrel (ʻuaʻu) breeding pairs in any given year.	Call rates/breeding rates and modeling	Notify USFWS and DOFAW and meet and confer to determine whether modifications to management are needed. If needed, go to Step 2.	KIUC will evaluate causes and develop an appropriate approach. Options may include modifying predator control strategy or other methods based on available information and technology.
All 10 conservation sites combined Conservation Measure 4. Manage and Enhance Seabird Breeding Habitat and Colonies at Conservation Sites	Growth rate for Hawaiian petrel (ʻuaʻu) breeding pairs annually of at least 1% to reach a target of 2,926 breeding pairs by year 25 of the permit term and 3,751 breeding pairs by the end of the permit term.	Hawaiian petrel (ʻuaʻu) breeding pairs in any year is lower than Appendix 6A, *Adaptive Management Comparison Tables*, Table 6A-4 based on 5-year rolling average to account for annual variability	Call rates/breeding rates and modeling.	Notify USFWS and DOFAW and meet and confer to determine whether modifications to management are needed. If needed, go to Step 2.	KIUC will evaluate causes and develop an appropriate approach. Options may include modifying predator control strategy or other methods based on available information and technology.

Conservation Measure	Metric of Success	Adaptive Management Triggers	Monitoring Strategy	Adaptive Management Response Step 1	Adaptive Management Response Step 2
All 10 conservation sites combined Conservation Measure 4. Manage and Enhance Seabird Breeding Habitat and Colonies at Conservation Sites	Maintain a 78.7% reproductive success rate for Hawaiian petrel (ʻuaʻu)	Less than 78.7% reproductive success rate for Hawaiian petrel (ʻuaʻu) based on a 5-year rolling average.	Annual colony monitoring at reference burrows: estimate of burrows, chicks, predation/loss, fledgling success	Notify USFWS and DOFAW and meet and confer to determine whether modifications to management are needed. If needed, go to Step 2.	Evaluate causes and develop an appropriate approach. Options may include modifying predator control strategy or other methods based on available information and technology.
Upper Limahuli Conservation Measure 4. Manage and Enhance Seabird Breeding Habitat and Colonies at Conservation Sites	Maintain a 66.7% reproductive success rate for Hawaiian petrel (ʻuaʻu)	Less than 66.7% reproductive success rate for Hawaiian petrel (ʻuaʻu) based on a 5-year rolling average.	Annual colony monitoring at reference burrows: estimate of burrows, chicks, predation/loss, fledgling success	Notify USFWS and DOFAW and meet and confer to determine whether modifications to management are needed. If needed, go to Step 2.	KIUC will evaluate causes and develop an appropriate approach. Options may include modifying predator control strategy or other methods based on available information and technology.
Pihea Conservation Measure 4. Manage and Enhance Seabird Breeding Habitat and Colonies at Conservation Sites	Maintain a 80.3% reproductive success rate for Hawaiian petrel (ʻuaʻu)	Less than 80.3% reproductive success rate for Hawaiian petrel (ʻuaʻu) based on a 5-year rolling average.	Annual colony monitoring at reference burrows: estimate of burrows, chicks, predation/loss, fledgling success	Notify USFWS and DOFAW and meet and confer to determine whether modifications to management are needed. If needed, go to Step 2.	KIUC will evaluate causes and develop an appropriate approach. Options may include modifying predator control strategy or other methods based on available information and technology.
North Bog Conservation Measure 4. Manage and Enhance Seabird Breeding Habitat and Colonies at Conservation Sites	Maintain a 78% reproductive success rate for Hawaiian petrel (ʻuaʻu)	Less than 78% reproductive success rate Hawaiian petrel (ʻuaʻu) based on a 5-year rolling average.	Annual colony monitoring at reference burrows: estimate of burrows, chicks, predation/loss, fledgling success	Notify USFWS and DOFAW and meet and confer to determine whether modifications to management are needed. If needed, go to Step 2.	KIUC will evaluate causes and develop an appropriate approach. Options may include modifying predator control strategy or other methods based on available information and technology.

Conservation Measure	Metric of Success	Adaptive Management Triggers	Monitoring Strategy	Adaptive Management Response Step 1	Adaptive Management Response Step 2
Pōhākea Conservation Measure 4. Manage and Enhance Seabird Breeding Habitat and Colonies at Conservation Sites	Maintain a 75.5% reproductive success rate for Hawaiian petrel (ʻuaʻu)	Less than 75.5% reproductive success rate for Hawaiian petrel (ʻuaʻu) based on a 5-year rolling average.	Annual colony monitoring at reference burrows: estimate of burrows, chicks, predation/loss, fledgling success	Notify USFWS and DOFAW and meet and confer to determine whether modifications to management are needed. If needed, go to Step 2.	KIUC will evaluate causes and develop an appropriate approach. Options may include modifying predator control strategy or other methods based on available information and technology.
Hanakoa Conservation Measure 4. Manage and Enhance Seabird Breeding Habitat and Colonies at Conservation Sites	Maintain a 86.4% reproductive success rate for Hawaiian petrel (ʻuaʻu)	Less than 86.4% reproductive success rate for Hawaiian petrel (ʻuaʻu) based on a 5-year rolling average.	Annual colony monitoring at reference burrows: estimate of burrows, chicks, predation/loss, fledgling success	Notify USFWS and DOFAW and meet and confer to determine whether modifications to management are needed. If needed, go to Step 2.	KIUC will evaluate causes and develop an appropriate approach. Options may include modifying predator control strategy or other methods based on available information and technology.
Hanakāpiʻai Conservation Measure 4. Manage and Enhance Seabird Breeding Habitat and Colonies at Conservation Sites	Maintain a 85.4% reproductive success rate for Hawaiian petrel (ʻuaʻu)	Less than 85.4% reproductive success rate for Hawaiian petrel (ʻuaʻu) based on a 5-year rolling average.	Annual colony monitoring at reference burrows: estimate of burrows, chicks, predation/loss, fledgling success	Notify USFWS and DOFAW and meet and confer to determine whether modifications to management are needed. If needed, go to Step 2.	KIUC will evaluate causes and develop an appropriate approach. Options may include modifying predator control strategy or other methods based on available information and technology.
Social attraction Conservation Measure 4. Manage and Enhance Seabird Breeding Habitat and Colonies at Conservation Sites	Produce at least one Newell's shearwater (ʻaʻo) breeding pair within each of the four social attraction sites by Year 10 of the permit term	One or more social attraction sites without a breeding pair by Year 5	Annual colony monitoring within social attraction sites: estimate of burrows, chicks, predation/loss, fledgling success	Notify USFWS and DOFAW and meet and confer to determine whether modifications to management are needed. If needed, go to Step 2.	KIUC will evaluate causes and develop an appropriate approach. Options may include modifying predator control strategy or other methods based on available information and technology.

Conservation Measure	Metric of Success	Adaptive Management Triggers	Monitoring Strategy	Adaptive Management Response Step 1	Adaptive Management Response Step 2
Predator control and invasive plant species control Conservation Measure 4. Manage and Enhance Seabird Breeding Habitat and Colonies at Conservation Sites	Growth rate for Newell's shearwater (ʻaʻo) breeding pairs annually of at least 1% to reach a target of 2,371 breeding pairs by Year 25 and 4,313 breeding pairs by the end of the permit term and for Hawaiian petrel (ʻuaʻu) a target of 2,926 breeding pairs by Year 25 and 3,751 breeding pairs by the end of the permit term.	Newell's shearwater (ʻaʻo) or Hawaiian petrel (ʻuaʻu) breeding pairs in any year is lower than Appendix 6A, *Adaptive Management Comparison Tables*, Table 6A-3 or Table 6A-4, and a determination that this is due to predator control and invasive plant species control efficacy issues.	Predator control monitoring and invasive species control monitoring	Notify USFWS and DOFAW and meet and confer to determine whether modifications to management are needed. If needed, go to Step 2.	KIUC will evaluate causes and develop an appropriate approach. Options may include modifying predator control strategy or other methods based on available information and technology.

6.4.1 Powerline Strike Monitoring and Adaptive Management

6.4.1.1 Effectiveness Monitoring

Biological objectives 1.1, 2.1, and 4.1 (Table 4-1) require that KIUC substantially reduce the extent and effect of collisions of covered seabirds and waterbirds in accordance with the location, extent, and schedule outlined in Chapter 4, Section 4.3, *Biological Goals and Objectives*. To meet these objectives, KIUC has been implementing powerline collision minimization projects (Conservation Measure 1) since 2020 as early implementation for the HCP. (Some minimization actions happened before this time during KIUC's Short-Term HCP as described in Chapter 4, Section 4.4.1, *Conservation Measure 1. Implement Powerline Collision Minimization Projects*.)

KIUC monitors powerline strikes along its powerlines before and after minimization projects are implemented. The goal of this monitoring is to verify and measure the reductions in covered species collisions, evaluating each modification span-by-span. Based on current strike reduction estimates (Travers et al. 2020), KIUC is expected to achieve a 65.3 percent reduction in covered seabird collisions from existing powerlines systemwide.[7] KIUC also expects to achieve a 90 percent reduction in powerline collisions of covered waterbirds (Shaw et al. 2021) using the techniques described under Chapter 4, Section 4.4.1, *Conservation Measure 1. Implement Powerline Collision Minimization Projects*.

KIUC will complete all of its planned powerline minimization projects by no later than the end of 2023. As such, KIUC expects that effectiveness monitoring will be completed by the end of 2026 to account for annual and seasonal variation.

KIUC cannot evaluate minimization effectiveness for new powerlines because there is no baseline (i.e., collision data prior to the installation of minimization techniques) against which to evaluate the percent strike reduction. As stated in Chapter 4, Section 4.4.1.3, *Future Transmission and Distribution Lines*, new powerlines will be installed in a way to reduce strike risk as much as practicable; KIUC is estimating an 80 percent reduction in powerline collisions on new lines for the covered seabirds based on data for existing powerlines and a 90 percent reduction for the covered waterbirds. These estimated strike reductions are assumed for the purpose of this HCP and cannot be included as a specific adaptive management trigger because there is no way to measure it during the permit term. However, KIUC's estimated amount of future powerline buildout (see Chapter 2, *Covered Activities*) is included in KIUC's population dynamics model, and therefore in the modeled future strike projections (Chapter 5, *Effects*). If KIUC's actual strikes are higher than predicted the population dynamics model in any year based on a 5-year rolling average (and powerline strike reduction is determined to be the issue), KIUC will evaluate its entire powerline system, including spans installed during implementation of the HCP.

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[7] KIUC is also estimated to achieve an 80 percent reduction in powerline collisions associated with new powerlines installed during the permit term through a combination of sighting in low-risk areas, reconfiguration, and bird flight diverters, to the maximum extent practicable.

6.4.1.2 Take Monitoring

KIUC will use acoustic song meters as described in Section 6.4.1.1, *Effectiveness Monitoring*, to continue estimating the annual number of powerline collisions of the covered seabirds and waterbirds. KIUC will compare the results of the Bayesian Acoustic Strike Model (Bayesian Model) (as described in Appendix 5D, *Bayesian Acoustic Strike Model*) with the strike projections from the Population Dynamic Model for Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu) to confirm that the number of powerline collisions attributed to the covered seabirds is not higher than predicted, and therefore is not at risk of exceeding the take limit established in Chapter 5, *Effects*. The results of this comparison will trigger adaptive management if strikes are higher than predicted in any year, based on a 5-year rolling average (Appendix A, Tables 6A-1 and 6A-2).

The Bayesian Model will be applied to the data obtained through acoustic take monitoring to estimate annual powerline strikes during HCP implementation. During implementation, raw strike data will be run through the Bayesian Model, which incorporates variables such as (i) potential geographic predictor variables such as mean slope of the landscape between adjacent poles and mean gradient of the landscape in the area surrounding the span, (ii) potential environmental variables such as mean annual windspeed within 328 feet (100 meters) of the span and (iii) potential structural predictor variables such as the number of wire layers and mean exposure. The resulting outputs are provided on a span-by-span basis.

Powerline strike monitoring will continue to be performed annually during HCP implementation for the duration of the permit term. However, the scope of the monitoring will be narrowed to the following high-risk locations once strike reduction monitoring is complete.

- Powerline Trail
- Mānā (Kekaha)
- Waimea Canyon Drive
- East Kīlauea
- Līhuʻe and Central Region

KIUC will sample high-risk spans in these locations that contain both minimized and unminimized spans to infer trends over its entire powerline system. KIUC specifically chose to minimize all locations in its powerline system with significant levels of take, and thus these areas will be the best indicator of whether take at the end of the permit term is likely to be exceeded. Areas within KIUC's powerline system that are unminimized have low take; in many cases, these spans have zero strikes.

Given that these spans contribute most of the collisions within KIUC's power grid, take estimates in these areas that exceed forecasts could lead to KIUC exceeding its take limit. In addition, because these areas have the most collisions, it is expected that any changes in these areas (whether negative or positive) will be the most apparent over time (i.e., the most quickly detectable). KIUC will track collisions at these spans annually during the permit term and implement adaptive management, if necessary. Trends at these high-risk spans may also result in adaptive management being implemented at non-monitored spans (e.g., if KIUC finds that light-emitting diodes [LEDs] are an issue at a high-risk span, they may implement adaptive management for LEDs systemwide).

As stated in Chapter 5, Section 5.4.2, *Effects Common to All Covered Waterbirds*, KIUC is requesting take of the covered waterbirds associated with 74 percent of all KIUC powerline collisions along powerline spans in Mānā (spans 1–113) and Hanalei (spans 462–478 and 1297–1328), and for each species based on the proportions of injuries and mortalities by species provided in Table 5-7 (8 percent Hawaiian stilt [aeʻo], 23 percent Hawaiian duck [koloa maoli], 4 percent Hawaiian coot [ʻalae keʻokeʻo], 15 percent Hawaiian common gallinule [ʻalae ʻula], 50 percent Hawaiian goose [nēnē]). The actual number of strikes will be estimated annually during HCP implementation by applying the acoustic data from the acoustic monitoring units at Mānā (Kekaha) to the Bayesian Model.

KIUC may also choose to monitor additional powerline spans if needed to accomplish the following. In these cases, observational monitoring may also be employed, at the discretion of KIUC in coordination with USFWS and DOFAW.

- Estimate powerline collisions in areas where conditions have changed (e.g., new line installation, after a large storm, large scale tree felling, or tree growth leading to line shielding).
- Estimate powerline collisions after testing a new minimization approach.
- Document improved minimization beyond the commitments in the HCP and for the purposes of adaptive management (see Section 6.2.2, *Adaptive Management*).
- Confirm take and/or identify issues in other areas not identified above.
- The data will be applied to the 2020 Bayesian Model to verify that powerline collisions at these high-risk spans have not increased beyond what is forecast in the HCP. The modeling results will be included in the following year's Annual Report (see Chapter 7, *Plan Implementation*).

KIUC will determine if the number of collisions identified in the Bayesian Model is higher than predicted (Appendix 6A, *Adaptive Management Comparison Tables*, Tables 6A-1 and 6A-2) using a 5-year rolling average, according to the following timelines, as long as trends are as expected (or better than expected). The first evaluation will occur in Year 5 of the permit term.

- Annual for Years 5 to 10 of the permit term (5 years)
- Every 2 years for Year 10 to 20 (10 years), unless strikes are higher than predicted in which case the adaptive management process identified in Table 6-3 would be triggered, and annual evaluations would be required until strikes were no longer higher than predicted using a 5-year rolling average.
- Every 5 years after Year 20 of the permit term unless strikes are higher than predicted, in which case the adaptive management process identified in Table 6-3 would be triggered, and annual evaluations would be required until strikes were no longer higher than predicted using a 5-year rolling average.

KIUC expects the annual number of strikes will not exceed KIUC's estimated average annual take (Chapter 5, *Effects*) due to significant early implementation of minimization and monitoring prior to the start of the permit term, as well as a robust adaptive management process.

6.4.1.3 Covered Seabirds Monitoring Protocol

As stated in Chapter 5, *Effects*, KIUC based its pre-minimization island-wide strike estimate for the covered seabirds on a 2020 Bayesian acoustic strike model using data from 2013 to 2019 (Travers et al. 2020). In summary, the model is based on data gathered from acoustic song meter sensors placed on power poles throughout the island to record powerline strikes. The sensors are placed at either (1) the base of power poles in quiet soundscapes (typically higher-elevation sites) or (2) were mounted on the power pole just below the lowest transmission lines when the pole was near traffic sounds. The complete data collection methods of the Infrastructure Monitoring & Minimization Project (IMMP) can be found in Appendix 5D, *Bayesian Acoustic Strike Model,* and are summarized below.

Using the results from the Bayesian acoustic strike model, KIUC began early implementation of powerline minimization projects in 2020, targeting high-strike powerline spans to reduce collisions. Following the completion of each powerline minimization project, the modified spans are monitored for one full seabird season using the same sampling methodology described above. This data is used to update the same Bayesian model used for pre-minimization collision estimates to quantify the change in the number of strikes per span to determine the effectiveness of KIUC's minimization actions. The actual strike reduction for each modified span is summed for all the spans thus modified when the island-wide strike models are run to estimate the number of systemwide collisions experienced in any given year.

There are three types of acoustic monitoring that have been used by KIUC since 2011, as follows. All three types of acoustic monitoring are used to collectively document the total number of strikes across KIUC's powerline systems and the strike reduction (i.e., effectiveness of minimization measures) for both existing and new powerlines.

- **Static Site Acoustic Monitoring.** This type of acoustic monitoring uses song meters that are maintained at the same location over the entire seabird season (March through December) and from year to year. Static site acoustic monitoring typically has two song meters units at each location; one for peak time (i.e., sunset to 3.5 hours after and 3.5 hours prior to sunrise to sunrise) recording and one for off-peak (i.e., gap in peak time) recording. The static locations are used to determine the seasonal and annual variation in seabird powerline collision and the increase or decrease in the strike rate. Static song meters must be put in high strike locations (not random) to be able to detect seasonal and long-term patterns robustly.

  Static locations were originally selected to monitor areas with the highest strike rates based on rover site monitoring (see below). Once minimization is implemented by KIUC, the static locations remain the same to determine the resulting strike reduction. If an area does not have static sites, then rover site acoustic monitoring is used to determine the strike reduction.

- **Rover Site Acoustic Monitoring.** Rover site acoustic monitoring uses song meters that are moved from location to location roughly every 30 days to ensure there is equal monitoring across KIUC's powerline system. They records strikes during the peak time (i.e., sunset to 3.5 hours after and 3.5 hours prior to sunrise to sunrise). This type of song meter is deployed based on random stratified design using vegetation height (exposure) and region of the island. Acoustic sensors are randomly assigned to spans, in proportion to the number of spans within each stratum. It ensures that there is sufficient and equal sampling across KIUC's entire system. This strategy ensures that acoustic sensors are sampling powerlines without human influence.

  Originally, rover site acoustic monitoring allowed KIUC to identify collision hot spots across its system, but now that those location are known, this type of monitoring is KIUC's primary tool to determine the amount of strike reduction following minimization implementation. Each minimized section receives random stratified monitoring at a minimum of 25 percent spatial coverage for a minimum of 28 days.

  Rover site acoustic monitoring is always utilized following minimization implementation, even if some static sites are present in the area. Up to 12 roving song meters will be operated at locations that have been modified. Rover song meters will be operated between May 15 and September 15 and will be relocated monthly, for a total of up to 48 unique monitoring locations each year. The rover units will be placed at systematic randomly selected locations such that each of the four types of line modifications (i.e., reconfiguration, static wire, LED diverters, and reflective diverters), will be monitored.

- **Check Site Acoustic Monitoring.** Check site acoustic monitoring is predominantly random rover sites that previously detected strike sounds. Check units are deployed typically in the following season to resample the random rover site and record all night from sunset to sunrise (rather than during the peak period) to provide strike variation across the night and across seasons. Each minimized section receives at least one check site.

In addition, IMMP[8] staff concurrently employ observational monitoring for the powerlines with acoustic monitoring devices using night vision. Observational surveys are used to estimate species-specific passage rates at elevations with powerline collision risk, and record seabird behavioral responses following each observed powerline interaction. The observational data is used to validate the acoustic monitoring system by (1) observing post-strike behavior to ascertain the level of injury or mortality; and (2) determining if there are issues with the acoustic monitoring system (i.e., song meters) in terms of the numbers of strikes versus observations of birds in the vicinity of the recording devices.

To facilitate detection of nocturnal collisions and observe post-collision impacts, night vision goggles in combination with near-infrared illuminators are used to enhance the capabilities of night vision and facilitate better visual tracking of individual seabirds pre- and post-collision. When conducting the surveys, observers are positioned to monitor the wires between two power poles with their field of view oriented from the first pole to the second pole, ensuring that powerlines were always in their view. Monitoring begins near to or following astronomical twilight (i.e., full darkness), requiring the optical equipment described above. The surveys cover approximately 1.5 to 3 hour time windows depending on location. Typically, each staff member conducts two surveys per night totaling 4 to 5 hours a night of observations. The overall observation effort is focused during darkness and the varying light levels that occur at the edge of night. Most observations occur between 15 minutes prior to sunset to 15 minutes after sunrise, and as such most survey effort is concentrated in the 3-hour windows around sunset and sunrise.

Given that new powerlines will have no unminimized spans (i.e., KIUC will install minimization devices at the time of construction), they will be monitored in same ways as other minimized spans on existing lines within KIUC's powerline system, except that there will be no baseline (i.e., no unminimized data) against which to measure the strike reduction. KIUC will only be able to determine the number of strikes resulting from the span or spans with minimization installed, but there will be no estimate of the strike reduction (i.e., amount of change from an unminimized state).

6.4.1.4 Covered Waterbird Monitoring Protocol

Waterbird monitoring also uses acoustic song meters and observations of waterbird movement to quantify collisions before and after minimization and to estimate the change in total strikes as a result of minimization activities. Effectiveness monitoring for the covered waterbird species is similar to that conducted for the covered seabirds, except that the monitoring effort will be focused

[8] Formerly called the Underline Monitoring Program (in reports before 2021).

on KIUC's powerlines spans with the greatest waterbird habitat and movement in the Plan Area (Mānā [spans 1–113] and Hanalei [spans 462–478 and 1297–1328]). KIUC applies a constant value (see Chapter 5, Section 5.4.2, *Effects Common to All Covered Waterbirds*) to estimate the proportion of all bird strikes assumed to be covered waterbirds for the 113 spans in Mānā and the 49 spans in Hanalei where covered waterbirds predominantly occur. As of 2021, KIUC is in the process of collecting data in Mānā to determine the effectiveness of bird flight diverters and transmission line and static wire removal implemented at that location.

6.4.1.5 Adaptive Management

Based on the current strike reduction estimates and KIUC's minimization plan (Appendix 4B, *KIUC Minimization Projects*), KIUC expects to reduce covered seabird strikes by 65.3 and by 90 percent for the covered waterbirds by Year 1 of the HCP (end of 2023). Based on this schedule, KIUC will finish strike reduction monitoring by 2026, allowing 3 years after all minimization is complete to monitor its strike reduction (other than when new powerlines or new/additional minimization methods are installed throughout the permit term). Because KIUC has invested substantial effort into early implementation of powerline minimization, it can implement any necessary adaptive management changes very early in the permit term (as soon as 2027). If KIUC finds that the strike reduction for the covered seabirds is less than 65.3 percent or the strike reduction for the covered waterbirds is less than 90 percent, adaptive management will be triggered and KIUC will implement a response, in consultation with USFWS and DOFAW, as identified in Table 6-3.

KIUC will also implement adaptive management if they find that the collisions are higher than predicted in any year as identified in Appendix 6A, *Adaptive Management Comparison Tables*, Tables 6A-1 and 6A-2, based on a 5-year rolling average. KIUC will work in close collaboration with its contractors, USFWS, and DOFAW to determine the cause and identify possible solutions.

KIUC will follow the process outlined in Section 6.2.2.3, *Adaptive Management Decision-Making Process for this HCP*, to determine the appropriate adaptive management response in close coordination with USFWS and DOFAW. The adaptive management response for the covered seabird and covered waterbirds is the same (i.e., additional minimization), although the trigger for waterbirds is based on the specific waterbird spans. Adaptive management changes for powerline collisions consists of modifying KIUC's minimization plan (Appendix 4B, *KIUC Minimization Projects*) to reduce the numbers of strikes in order to meet biological objectives 1.1, 2.1, and 4.1 (Chapter 4, Section 4.3, *Biological Goals and Objectives*) and to limit the potential for exceedance of the permitted take limit (as described in Section 6.4.1.2, *Take Monitoring*). Adaptive management changes for powerline strike minimization may include the following:

- Minimization on unmodified spans.
- Additional minimization on previously modified spans (e.g., adding bird flight diverters on reconfigured spans).
- Novel minimization techniques that incorporate new technology.
- Replacing less effective techniques with those with higher strike reductions.

KIUC will work in conjunction with USFWS and DOFAW consistent with Section 6.2.2.3, *Adaptive Management Decision-Making Process for this HCP*, regarding new strategies and technologies, as well as any changes (other than minor adjustments) to the monitoring protocols to measure powerlines collisions.

6.4.2 Light Attraction Monitoring and Adaptive Management

Biological objectives 1.2, 2.2, and 3.2 require that KIUC minimize artificial light attraction on the covered seabird fledglings from all existing and future KIUC streetlights and existing covered facilities. KIUC will achieve this by continuing to implement practicable conservation measures through the permit term (Chapter 4, Section 4.4.2, *Conservation Measure 2. Implement Measures to Minimize Light Attraction*).

6.4.2.1 Effectiveness Monitoring

Streetlights

As stated in Chapter 4, Section 4.3.1, *Newell's Shearwater (ʻaʻo)*, KIUC, in partnership with the County of Kauaʻi and State of Hawaiʻi, installed full-cutoff shields on all its streetlights within the Plan Area in 2017. Although KIUC owns and operates the streetlights, KIUC is not able to modify them without County and State approval. As stated above, biological objectives 1.2, 2.2, and 3.2 require that KIUC continue to implement practicable conservation measures throughout the permit term. Accordingly, KIUC will maintain full-cutoff shields on all existing streetlights and install full-cutoff shields on all new streetlights throughout the permit term. No effectiveness monitoring for KIUC streetlights is needed to meet the biological objectives.

Monitoring KIUC streetlights for light attraction is not feasible or practicable given the wide distribution of streetlights across the island and their locations. In most cases, streetlights occur in areas with other (often many other) light sources from residences, vehicles, or commercial operations. In these cases, it is often impossible to determine if a seabird became grounded due to a KIUC streetlight or a non-KIUC light source nearby. KIUC streetlights in more remote areas that are the only light source are often surrounded by private land for which access is often not possible. Full-cutoff shields on streetlights have been determined by KIUC, USFWS, and DOFAW, to be the best practicable minimization measure and for the purposes of this HCP are assumed to be effective.

Covered Facilities

The number of grounded seabirds will determine the efficacy of Conservation Measure 2. Implement Measures to Minimize Light Attraction, at KIUC's covered facilities. KIUC monitors its covered facilities (Port Allen Generating Station and Kapaia Power Generating Station) according to the *KIUC Site Monitoring Protocols and Procedures for Protected Seabirds* (Appendix 6B). During the seabird fallout season (September 15–December 15), responsible KIUC staff at the covered facilities conduct twice daily searches targeted specifically at finding grounded seabirds—once 1 hour prior to sunrise and once 3 to 4 hours after sunset. KIUC will also install panning cameras on building roofs and check these cameras regularly between 10 p.m. and sunrise to monitor for grounded birds on top of KIUC facility buildings.

The following steps will be taken when any downed seabird is discovered alive, as described in Appendix 6B.

- At least one photograph will be taken of the scene showing the bird as it was found.
- The location where the seabird was found will be marked on a satellite image.
- KIUC staff will deploy the KIUC Oppenheimer Seabird Recovery Kit, put on protective gloves, carefully wrap the bird in the clean towel from the kit, and gently place it in the recovery box.

- The KIUC Seabird Recovery Reporting Form (Appendix 6B) will be completed.
- The bird will be placed in the nearest SOS Aid Station, and SOS will be called to report that the seabird has been placed there. KIUC staff will then ensure that the retrieved bird receives prompt attention by SOS staff or volunteers.
- Within 24 hours of finding a seabird, KIUC will inform USFWS and DOFAW via email and include the completed KIUC Seabird Recovery Reporting Form and information concerning the bird's disposition.

If a dead bird is found the protocol is similar except that KIUC staff must place the bird in the refrigerator in two plastic storage bags and contact SOS for retrieval. The KIUC Seabird Recovery Reporting Form (Appendix 6B) will be completed and USFWS and DOFAW will be contacted within 24 hours.

To determine the effectiveness of light attraction minimization at KIUC's covered facilities, KIUC will review the monitoring results from the previous year to determine how many seabirds were grounded with the implementation of KIUC's conservation actions. The results of the covered facility monitoring will also be included in KIUC's annual report (see Section 7.7, *Annual Reporting*).

6.4.2.2 Take Monitoring

Streetlights

Take of covered seabirds from KIUC streetlights was estimated based on inferences used in the light attraction model that is described in Appendix 5C, *Light Attraction Modeling*. Because take from KIUC streetlights cannot be measured in the field, ongoing take from streetlight attraction will continue to be assumed throughout the permit term to be consistent with the model estimate. This approach is consistent with the No Surprises assurances provided by the federal ITP and state ITL.

Covered Facilities

The facility monitoring described under Section 6.4.2.1, *Effectiveness Monitoring*, will allow KIUC to compare the actual number of covered seabirds found in the covered facilities during the permit term to the amount estimated in Table 5-5. If actual take at both covered facilities combined is higher than estimated in the HCP as measured by a rolling 5-year average, KIUC will implement an adaptive management change as shown in Table 6-3.

Night Lighting for the Restoration of Power

As stated in Chapter 5, Section 5.3.1.2, subsection *Fallout from Night Lighting for Restoration of Power*, the take estimate for streetlights is conservative (i.e., likely overestimates take). Fallout during the seabird fledging season (September 15 to December 15) from lighting at temporary work areas is expected to be rare given that the lighting event is short in duration (typically 1 hour on average; see Chapter 2, Section 2.1.4, *Night Lighting for Restoration of Power*). In addition, nighttime work is only associated with emergency outages that happen in the evening hours. Based on these factors, the HCP assumes the operation of temporary lighting for restoring power does not change the overall estimated take of covered seabirds from light attraction. KIUC staff will search for grounded and circling seabirds within 0.1 mile (0.16 kilometer) of the construction site in accessible areas (e.g., public land) according to the same methodologies as the covered facilities (Appendix 6B, *KIUC Site Monitoring Protocols and Procedures for Protected Seabirds*), except that only one search event will be performed following completion of the emergency work.

6.4.2.3 Adaptive Management

As described above, KIUC will continue to implement practicable conservation measures related to covered streetlights throughout the permit term. Because KIUC is already implementing these streetlight minimization measures to the maximum extent practicable, no additional measures or adaptive management changes are required. Adaptive management is triggered if KIUC finds that the number of grounded covered species in the two covered facilities combined in any year (as measured by a 5-year rolling average) is greater than what is expected at the covered facilities (see Chapter 5, Table 5-5) (six or more groundings of Newell's shearwater ['a'o], and 1 or more grounding of Hawaiian petrel ['ua'u] or band-rumped storm-petrel ['akē'akē]). KIUC will follow the process outlined in Section 6.2.2, *Adaptive Management*, to determine the appropriate adaptive management response in close coordination with USFWS and DOFAW. The adaptive management trigger for take and effectiveness monitoring are the same (i.e., number of grounded birds), and they would result in the same response, depending on the cause. Adaptive management changes for light attraction at the covered facilities may include the following.

- Improved or more frequent training for KIUC facility staff to promptly attend to (i.e., improve detectability) and properly handle downed seabirds (i.e., improve survivorship).
- Reassessment of light intensity and light shielding at either or both covered facilities.
- Improved predator control at either or both covered facilities.
- Changing the wavelength of the LED if research shows a different LED wavelength is more bird-friendly.
- Novel technology to improve light shielding or otherwise further reduce light attraction.

Adaptive management for night lighting for the restoration of power is not possible due the emergency nature of the work. As stated above, KIUC will search for grounded birds at construction sites and count these birds against its take limit. If KIUC finds that the number of grounded birds due to night lighting is significantly greater than anticipated and could result in KIUC exceeding its combined take estimate for light attraction (Chapter 5, *Effects*, Table 5-5), KIUC will work with USFWS and DOFAW to find a solution. This may include, but is not limited to, increased minimization, if practicable, at KIUC powerlines, or increased or targeted monitoring to find, rescue, and turn in more covered seabirds to the SOS Program (see Section 6.4.3, *SOS Program Monitoring and Adaptive Management*).

6.4.3 SOS Program Monitoring and Adaptive Management

6.4.3.1 Effectiveness Monitoring

KIUC is required to fund the rescue, rehabilitation, and release of the covered seabirds and the covered waterbirds through the SOS Program. Conservation Measure 3 requires KIUC to fund the operation of the SOS Program at a level sufficient to treat all covered seabirds and covered waterbirds that are provided to the facility.

The SOS Program is based on opportunistic findings of grounded birds by the public and volunteers. As such, there are no monitoring protocols for this program. To determine the effectiveness of

KIUC's funding of the program, KIUC will review and evaluate the SOS Program annual report, which is submitted to KIUC each spring for the previous calendar year. KIUC will also coordinate closely with SOS Program staff, to track the number of covered seabirds and covered waterbirds that are processed each year. KIUC will review data on the numbers of rescues and releases of covered seabirds and covered waterbirds to compare the results with previous years, which will inform adaptive management. The assumption here is that KIUC's funding of the SOS Program during HCP implementation (see Chapter 7 for funding commitments) will be sufficient to process at least the average amount of covered seabirds and covered waterbirds (based on data from 2019–2021, Table 6-4) and some small amount of increase during the HCP permit term. However, the HCP also acknowledges that significant increases in the number of covered seabirds and covered waterbirds processed by SOS could necessitate increased funding beyond the funding commitment of the HCP. Annual assessments of the SOS Program will inform adaptive management, as described below (see Section 6.4.3.2, *Adaptive Management*). In addition, the results of the SOS Program relevant to the covered species will be included in KIUC's Annual Report (see Chapter 7, Section 7.7, *Annual Reporting*).

Table 6-4. Average Number of Covered Species Rehabilitated by the SOS Program

Year	Number of Covered Seabirds[a,b]	Number of Covered Waterbirds[a,b]
2019	105	91
2020	132	99
2021	102	101
3-Year Average	113	97

[a] Totals do not include birds dead on arrival.
[b] Source: Bache 2019, 2020, 2021.

6.4.3.2 Adaptive Management

As described in Section 6.4.3.1, *Effectiveness Monitoring*, KIUC will evaluate the SOS Program's annual reports and coordinate with SOS Program staff. If for 3 years in a row the number of individuals of the covered species turned in to SOS increases by 10 percent or greater as compared to the previous 3-year average, adaptive management will be triggered. KIUC will coordinate with SOS, USFWS, and DOFAW to identify the reason for the change and determine whether the current level of SOS funding is sufficient to process the increased level of covered seabirds coming to SOS. If it is determined that the current level of SOS funding is not sufficient to rehabilitate the increased number of individuals of covered species, KIUC will increase its level of funding by 50 percent of the increase in covered species.[9] Additionally, if the number of birds turned in later drops back to the 3-year historic average (Table 6-4), KIUC will consult with SOS, USFWS, and DOFAW to determine if funding can be reduced back to the original level.

[9] For example, a 10 percent increase in covered species turned in to SOS = a 5 percent increase in KIUC funding; a 20 percent increase in covered species turned in to SOS = a 10 percent increase in KIUC funding.

6.4.4 Conservation Site Monitoring and Adaptive Management

6.4.4.1 Effectiveness Monitoring

KIUC will continue to use the same monitoring protocols that have been used and refined for more than 10 years through the Short-Term HCP to evaluate management effectiveness at the conservation sites to meet the above biological objectives. Each of the following sections describes how KIUC will monitor and collect data from the conservation sites that will allow them to determine the effectiveness of site management. This, in turn, will allow KIUC to determine when biological objectives 1.3 and 2.3 are met.

Monitor Status of Covered Seabird Colonies in the Conservation Sites

KIUC will monitor the covered seabird colonies within the 10 conservation sites annually to ensure that the number of Newell's shearwater ('a'o) and Hawaiian petrel ('ua'u) breeding pairs and new chicks produced annually are increasing, as described in Objective 1.3 for Newell's shearwater ('a'o) and Objective 2.3 for Hawaiian petrel ('ua'u). Specifically, monitoring the number of covered seabird breeding pairs, breeding pair growth rate, and reproductive success rate will determine if the management actions (e.g., predator control, social attraction) implemented at the conservation sites are effective at achieving the desired metrics under Objective 1.3 and Objective 2.3.

- Metric 1. Maintain an annual minimum of 1,264 breeding pairs of Newell's shearwater ('a'o) and 2,257 breeding pairs of Hawaiian petrel ('ua'u) for as determined by call rates and burrow monitoring.
- Metric 2. Reach a target of 2,371 breeding pairs for Newell's shearwater ('a'o) and 2,926 breeding pairs for Hawaiian petrel ('ua'u) by year 25 of the permit term and 4,313 breeding pairs for Newell's shearwater ('a'o) and 3,751 breeding pairs for Hawaiian petrel ('ua'u) by the end of the permit term.
- Metric 3. Growth rate for breeding pairs annually of at least 1 percent for both Newell's shearwater ('a'o) and Hawaiian petrel ('ua'u), as measured by a 5-year rolling average.
- Metric 4. Maintain a 5-year rolling average 87.2 percent reproductive success rate for Newell's shearwater ('a'o) and 78.7 percent reproductive success rate for Hawaiian petrel ('ua'u).
- Metric 5. Eradicate terrestrial predators within predator exclusion fencing.
- Metric 6. Produce at least one Newell's shearwater ('a'o) breeding pair within each of the four social attraction sites by Year 10 of the permit term.
- Metric 7. Ensure that invasive plant and animal species do not preclude meeting the objective metrics above.

The monitoring protocol described below was developed by Raine and Travers and is the current method used to document and monitor the covered seabird colonies (Archipelago Research and Conservation 2022).

Burrow Monitoring

Burrows identified as those of either Newell's shearwater ('a'o) and Hawaiian petrel ('ua'u) will be monitored at each of the 10 conservation sites to evaluate the effectiveness of the management actions at meeting metrics 1 through 4 and 6 above. In addition, burrows with unidentified seabirds will also be monitored. Burrow monitoring will track the number of breeding pairs in each conservation site, the growth rate of those breeding pairs over time, and the nesting outcomes (i.e., reproductive success). Burrow monitoring also includes camera monitoring at burrows to document predation events (which is relevant to metric 6).

Eight seabird monitoring visits are conducted at each conservation site based on the following schedule, which has been refined over the last decade by Raine et al. The schedule is somewhat flexible each breeding season by necessity due to logistical considerations and weather conditions.

- February (prior to covered species arrival)—Remote wildlife cameras and song meters deployed for the season.
- April (covered species arrival)—Burrow checks, equipment maintenance.
- June (incubation)—Burrow checks, equipment maintenance.
- July (chicks hatching)—Auditory surveys
- August (early chick rearing)—Burrow checks, equipment maintenance.
- October (beginning of Newell's shearwater ['a'o] fledging)—Burrow checks, equipment maintenance.
- November (end of Newell's shearwater ['a'o] fledging, beginning of Hawaiian petrel ['ua'u] fledging)—Burrow checks, equipment maintenance.
- December (end of Hawaiian petrel ['ua'u] fledging)—Final burrow checks, remove remote wildlife cameras.

Each previously located burrow has been marked with a unique identification tag[10] and its location recorded using a handheld global positioning system (GPS) unit. Wherever possible, each burrow had also been identified to species (although in some cases where nest chambers are too convoluted to see the bird, the species is listed as 'UNPE-Unidentified Procellariid' until species confirmation is possible.

Searches are also undertaken to locate new nest sites and new nesting areas within each management area. Searches in each management area employ two methods:

- Evening and dawn auditory surveys supplemented with night-vision equipment, during which birds are observed in flight and their burrow location estimated by where they landed. Those areas were then searched.
- Diurnal cold searches, during which personnel actively search the vegetation for nest sites in areas identified as having high levels of seabird activity, particularly ground activity indicative of breeding birds, during recent auditory surveys.

It is assumed that the numbers of burrows found will increase as the number of seabirds within each conservation site increases over the 50-year permit term. When this occurs, it may not be

[10] Red-colored cattle tags with black numbering for all burrows in Hono O Nā Pali NAR and orange-colored cattle tags with black numbering for all burrows in Upper Limahuli Preserve.

possible to monitor all burrows, at which point it will be necessary to monitor a subset of burrows. If this occurs, the survey team will design their burrow monitoring to represent the spatial distribution of the targeted population using a subset of burrows (e.g., by using a stratified random sample).

During burrow checks, each burrow is inspected to assess breeding status. For deep burrows where direct visual inspection is not possible, a hand-held camera is used to take photos into the back of the burrow. At all times, care is taken to minimize damage to surrounding vegetation and burrow structure.

During each burrow check, data is collected via specially designed apps to record the following signs of activity within or around the nest.

- The presence of adult, egg, or chick
- Scent, signs of digging or trampling
- Presence of feathers, guano, or eggshell

A note is also made as to whether it was possible to see to the back of the burrow (e.g., was the burrow fully inspected, or was there a possibility that something was missed). Any signs of depredation (e.g., a dead adult or chick in front of burrow or inside burrow, chewed feathers or egg) or the presence of scat/droppings/prints that indicate a predator has been in the vicinity of the nest are also recorded. In instances where a seabird carcass is located, it is photographed, collected, and removed for further inspection. Data collected on depredations include a GPS point, the species of predator involved (if known), and species and age of the bird that has been depredated.

At the end of the season, a final status is assigned to each nest using the following categories:

- Active, breeding confirmed, success—Breeding was confirmed as having been initiated during the season through the presence of (i) an adult during the day in June or July, apparently incubating, (ii) an egg, (iii) down, or (iv) chick. Nest successfully fledged a chick. As the site is remote and not visited regularly enough to see the chick fledge, a successful fledging is considered in the following scenario: A chick was confirmed in burrow up until typical fledging month (October for Newell's shearwater ['a'o], November/early December for Hawaiian petrel ['ua'u]) and on the following check the presence of small amounts of down outside the nest site indicate that the chick was active outside the burrow and subsequently fledged. No signs of depredation or predator presence were noted. Burrows with cameras provide information on exact fledging date and time.
- Active, breeding confirmed, failure—Breeding was confirmed as having been initiated during the season through the presence of (i) an adult during the day in June or July, apparently incubating, (ii) an egg, (iii) down, or (iv) chick. Nest did not fledge a chick. The failure stage (egg or chick) and cause of failure (e.g., depredation of chick or egg, abandonment, depredation of breeding adult) is recorded where known. Burrows with cameras can provide information on depredation events and predator visitations pertinent to nest failure.
- Active, breeding confirmed, outcome unknown—Breeding was confirmed as having been initiated during the season through the presence of (i) an adult during the day in June or July, apparently incubating, (ii) an egg, (iii) down, or (iv) chick. Breeding was confirmed at the site; however, no subsequent visits were made, no visits were made late enough in the season to confirm fledging, or signs were inconclusive. A very small number of burrows fit into this category as every effort is made to assess the final status of all burrows.

- Active, unknown—The presence of an adult bird, or signs of an adult bird (e.g., guano, feathers, trampling) indicate that a bird was present during the breeding season, but it was not possible to confirm whether breeding occurred and failed or breeding was never initiated. Either way no chick fledged. Situations like this arise in instances where (i) it was not possible to examine the back of the nesting chamber due to the structure of the burrow or (ii) the burrow is discovered late in the breeding season and, as it was not monitored during the egg-laying period, it is not clear if breeding had been initiated.
- Active, not productive—The presence of an adult bird, or signs of an adult bird (e.g., guano, feathers, trampling) indicate that a bird was present during the breeding season, but burrow inspections reveal that no breeding took place (i.e., no egg was ever laid).
- Active, prospecting—Bird(s) recorded visiting nest, but signs are indicative that these are prospecting and not breeding birds. Examples would be new excavations within a previously inactive burrow, a single visit during the breeding season to a previously inactive burrow, a visit to a burrow where both adults had been confirmed killed the year before, or the preliminary excavation of a burrow-like structure combined with the confirmed presence of a seabird.
- Inactive—No sign (e.g., bird presence, feathers, guano, digging) that the burrow has been visited in that breeding season.
- Status unknown—There was no way to assess what had happened in the burrow during the year (i.e., burrow found at the end of the season with seabird sign but no indication of what happened, or burrow monitored at points during the season but breeding status and outcome unknown).
- Did not monitor—Burrow not checked at all in the year (due to safety reasons, or they could not be located in the following monitoring season).

During colony monitoring visits, surveyors continue to look for any sign of breeding activity (e.g., guano, feathers, scent). If any sign is noticed, the surveyors search the area for new burrows. Newly identified burrows are then included in the monitoring project as outlined above. The addition of new burrows to the overall monitoring project provides a larger sample size to assess breeding probability and breeding success, as well as the impact of introduced predators (which cannot be adequately assessed if only a small number of burrows in a restricted area of the site are monitored). Ultimately, the number of burrows known within each conservation site is used to understand the minimum number of breeding pairs present within each management site, as well as being one of the factors needed in the estimation of site-specific population estimates.

Incidences of depredation (or signs of introduced predators) either at known nesting burrows or along trails are also recorded when they are observed during trips to each area, with locations logged using a handheld GPS. Any depredated seabird bodies or predator scat/pellets are photographed *in situ* and then bagged and removed for further analysis if necessary (i.e., if the cause of depredation is not immediately apparent). If scat is located, it is subsequently examined for the presence of seabird feathers/bones indicative of a depredation event. When instances of depredation or fresh predator sign were recorded, the appropriate predator control team (depending on the conservation site) is notified immediately to ensure that predator control efforts occur in the area as soon as possible to minimize further depredation events. This is particularly important for barn owl, feral pig, and feral cat sightings, as these predators can cause significant damage to the colony in a relatively short time and need to be removed before they become established.

A subset of up to 30 burrows are monitored at each site by remote wildlife cameras[11] each month from March to December, with the exact number depending upon availability of camera units and the number of burrows that are active. These cameras are mounted on poles located 3 to 5 feet (0.9 to 1.5 meters) away from the burrow entrance, with the camera pointed directly at the burrow mouth. Cameras are set on a "rapidfire" setting (motion sensor activated, with a trigger speed of ≤ 1.5 seconds), and are tested at the time of deployment and during battery changes to ensure that the camera would fire when something moved in front of the burrow mouth. These camera stations are useful in identifying individual feral cats to help inform predator control staff whether there is more than one animal in the area and/or the key areas in which the individual animal is concentrating its hunting activities.

Memory cards used to record photographs are switched out on each visit to minimize risk of data loss. Batteries are replaced as needed to ensure continuous coverage over the season. data cards are reviewed while in the field to assess activity levels and presence/absence of seabird predators at the burrow. If any predator is observed, monitoring personnel inform predator control personnel as soon as possible.

If a burrow fails during the season or the chick successfully fledged, then the camera is moved to a new active burrow on the next check, with burrows chosen based on ease of camera placement and field of view. At each check, data are collected via specially designed apps to record battery power, percentage of memory card storage usage, and whether there are any issues with the unit. If a camera is malfunctioning in the field, it is brought back to the office and sent back to the manufacturer for repair; where possible, defective cameras are replaced immediately in the field with a functioning unit.;

Call Rate Monitoring

Call rate monitoring is undertaken using acoustic song meters.[12] Call rate monitoring using song meters is a critical tool for determining trends in abundance. Call rates for both Newell's shearwater ('a'o) and Hawaiian petrel ('ua'u) are significantly correlated to the number of breeding birds in an area (Raine et al. 2019). Therefore, plotting the change in call rates allows researchers to assess whether the colony is responding to management actions. This approach allows a larger scale of assessment of management that is not possible through burrow checks alone. Acoustic song meters in conjunction with burrow monitoring data will be used to evaluate the effectiveness of the management actions at meeting metrics 1, 2, 3, 4, and 6 above.

Song meters are attached to poles and elevated 1 foot (0.3 meter) above the ground. One song meter will be placed at each of the previously established static monitoring points (14 static units deployed at Upper Limahuli, 10 each at Pōhākea, Hanakāpi'ai, Hanakoa, North Bog, Honopū, and Pihea) at each of the conservation sites. Song meter locations will be determined within Conservation Site 10 once it is selected. Permanent static locations were selected such that sensor microphones were sheltered from prevailing winds and were well away from moving vegetation such as branches, grasses, or ferns.

Five months of data are collected annually between May and September to cover both the recruitment phase (May to early June) and incubation through early chick rearing (June to September). Five months of data collection allows for a more robust analysis by reducing the

[11] Current model used is the Reconyx Hyperfire HP2X. Other similar models may be used in the future.

potential impact of data loss due to weather or malfunctioning equipment (units are maintained, and thus problems are detected, once per month). Five months also covers the cover the peak vocal period for the two target species.

Song meters are powered by batteries and recordings are stored on memory cards. All sensors are fitted with two omnidirectional microphones that had water repellent applied to them to improve waterproofing. Microphones are arrayed horizontal to the ground and one on each unit had an additional wind screen installed over it. All units also have plastic rain guards erected above them to help waterproof the units.

The song meters record on two channels at a sampling rate of 22 kilohertz and be programmed to record 1 minute out of every 5 minutes for 5 hours after sunset, and 1 minute out of every 10 minutes for 5 hours before sunrise. Song meter recordings will be analyzed[13] for (a) first arrival dates, and (b) calling rates during the recruitment stage and breeding stage (5 months: May through September). Song meters will be analyzed to detect call rates of Newell's shearwater (ʻaʻo), Hawaiian petrel (ʻuaʻu), and barn owls.[14]

At each check, data are collected via specially designed apps to record memory card percentage and functionality of the two microphones. SD cards and batteries were also swapped out regularly (memory cards on every visit and batteries every two visits). If a microphone is malfunctioning, then it is immediately replaced with a new microphone in the field. Even if both microphones are functioning properly, one is switched with a new microphone to decrease the likelihood of microphone failure. Habitat, topography, and vegetation data are also collected on the iPad Mini around all deployed song meters the first year the units are deployed.

A single additional auditory survey trip will be undertaken to each of the conservation sites in July, with the focus dependent on management priorities (e.g., attempting to locate new Newell's shearwater [ʻaʻo] breeding sites, assessing the effectiveness of social attraction sites, updating auditory survey polygons to assess population size changes and assisting with real-time barn owl monitoring). Auditory surveys provide data that are used in the creation of population estimates and seabird distribution mapping, as well as information used by the surveyors to locate new burrow clusters. Data collected on barn owl activity during the surveys is also passed on to predator control teams to help inform predator control operations.

Auditory surveys are not conducted during the week of the full moon, as birds are not vocal during full moon nights. During auditory survey trips, surveys are undertaken in the evening and the early morning, which are the peak periods of seabird movement to and from the sea and breeding colonies. Evening surveys start at sunset and last for 2 hours. Morning surveys start 2 hours before dawn and last for 1.5 hours.

Surveys are split into 30-minute sessions, with 5 minutes allotted for the collection of weather data, 25 minutes for auditory surveying, and 5 to 10 minutes for concurrent night vision. Surveyors record all seabird calls (classified as a single unbroken note or series of notes) heard during the survey period and any bird actually seen during each period (either by eye or through night-vision

[13] Song meter data are currently analyzed by an outside vendor, Conservation Metrics, Inc., although this may change in the future.

[14] Band-rumped storm-petrels (ʻakēʻakē) are not included because they do not breed in the conservation sites, with the exception of Honopū PF where band-rumped storm-petrels (ʻakēʻakē) may breed in future due to social attraction efforts at that site.

equipment). For each record, data are collected on time of observation, species, direction from observer, distance from observer, and the behavior of bird (with particular attention paid to circling behavior and ground-calling).

At the end of the survey trip, observers create polygons on maps of the survey area identifying where seabird activity are recorded. These are categorized using detections such as the following:

- Birds in transient flight between inland nesting areas and the sea
- Birds circling to gain altitude before flying further inland or out toward the sea
- Birds persistently circling and calling within a restricted area over an extended period of time
- Birds calling from the ground

Detections are then translated into polygons on the maps (where applicable), which are defined as hotspot-heavy and hotspot-light. Hotspot-heavy and hotspot-light are defined as polygons where there is aerial calling activity only, with heavy denoting localized aerial activity with continuous calling and light denoting localized aerial activity (i.e., sporadic calling). Hotspot-heavy and ground-calling polygons are the best indicators of actual breeding activity in any given area. These polygons and the definition of the polygons have been the standard protocol since endangered seabird surveys started on Kaua'i in 2006 and as such are directly comparable with each other across years.

All ground-calling locations are individually recorded on a map in the field and later added to ArcGIS. Ground-calling locations are those where birds are confirmed calling from the ground (as opposed to from the air), as this is indicative of breeding activity and is arguably the most important record of seabird activity in any area. At the end of the season, ground-calling locations from auditory surveys in all years are combined. Any locations that are within 82 feet (25 meters) of each other are removed (to be conservative, as they may have related to the same bird and this helped prevent double counting) as well as any ground-calling locations within 82 feet (25 meters) of a known burrow. All others are included on the distribution maps.

It is possible that call rate saturation may occur during the 50-year permit term if the number of covered birds increases greatly within the conservation sites. Call rate saturation could result in it being impossible to detect trends in calls rates; however it is important to remember that the Population Dynamic Model projects that both species will only increase at a 1 percent growth rate. If call rate saturation does occur, it is expected to happen much later in the permit term because call rates would need to exceed 30 calls per minute[15] on average at each conservation site (Raine pers. comm.). Call rate saturation would be addressed through adaptive management. KIUC would work with USFWS, DOFAW, and the survey team to adjust or revise the monitoring protocol to ensure that call rate saturation does not affect the data necessary to determine the effectiveness of KIUC's management with the conservation sites to meet Objectives 1.3 and 2.3.

Social Attraction Monitoring

Social attraction monitoring is the primary means of determining the effectiveness of the social attraction management action and whether metric 5 is met. Social attraction also contributes to determining the effectiveness of predator control in the conservation sites and meeting the other metrics under Objectives 1.3 and 2.3.

[15] In 2021, calls per minute were lowest at Pihea (6.13 calls/min) and highest at Upper Limahuli Preserve (17.59 calls/min) (Archipelago Research and Conservation 2022).

The solar-powered sound system is installed in the social attraction site to broadcast calls over the restored habitat with the artificial burrows. The calls are broadcast throughout the peak breeding season (April through mid-September) and stopped prior to the emergence of fledglings. The contents of all artificial burrows within the predator exclusion fencing will be checked during the monthly trips to each conservation site to document and record any seabird sign at each burrow. Cameras will also be used to monitor the artificial burrow entrances and trails within area. This data will be used to document burrow occupancy, as well as the presence of predators, should they recur within a fenced area.

Additional Monitoring Activities

In addition to the activities outlined above, during each monitoring trip the following activities will also be performed.

- Data will be collected on any sign of predators (e.g., rats, cats, pigs, barn owls) or predation events (e.g., a dead covered seabird or predator-damaged eggs). In instances where a seabird carcass is located, it will be photographed, collected, and removed for further inspection. If possible, the age of the carcass will be determined.[16] Breeding status of predated adults will also be assessed by looking for evidence of a brood patch.
- Monitoring staff will immediately contact the predator control team to coordinate efforts to locate and remove the predator when (a) a fresh predation event is found; (b) fresh sign of cats, dogs, or barn owl activity are observed; or (c) cats, dogs or barn owls are observed on photographs captured by burrow monitoring cameras.
- If time allows, searches will also be undertaken to locate new burrows and new breeding areas within the conservation sties. Any new burrows found will be tagged and incorporated into the burrow monitoring program unless, as described above, burrow abundance exceeds monitoring capacity, in which case the survey team will design their burrow monitoring to represent the spatial distribution of the targeted population using a subset of burrows, rather than monitoring each burrow. If possible, staff will note any banded birds occupying monitored burrows or otherwise being present at the sites. If any birds are observed on camera or by direct observation to be banded, personnel will attempt to document the band number if it does not interfere with the bird's safety or the day's work plan.
- If KIUC staff note spread or prevalence of invasive plant species in the field they will alert KIUC and KIUC will work with USFWS and DOFAW to address the issue through adaptive management. Invasive plant monitoring occurs incidentally during other activities at the conservation site (e.g., burrow monitoring, predator control). Therefore, there is no specific monitoring protocol or adaptive management triggers for invasive plant species included in this HCP. However, adaptive management responses related to the conservation sites and the covered seabird breeding pairs will evaluate invasive plant species as one possible cause of reduced success.

[16] Age can be determined generally by the wear of primary and secondary feathers and evidence of sun bleaching on the wing coverts or head feathers.

This data will be used to determine if the management actions have been effective at meeting the metrics for biological objectives 1.3 and 2.3 for Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu). The following metrics, as required by the objectives will be evaluated.

- Annual population estimate and growth rate within each conservation site and all conservation sites combined (as determined by call rates and burrow monitoring data).
- Evidence of at least one breeding pair within each of the four social attraction sites by Year 10 of the permit term.
- Call rate and call rate trend within each conservation site and at all conservation sites combined.
- Annual reproductive success rate within each conservation site and at all conservation sites combined.

Population trends of Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu) will be evaluated by updating the population dynamics model (Appendix 5E, *Population Dynamics Model for Newell's Shearwater (ʻaʻo) on Kauaʻi*) with monitoring data from all conservation sites each year.

Model parameters other than the performance at the conservation sites will be held constant to facilitate comparisons across years and to assess progress towards meeting biological objectives 1.3 and 2.3. However, if new information strongly suggests that other model assumptions should be adjusted, KIUC may update model parameters and provide these results as well. Any adjustments to model parameters must be mutually agreed to by KIUC, USFWS, and DOFAW and be documented in the next annual report along with a justification for the change.

Monitoring of the conservation sites will continue annually throughout the permit term. However, if biological objectives 1.3 and 2.3 are met and this is confirmed for least 3 consecutive years, KIUC may reduce the frequency and intensity of monitoring at the conservation sites following agreement from USFWS and DOFAW. Specifically, KIUC may reduce monitoring frequency from annual to biannual (every 2 years).

Evaluate the Effectiveness of Predator Control in the Conservation Sites

KIUC has been funding monitoring for the presence of pigs, cats, mice, rats, and barn owls in many of the conservation sites since 2011. Biological objectives 1.3 and 2.3 require that invasive animal species do not preclude meeting the other metrics related to covered seabird population abundance and population growth in the conservation sites. Predator monitoring at each conservation site, outside of areas with predator exclusion fencing, will consist of the following measures.

- Operate 10 camera traps (game cameras) at locations chosen to give a breadth of spatial coverage at each conservation site. The images will be reviewed every 4 to 6 weeks for evidence of predators.
- Review burrow monitoring camera (up to 30 at each site) images every 4 to 6 weeks for evidence of predators.
- Opportunistically observe predator signs (e.g., carcasses, sightings, tracks, scat, fur, wallows) while working in the colonies on other tasks. Any predated seabird bodies or predator scat/pellets will be photographed *in situ* and then bagged and removed for further analysis if necessary. If scat is located, it will be subsequently examined for the presence of seabird feathers indicative of a predation event. Locations of predator evidence will be logged using a handheld GPS and observations recorded.

- Record the location, number, and species of predators trapped or otherwise removed.

For areas within predator exclusion fencing, once the terrestrial predator exclusion fences are complete and predators are eradicated from Upper Limahuli Preserve, Site 10, Pōhākea PF, and Honopū PF (as determined by monitoring, using the above protocol), predator monitoring at those sites will be modified as follows.

- The trail camera traps will be repositioned to selectively monitor the containment zone (Chapter 4, Section 4.4.4.2, *Management Actions*), weatherports, helicopter landing zones, and other areas suspected to be or confirmed to be areas where predator incursions are more likely to occur or be detected. The fence perimeter will be monitored with cameras inside the fence.
- Perimeter walks will occur on a monthly interval and any damage to the fence will be immediately reported and addressed. Monitoring of the fenceline will include searching for any signs of barn owl use/presence.

The results of the monitoring outlined above will be used throughout the year to make minor adjustments to the predator control efforts and methods to be as effective and efficient as possible (Section 6.2.2.1, *Minor Adjustments vs. Adaptive Management*). The effectiveness of predator control and the trigger for adaptive management will be determined based on the outcomes for the covered species metrics under Objectives 1.3 and 2.3. For example, if the number of Newell's shearwaters (ʻaʻo) or Hawaiian petrels (ʻuaʻu) is below 1,264 or 2,257 breeding pairs, respectively, in any year, KIUC would evaluate the cause, which would include an evaluation of the predator control program to determine its effectiveness. Similar evaluations would occur for breeding pair growth rates and reproductive success rates if they were not achieving their metrics of success (Table 6-3).

The following data, collected by the predator control team, will be used to adaptively refine and adjust predator management in the conservation sites (Hallux 2020).

- Average daily animal removal rates (animals removed per trap per day) by species and conservation site examined across all trap types per year.
- Number of animals (by species) captured by trap type.
- Percentage of animals (by species) detected at camera locations by site.
- Number of individual cats by site.
- Daily and monthly probability (i.e., likelihood) of animal presence (by species) by site and year.
- Change in call rate of barn owls at each site, as measured using acoustic monitoring.

Additional metrics may be added in the future if predator control techniques or technology changes.

No effectiveness monitoring is required for Objective 3.3. If predator control is occurring for the other covered seabird species in the conservation sites, Objective 3.1 is assumed to be met. Any minor adjustments or adaptive management changes to predator control for the other covered seabird species is assumed to benefit band-rumped storm petrel (ʻakēʻakē).

6.4.4.2 Adaptive Management

The conservation measures that are proposed in the conservation sites have been implemented and refined for last 10 years and have proven to be highly effective at reducing the abundance of predators and increasing the abundance of the covered seabirds within the conservation sites

(Raine et al. 2020). As such, KIUC does not expect that the conservation measures within the conservation sites will require significant refinement during the permit term.

As stated in Chapter 5, Section 5.3.3.1, *Newell's Shearwater (‘a‘o)*, and Section 5.3.3.2, *Hawaiian Petrel (‘ua‘u)*, the data analysis and modeling used to estimate adverse, beneficial, and net effects on these species required the application of assumptions that in some cases have a high level of uncertainty. KIUC addressed this uncertainty, in part, by using conservative assumptions that err on the side of likely overestimating adverse effects to the species and likely underestimating the benefits. Despite these assumptions, adaptive management at the conservation sites may be necessary if the biological objectives are not likely to be met.

Specific adaptive management triggers have been developed for each conservation site or combinations of conservation sites that are relevant to either Newell's shearwater (‘a‘o) or Hawaiian petrel (‘ua‘u). These adaptive management triggers were designed with the following goals and constraints in mind:

- Each trigger serves as an early warning to detect potential performance problems at individual conservation sites.
- Utilize metrics that are measured annually in the field at each conservation site.
- Utilize measures such as rolling averages that "smooth" out annual variability but still allow annual assessments of performance.

With these concepts in mind, adaptive management would be triggered if any of the following parameters are not met (Table 6-3).

- Maintain an annual minimum of 1,264 Newell's shearwater (‘a‘o) breeding pairs at all 10 conservation sites combined.
- Growth rate for Newell's shearwater (‘a‘o) breeding pairs annually of at least 1 percent to reach a target of 2,371 breeding pairs by Year 25 of the permit term and 4,313 breeding pairs by the end of the permit term, based on a 5-year rolling average, at all 10 conservation sites combined.
- Maintain a 87.2 percent reproductive success rate for Newell's shearwater (‘a‘o) at all 10 conservation sites combined annually, based on a 5-year rolling average.
- Maintain a 87 percent reproductive success rate for Newell's shearwater (‘a‘o) at the Upper Limahuli conservation site, based on a 5-year rolling average.
- Maintain a 81.3 percent reproductive success rate for Newell's shearwater (‘a‘o) at Conservation Site 10, based on a 5-year rolling average.
- Maintain a 93.7 percent reproductive success rate for Newell's shearwater (‘a‘o) at the Pōhākea conservation site, based on a 5-year rolling average.
- Maintain a 86.8 percent reproductive success rate for Newell's shearwater (‘a‘o) at the Hanakāpī‘ai conservation site, based on a 5-year rolling average.
- Maintain a minimum of 2,257 Hawaiian petrel (‘ua‘u) breeding pairs annually at all 10 conservation sites combined.
- Growth rate for Hawaiian petrel (‘ua‘u) breeding pairs annually of at least 1 percent to reach a target of 2,926 breeding pairs by year 25 of the permit term and 3,751 breeding pairs by the end of the permit term, based on a 5-year rolling average, at all 10 conservation sites combined.

- Maintain a 78.7 percent reproductive success rate for Hawaiian petrel (ʻuaʻu) at all 10 conservation sites combined, based on a 5-year rolling average.
- Maintain a 66.7 percent reproductive success rate for Hawaiian petrel (ʻuaʻu) at the Upper Limahuli conservation site, based on a 5-year rolling average.
- Maintain a 80.3 percent reproductive success rate for Hawaiian petrel (ʻuaʻu) at the Pihea conservation site, based on a 5-year rolling average.
- Maintain a 78 percent reproductive success rate for Hawaiian petrel (ʻuaʻu) at the North Bog conservation site, based on a 5-year rolling average.
- Maintain a 75.5 percent reproductive success rate for Hawaiian petrel (ʻuaʻu) at the Pōhākea conservation site, based on a 5-year rolling average.
- Maintain a 86.4 percent reproductive success rate for Hawaiian petrel (ʻuaʻu) at the Hanakoa conservation site, based on a 5-year rolling average.
- Maintain a 85.4 percent reproductive success rate for Hawaiian petrel (ʻuaʻu) at the Hanakāpiʻai conservation site, based on a 5-year rolling average.
- At least one Newell's shearwater (ʻaʻo) breeding pair within each social attraction site by Year 10 of the permit term.

Appendix 6A, *Adaptive Management Comparison Tables*, Tables 6A-3 and 6A-, provides annual rolling averages for the Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu) growth at all 10 conservation sites combined during the 50-year permit term, using the outputs from the population dynamics models. These tables will be used on an annual basis during the permit term to evaluate whether the covered seabirds populations in the conservation sites collectively are on track to meeting or exceeding the biological goals and objectives or are underperforming (in which case adaptive management would be triggered, as stated above). It should be noted that by their nature (given that they are averages of multiple years of data), the 5-year rolling averages are slightly lower than the individual number used in the biological objective. However, if the 5-year rolling average is met, the individual year threshold (25 years or 50 years, as required by the biological goals and objectives) is also met.

If any of these thresholds in the bullet list above are not met, an adaptive management change will be triggered (Table 6-3). KIUC will follow the process outlined in Section 6.2.2, *Adaptive Management* and Table 6-3, to determine the appropriate adaptive management responses in close coordination with and in agreement from the USFWS and DOFAW. Adaptive management changes at the conservation sites may include the following.

- Alter the timing, location, intensity, or type of predator control
- Alter the timing, location, intensity, or methods for invasive plant species control
- Increase the number of conservation sites or install additional predator exclusion fencing.
- Increase the number, type, location, or attraction methods for social attraction sites.
- Install artificial burrows in areas where predator exclusion fences are not practicable, but predator control will be conducted.
- Initiate social attraction within predator exclusion fences for Hawaiian petrel (ʻuaʻu)
- Play sounds to deter predators (e.g., play sounds of humans or large predatory cats).

- Use scent camouflage to cover area so predators cannot use scent trails.
- Use scent attraction to encourage nesting.
- Use decoys of nesting birds to attract predators into traps.
- Use drones to locate ungulates and possibly barn owls.
- Novel vertebrate pesticides for predator control.

If adaptive management changes in the conservation sites prove ineffective or infeasible, KIUC may choose to enhance or expand minimization measures to further reduce take of the covered species (i.e., increase strike reduction beyond 65.3 percent).

6.4.5 Green Sea Turtle (honu) Monitoring and Adaptive Management

6.4.5.1 Effectiveness Monitoring

The effectiveness of the green sea turtle (honu) nest detection and shielding program will be evaluated based on the outcomes of the annual monitoring program described under Conservation Measure 5, *Implement a Green Sea Turtle Nest Detection and Temporary Shielding Program*, described in Chapter 4, *Conservation Strategy*. The goal of the green sea turtle (honu) monitoring program is to determine the outcome of shielded nests. The monitoring program endeavors to have monitors present at or near the time of emergence to verify shielding is effective at preventing (or substantially reducing) light disorientation of hatchlings. If any hatchlings are disoriented due to KIUC streetlights, this could indicate that the temporary light shields are not as effective as assumed in this HCP. Please see Section 4.4.5, *Conservation Measure 5. Implement a Green Sea Turtle Nest Detection and Temporary Shielding Program*, for the green sea turtle (honu) monitoring requirements for the KIUC HCP.

6.4.5.2 Take Monitoring

Minimization of green sea turtle (honu) hatchling disorientation will require systematic, intensive surveys that not only locate active nests but also document the fate of every green sea turtle (honu) nest that has the potential to be affected by KIUC streetlights. Take of green sea turtle (honu) nests for the KIUC HCP is defined as a nest (documented or undocumented by the monitoring program) with at least one hatchling disoriented by KIUC streetlights. As described in Chapter 4, Section 4.4.5, *Conservation Measure 5. Implement a Green Sea Turtle Nest Detection and Temporary Shielding Program*, the green sea turtle (honu) monitoring program consists of drone surveys, a volunteer monitoring program, and shielding the nest with shade cloth fencing. This monitoring approach has been adapted from the Kaua'i Seabird HCP (State of Hawai'i Division of Forestry and Wildlife 2020). The complete monitoring methods can be found in the conservation measure in Section 4.4.5, *Conservation Measure 5. Implement a Green Sea Turtle Nest Detection and Temporary Shielding Program*.

6.4.5.3 Adaptive Management

The KIUC HCP assumes that the nest shielding program will be highly effective. As a result, very few green sea turtle (honu) hatchlings are expected to disoriented during the 50-year permit term. As such, the KIUC HCP estimates that no more than one nest will be taken per year. To ensure that this goal is achieved, if there is more than one green sea turtle (honu) nest taken in any year or any hatchlings in an undocumented nest are taken due to KIUC streetlight attraction, adaptive management will be triggered (Table 6-3). KIUC will implement adaptive management changes during the next green sea turtle (honu) nesting season. KIUC will follow the process outlined in Section 6.2.2 *Adaptive Management* and Table 6-3, to determine the appropriate adaptive management change in close coordination with USFWS, DOFAW, and DAR.

KIUC will begin the adaptive management process by investigating the conditions that may have led to the hatchling disorientation, evaluating the following factors.

- Was the beach monitored by drone or on foot?
- Was the nest located during monitoring?
- Was the nest shielded?
- Was the shielding effective at preventing hatchling disorientation?
- Were monitors present at the time of nest hatching?
- Were there any other factors that may have contributed to the taking?

Depending on the answers to these questions, KIUC's adaptive management response will address the specific issue that occurred. For example, if the nest was not located during monitoring, KIUC may need to increase the monitoring frequency, change the monitoring methods, or may need to increase the number of beaches that are monitored on foot. If the issue was that the shielding was not effective, KIUC may need to change the type of shielding material, shield height, or add additional protective mechanisms (e.g., fences around the shields). If the shield was vandalized, KIUC may need to have the monitor visit the shielded nest more frequently prior to hatching.

If take occurs, KIUC will email USFWS, DOFAW, and DAR as soon as possible with the details of the event. KIUC will solicit input from USFWS, DOFAW, and DAR, on possible adaptive management responses according to the procedure described in Section 6.2.2, *Adaptive Management*. KIUC will also describe in the annual report the taking and any adaptive management changes implemented.

6.4.6 Adjusting Monitoring Methods

KIUC's current monitoring efforts are considered the best available science (Chapter 5, *Effects*). However, monitoring methodologies are constantly evolving and become more effective and efficient with new technologies. Hence, improved monitoring methodologies (e.g., better microphones, improved vibration sensors, enhanced analysis software) are expected to become available. KIUC will utilize new technology to the maximum extent practicable and may adopt them into its program under the following circumstances.

- Species experts believe that the newer technology provides more accurate or more reliable results that can be integrated into the pre-existing dataset.
- Data obtained through the updated technology is sufficiently compatible with that collected in earlier years of the monitoring program to allow long-term trend analysis.
- The improved technology does not substantially increase the cost of the monitoring.

KIUC will make changes to monitoring methods only after discussing them with USFWS and DOFAW and gaining their concurrence on the proposed change.

Chapter 7
Plan Implementation

7.1 Overview

This chapter describes how KIUC will implement the HCP. The chapter describes the following implementation topics.

- Implementation structure of the HCP, including the responsibilities of KIUC, U.S. Fish and Wildlife Service (USFWS), and the State of Hawaiʻi Division of Forestry and Wildlife (DOFAW) (Section 7.2, *Implementation Responsibilities*).
- Regulatory assurances requested for this HCP under the federal Endangered Species Act (ESA) and Hawaiʻi Revised Statutes (HRS) (Section 7.3, *Regulatory Assurances*);
- Estimated costs of HCP implementation (Section 7.4, *Costs of KIUC HCP Implementation*) funding assurances (Section 7.5, *Funding Assurances*).
- The process to revise or amend the HCP during implementation (Section 7.6, *Revisions and Amendments*).
- Requirements for annual reporting to USFWS and DOFAW (Section 7.7, *Annual Reporting*).

7.2 Implementation Responsibilities

This section describes the implementation responsibilities of KIUC as the permittee and the responsibilities of USFWS and DOFAW in supporting and overseeing HCP implementation.

7.2.1 Responsibilities of Kauaʻi Island Utility Cooperative

Immediately following issuance of the incidental take permit (ITP) and state incidental take license (ITL), KIUC would fully undertake HCP implementation. KIUC has been conducting early implementation during the HCP preparation phase and in transition from the Short-Term HCP to this HCP. Management actions that have already been implemented for many years will continue (e.g., conservation site management and monitoring). Additionally, some new conservation measures and management actions will be implemented as a part of this HCP. KIUC has an HCP Program Manager who managed HCP preparation and early implementation and will be responsible for day-to-day administration and implementation of the KIUC HCP during the 50-year permit term. KIUC will be responsible for implementing the conservation strategy (Chapter 4, *Conservation Strategy*) to achieve the biological goals and objectives of the HCP. KIUC will implement all the actions described in the HCP, including the following.

- Implementing the HCP conservation measures.
- Implementing the monitoring and adaptive management program.
- Providing oversight and coordination of HCP administration of program funding and resources.
- Preparing annual reports, work plans, and budgets.

- Fulfillment of compliance monitoring, effectiveness monitoring, and HCP reporting requirements.

The following sections describe how KIUC will implement the HCP. Some of these job functions will be performed by KIUC staff. KIUC will also hire contractors to provide many services under the direction and oversight of the HCP Program Manager. As the sole permittee, KIUC is ultimately responsible for the implementation of all HCP conservation measures and other commitments.

7.2.1.1 Conservation Measures and Monitoring Actions

KIUC will implement all the conservation measures described in Chapter 4, *Conservation Strategy*, and the monitoring and adaptive management actions described in Chapter 6, *Monitoring and Adaptive Management Program*. KIUC is also responsible for monitoring for changed circumstances identified in Section 7.3.1, *Changed Circumstances*, that might arise. If any changed circumstances do arise, KIUC must follow the procedures outlined in this chapter to identify and implement the appropriate remedial measure to address the specific changed circumstance.

7.2.1.2 Oversight and Coordination

KIUC is responsible for executing the requirements of the HCP, the federal ITP, and state ITL. Implementation tasks include support of permanent and seasonal administrative and technical staff who will be responsible for overseeing and ensuring the day to-day tasks of implementing the HCP "on the ground." Implementation tasks will also address activities such as managing program funding and resources, ensuring minimization actions are implemented according to the location and schedule identified in the HCP, maintaining a database of relevant information, tracking impacts and conservation, and reporting all relevant information to the Wildlife Agencies annually (Section 7.7, *Annual Reporting*).

KIUC will also prepare an Annual Work Plan to identify ongoing and project-specific actions for the following year. KIUC will develop a budget and schedule for HCP implementation each year and assign staffing responsibilities using the cost estimate (Section 7.4, *Costs of KIUC HCP Implementation*) and schedule (Chapter 6, Table 6-1, *Schedule for HCP Compliance*) identified in this HCP. All of the HCP conservation measures will be implemented on an annual basis (unless USFWS and DOFAW approve a reduced frequency during the permit term) to achieve the HCP biological objectives. The specific techniques that will be used to implement the conservation measures are described in Chapter 4, *Conservation Strategy*. These techniques may change based on HCP monitoring results and adaptive management (see Chapter 6, *Monitoring and Adaptive Management Program*), which could have budget and schedule implications. The Annual Work Plan will be presented at the annual meeting that is held by KIUC near the end of each calendar year in October or November. The Annual Work Plan must be consistent with the HCP and is in addition to the annual progress reporting (see Section 7.7, *Annual Reporting*). KIUC will present the Annual Work Plan to USFWS and DOFAW for comments prior to implementation in the following calendar year.

7.2.1.3 Budget Administration

KIUC will develop, propose, and administer budgets for general plan administration. Specific responsibilities will include developing and monitoring budgets, processing invoices, managing financial reserves, identifying cost savings, and managing administrative contracts (e.g., liability insurance). KIUC is governed by a nine-member board. KIUC Board approval will be required for the

HCP, the Annual Work Plans, and the associated estimated HCP budget as part of their annual operational budget approval process. KIUC will establish processes to ensure timely implementation and proper oversight of annual budgets and related HCP expenditures.

7.2.1.4 Geographic Information System/Database Maintenance

KIUC will use a geographic information system (GIS) or other equivalent spatially explicit database to collect, store, and use the relevant data necessary for HCP implementation. KIUC will maintain the database to track compliance as well as monitoring and adaptive management programs. KIUC will use the database to summarize take and conservation by year and cumulatively, as well as track the spatial location of management actions and monitoring to demonstrate progress of meeting the HCP biological goals and objectives. KIUC may also hire contractors to provide these functions. Data will be made accessible to USFWS and DOFAW.

7.2.1.5 Consultants and Contractors

KIUC will retain consultants to meet any technical, scientific, or other staffing needs that cannot be effectively or efficiently addressed through in-house staff. It is expected that KIUC will use consultants more heavily for administrative tasks during the early stages of HCP implementation, becoming less necessary as KIUC develops systems and processes for HCP implementation. It is expected that consultant and contractors will be used throughout the life of the HCP for management and monitoring of the covered species.

7.2.2 Responsibilities of U.S. Fish and Wildlife Service

Consistent with their authority under the federal ESA, USFWS will have responsibility to monitor implementation of the terms and conditions of the ITP and HCP. Specifically, USFWS will have responsibility during HCP implementation to do the following.

- Review and verify HCP Annual Reports submitted by KIUC for completeness and compliance (see Section 7.7, *Annual Reporting*, for Annual Report requirements) and to determine whether KIUC is making progress towards achieving the biological goals and objectives of the HCP and implementing all applicable requirements of the HCP.
- With DOFAW and the Endangered Species Recovery Committee (ESRC),[1] make recommendations to KIUC regarding adaptive management changes according to the adaptive management process described in Chapter 6, Section 6.2.2, *Adaptive Management*.
- Receive and review reports from KIUC regarding observations of injury or mortality of the covered species.
- Review and verify monitoring reports provided by KIUC.
- Participate in periodic HCP coordination meetings with KIUC and DOFAW as necessary to stay informed about HCP implementation and to provide technical advice to KIUC, as necessary or requested.
- Visit mitigation sites and KIUC facilities as needed to observe the progress and results of HCP conservation measures, which will be coordinated with the KIUC HCP Program Manager.

[1] USFWS is also a member of the ESRC.

- Coordinate with the KIUC HCP Program Manager and DOFAW regarding any potential compliance issues and work cooperatively to resolve these issues. If compliance issues cannot be resolved, take enforcement action as necessary and appropriate.
- Provide technical assistance if KIUC requests a minor modification or major amendment to the HCP (see Section 7.6, *Revisions and Amendments*, for details on these procedures).

7.2.3 Responsibilities of the State of Hawai'i Department of Land and Natural Resources

The State of Hawai'i Department of Land and Natural Resources (DLNR) provides regulatory oversight for the State of Hawai'i, as authorized by statute, to ensure that all HCPs and State ITLs issued by the Board of Land and Natural Resources (BLNR) comply with the provisions of applicable State of Hawai'i regulations. The DLNR through DOFAW will have the following responsibilities during HCP implementation.

- Review HCP Annual Reports submitted by KIUC for completeness, accuracy, and compliance (see Section 7.7, *Annual Reporting*, for Annual Report requirements) and to determine whether KIUC is making progress towards achieving the biological goals and objectives of the HCP and implementing all applicable requirements of the HCP.
- Provide HCP Annual Reports to the ESRC for their review and recommendations for adaptive management.
- Consider recommendations from the ESRC regarding adaptive management or other changes to the HCP to improve its effectiveness and coordinate with USFWS and KIUC regarding these recommendations.
- With USFWS, make recommendations to KIUC regarding adaptive management changes according to the adaptive management process described in Chapter 6, Section 6.2.2.3, *Adaptive Management Decision-Making Process for this HCP*.
- Receive and review reports from KIUC regarding observations of injury or mortality of the covered species.
- Review and verify monitoring reports provided by KIUC.
- Participate in HCP coordination meetings with KIUC and USFWS as necessary to stay informed about HCP implementation and to provide technical advice to KIUC, as necessary or requested.
- Coordinate with the KIUC HCP Program Manager and USFWS regarding any potential compliance issues and work cooperatively to resolve these issues. If compliance issues cannot be resolved, take enforcement action as necessary and appropriate.
- Visit conservation sites and KIUC infrastructure and facilities as needed to observe the progress and results of HCP conservation measures, which will be coordinated with the KIUC HCP Program Manager.
- Provide technical assistance if KIUC requests a minor modification or major amendment to the HCP (see Section 7.6, *Revisions and Amendments*, for details on these procedures).

7.2.4 Responsibilities of the Endangered Species Recovery Committee

The Hawai'i Revised Statutes (HRS) require the ESRC to review all HCPs annually "to ensure compliance with agreed to activities and, on the basis of any available monitoring reports, and scientific and other reliable data, make recommendations for any changes."[2] To fulfill this requirement, the ESRC will review the KIUC Annual Report (see Section 7.7, *Annual Reporting*, for details on the Annual Report) and any other relevant reports and data to determine whether the KIUC HCP is in compliance with the terms of the HCP and State ITL. The ESRC (and/or DOFAW staff as ESRC representative) may conduct an annual site visit on the Island of Kaua'i to fulfill its statutory duty,[3] which would be coordinated with the KIUC HCP Program Manager. The ESRC is supported and advised by DOFAW and the DLNR as described in the section above. Note that site visits are required prior to ESRC making HCP recommendation to the BLNR.

7.3 Regulatory Assurances

No Surprises assurances are provided by the federal ESA through the "No Surprises" rule (50 Code of Federal Regulations [CFR] Section 17.22.32). This rule provides assurances to ITP holders that USFWS will not require the commitment of additional land, water, or financial compensation; or additional restrictions on the use of land, water, or other natural resources beyond the level otherwise agreed to in the HCP without the consent of the permittee. HCP permittees may provide additional mitigation, but only voluntarily. No Surprises assurances remain in place if the HCP is being properly implemented. For example, the No Surprises assurances would not apply to situations where authorized take levels are exceeded, or the minimization or mitigation measures are not meeting success measure targets.

As part of the No Surprises assurances, an HCP must identify and analyze reasonably foreseeable changed circumstances that could affect a species or geographic area during its term (50 CFR Section 17.3). Should such a changed circumstance occur, the permittee is required to implement the measures specified in the HCP to respond to this change. HCP permittees are not required to implement remedial actions for any unforeseen circumstances. These terms are defined and explained below.

The HRS provides for regulatory "incentives" in Section 195D-23 that are similar to the regulatory assurances provided by the federal ESA. The State cannot, in order to protect a threatened or endangered species, "impose additional requirements or conditions, or modify any existing requirements or conditions to mitigate or compensate for changes in the conditions or circumstances of any species or ecosystem, natural community, or habitat covered by the [HCP]." Allowable exceptions are as follows (any single item alone is an exception).

- KIUC consents to the changes.
- BLNR finds that the changes would not impose new restrictions on land available for development and would not increase cost to HCP parties.

[2] Section 195D-25(b)(2).

[3] The ESRC may not conduct more than one site visit per year to each property that is the subject of an HCP (HRS Section 195D-25(b)(6)).

- BLNR pays for any additional cost and KIUC consents to the changes.
- Extraordinary new circumstances or information indicates failure to change plan would appreciably reduce likelihood of survival or recovery of any threatened or endangered species. If additional mitigation measures are subsequently deemed necessary to provide for the conservation of a species that was otherwise adequately covered under the terms of the HCP as a result of extraordinary circumstances, the obligation for executing mitigation measures shall rest with the State, or the federal government with its consent, and not with KIUC.

7.3.1 Changed Circumstances

The federal No Surprises regulation defines changed circumstances as those circumstances affecting a species or geographic area covered by the HCP that can be reasonably anticipated by the applicant or USFWS and that can be planned for. Accordingly, this regulation requires that changed circumstances be identified in the HCP along with remedial measures that would be implemented by the permittee to address these changes. The changed circumstances that could arise in the Plan Area have been identified and are described in Section 7.3.3, *Changed Circumstances Addressed by this HCP*.

Changed circumstances are defined by federal regulation as follows.

> changes in circumstances affecting a species or geographic area covered by [an HCP] that can reasonably be anticipated by [plan] developers and the Services and that can be planned for (e.g., the listing of new species, or a fire or other natural catastrophic event in areas prone to such events) (50 CFR Section 17.3).

If a changed circumstance occurs within the Plan Area, KIUC will notify USFWS and DOFAW within 30 days of this changed circumstance. KIUC will evaluate the extent of the changed circumstance and identify and implement an appropriate response based on the remedial measures described in Section 7.3.3, *Changed Circumstances Addressed by this HCP*, to the extent necessary to address the effects of the changed circumstances on the HCP's conservation strategy. KIUC will also notify both agencies of their plans to implement remedial measures to address a changed circumstance. USFWS and DOFAW will not require any additional conservation or mitigation to address changed circumstances that are not identified in the HCP, without the consent of KIUC, if the KIUC HCP is found to be properly implemented. Properly implemented means that the commitments and the provisions of the HCP, ITP, and State ITL have been or are being fully implemented and the biological goals and objectives are being met.

7.3.2 Unforeseen Circumstances

Unforeseen circumstances are defined by federal regulation as follows.

> [Unforeseen circumstances are] changes in circumstances affecting a species or geographic area covered by a conservation plan or agreement that could not reasonably have been anticipated by plan or agreement developers and the Service at the time of the conservation plan's or agreement's negotiation and development, and that result in a substantial and adverse change in the status of the covered species (50 CFR Section 17.3).

In the event of unforeseen circumstances during the permit term, USFWS, DOFAW, and KIUC will work together to identify opportunities to redirect existing resources to address unforeseen circumstances, as needed to maintain the benefits of the HCP. However, the HCP provides regulatory assurances to KIUC consistent with the federal No Surprises regulation and the HRS Section 195D-23 that USFWS and DOFAW will not do the following:

- Require the commitment of additional land, water, or financial compensation by KIUC in response to unforeseen circumstances above and beyond those agreed to elsewhere in the HCP.
- Impose additional restrictions on the use of land, water, or natural resources otherwise available for use by KIUC under the original terms of the HCP in response to unforeseen circumstances.

As described in the No Surprises regulation, it is USFWS' responsibility to demonstrate the existence of unforeseen circumstances using the best scientific and commercial data available. KIUC as the permittee is only responsible for the changed circumstances as defined and described in the HCP. Unforeseen circumstances are circumstances that are highly unlikely and not reasonably foreseeable to occur during the permit term and, as determined by the federal No Surprises regulations, are not the management, monitoring, or funding responsibility of KIUC as the permittee.

The federal No Surprises regulation does not limit or constrain USFWS or any federal, state, local, or tribal government agency, or private entity, from taking additional actions at its own expense to protect or conserve covered species. The federal No Surprises regulation also does not prevent USFWS from asking KIUC to voluntarily undertake additional mitigation on behalf of the affected species.

As described above, an allowable exception to the State's regulatory assurances includes "extraordinary new circumstances or information indicates that failure to modify the plan or agreement is likely to appreciably reduce likelihood of survival or recovery of any threatened or endangered species".[4] Under the Hawai'i ESA (HRS Section 195D-23(a)(5)), "extraordinary new circumstances" represent circumstances that indicate that failure to modify the plan or agreement is likely to appreciably reduce the likelihood of the survival or recovery of any threatened or endangered species in its natural habitat. If additional mitigation measures are subsequently deemed necessary to provide for the conservation of a species that was otherwise adequately covered under the terms of an HCP, safe harbor agreement, or State ITL because of extraordinary circumstances, the primary obligation for executing mitigation measures rests with the State, or the federal government with its consent, and not with KIUC.

7.3.3 Changed Circumstances Addressed by this HCP

The changed circumstances in this section are recognized by this HCP. The descriptions in this section also discuss the risk of these changed circumstances along with remedial actions that would be funded and implemented to address impacts of changed circumstances on the covered species. KIUC will maintain sufficient financial reserves to fund any remedial action described in this section, as they arise. The following changed circumstances are recognized by this HCP and described in the following subsections.

- Severe weather and the effects of climate change (e.g., hurricanes, flooding, landslides, heat waves, sea level rise)
- New invasive species

[4] HRS Section 195D-23(a)(5).

- Disease outbreak in covered species
- Vandalism
- Population declines due to issues at sea

The following information is provided for each identified changed circumstance.

- A brief overview.
- A risk assessment that summarizes historical data to estimate the frequency and intensity of foreseeable impacts over the duration of the HCP.
- A process for coordinating with the agencies for evaluation prior to implementing actions.
- Preventive measures that KIUC has committed to in the HCP that will help reduce the potential for impacts on covered species from the changed circumstance.
- Thresholds for foreseeable rates of occurrence and magnitude derived from the risk assessment.
- Remedial measures that KIUC will implement to address foreseeable impacts on the covered species.
- Thresholds for unforeseeable rates of occurrence and magnitude derived from the risk assessment.

7.3.3.1 Severe Weather, Natural Hazards, and the Effects of Climate Change

Severe weather, natural hazards, and ongoing climate change can reasonably be anticipated to affect covered species or the geographic area covered by this HCP. Severe weather may include hurricanes, flooding caused by tropical storms, and heavy rain events such as Kona storms (Table 7-1). Natural hazards include tsunamis, landslides triggered by heavy precipitation, and wildfire triggered by drying (a combination of reduced moisture and higher temperature in conjunction with flammable invasive grasses). Many of these weather and hazard events may be intensified by climate change. For example, tsunamis deposit large amounts of water ashore and the reach of that water may be exacerbated by sea level rise. Rising temperatures are causing new stressors such as heat waves. Some of these situations are at the scale of the entire Plan Area and may affect all covered species (e.g., hurricanes, heat waves), whereas other severe weather events or natural hazards are expected to only affect a subset of the covered species (Table 7-1).

Risk Assessment

Climate models offer insights into future trajectories of temperature, precipitation, and related variables, as well as sea level rise. However, projections often exhibit considerable variability across models and may even differ on the direction of a future climate change, such as whether a location will become wetter or drier. Different greenhouse gas scenarios or pathways also introduce variability into how models perform and can result in large differences in the projected magnitude of climate change. Climate modeling has less utility for examining trajectories of severe weather because such events are, by their nature, statistically rare occurrences. Trying to extract a clear indication of the likelihood of extreme weather events increasing or decreasing in frequency or intensity by examining the tails (outliers) of climate model distributions is fraught with uncertainty because of the large amount of variability or scatter that is produced across both the suite of models and their tails. While statistical approaches have been proposed for such investigations (e.g., Vavrus et al. 2015), there is no agreed-upon standard. Moreover, severe weather occurs at different geographic scales—from hurricanes and tropical cyclones that travel across hundreds or thousands of miles of ocean, to local and regional storms derived from convective processes (i.e., movement of warm, moist air masses from the Earth) influenced by local topography. Global climate models operate on grid boxes congruent with large-scale events like temperature change or hurricane activity. Those same grid boxes are too large, however, to pinpoint localized events like a heavy rainfall. How severe weather will change in the future due to ongoing climate change is, in many instances, very difficult to estimate due to the complexity of interactions and feedbacks between regional and global processes (Stammer et al. 2018). Our current ability to project changes in the frequency and intensity of tropical cyclones and other extreme precipitation events specific to Kaua'i over the 50-year permit term of the HCP is limited. Examining and extrapolating from past climate trends is one approach to assessing the likelihood of future extreme events because climate change has already been underway for decades and its signature on current extreme events is routinely examined (e.g., Cho 2021).

Changes in the climate of the Hawaiian Islands are already evident. Since 1950, temperatures across the Hawaiian Islands have risen by about 2°F, with a sharp increase in warming over the last decade. The number of hot days and very warm nights increased dramatically during the 2015–2020 period compared to the 1951–1980 average, with 58 days of maximum temperature of 90°F or higher during 2019 as opposed to the long-term average of about eight, and over 80 nights that year at 75°F or higher compared to the long-term average of 27. The rate of temperature increase has been the greatest at high elevations (Stevens et al. 2022).

Under a higher emissions pathway, historically unprecedented warming is projected through 2100. Even under a lower emissions pathway, annual average temperatures are projected to most likely exceed historical levels by the middle of the century (i.e., about halfway through the HCP permit term). However, a large range of temperature increases is projected under both pathways, and under the lower pathway, a few projections are only slightly warmer than historical records. Rising temperatures will cause future heat waves to be more intense. Warming, accompanied by reduced rainfall in some areas, will stress native plants and animals, especially in high-elevation ecosystems.

Precipitation varies greatly across individual islands and the island chain. Nonetheless, precipitation trends are also apparent. Hawai'i has historically experienced drier than normal conditions during the El Niño wet season (November to April) and greater than normal rainfall during the La Niña wet season. Since the early 1980s, Hawai'i has experienced drier conditions during the wet season of La Niña years. In fact, a drying trend in La Niña years has been evident since 1956. Moreover, El Niño events have occurred more frequently over the last two decades, resulting in more drying (Stevens et al. 2022). Both El Niño and La Niña episodes are projected to increase in frequency and magnitude as the world warms (Keener et al. 2018). Larger total acres burned by wildfires are more likely to occur in the year following an El Niño event (Stevens et al. 2022).

Overall, annual rainfall has decreased throughout the island chain since the 1920s and the decrease is particularly in evidence during recent years in the wet season (Frazier et al. 2022). A 500-year historical reconstruction of winter precipitation concluded that a general drying trend, though with substantial decadal and longer-term variability, goes back 160 years (Díaz et al. 2016). In 10 of the 15 years since 2007, wet-season precipitation was below average, with 4 of the remaining 5 years being very near average. All of the 17 significantly above-average wet years occurred prior to 2006. The changing La Niña rainfall pattern and the increasing frequency of El Niño seem to have contributed to a long-term drought that started in 1980. An increase in the frequency of the trade wind inversion is also linked to a decrease in precipitation at high elevations. The number of consecutive dry days across the Hawaiian Islands has increased since the 1950s. An increase in drought conditions has been detected in Kauaʻi in recent years, particularly on the windward side of the island and at high elevations. Such conditions lead to a lack of usable water and an increased risk of fire (Stevens et al. 2022).

Increasing trends in extreme 30-day rainfall and the lengths of consecutive dry-day and consecutive wet-day periods indicate that Hawaiʻi's rainfall is becoming more extreme and suggest that both droughts and floods are becoming more frequent in Hawaiʻi (Kenner et al. 2018). Nonetheless, the most recent analysis by NOAA states that extreme precipitation events have become less frequent on Kauaʻi (Stevens et al. 2022). This is one area in which there appears to be conflicting reports. Any seemingly contradictory information may stem from different time frames of analysis or the lack of weather stations from which to extract data. In revising the Precipitation-frequency Atlas of the United States for the Hawaiian Islands (Volume 4 of its continental Atlas 14 project), NOAA also revised downward the magnitude of 100-year, 60-minute and 24-hour flood events. Over most of Kauaʻi, the 100-year flood has diminished as much as 50 percent since the last atlas was published in the 1960s (Perica et al. 2011).

Precipitation projections for Hawaiʻi are particularly challenging to estimate due to the state's high and steep topography, which leads to pronounced variability in climate over distances much smaller than climate model grid cells. Moreover, natural year-to-year variability in rainfall is much larger than the small changes in precipitation being projected even under higher emissions scenarios for the middle of the century. Hawaiʻi appears to straddle the transition between wetter conditions in the tropics and drier conditions in the subtropics that arises from climate models. It is likely that the currently wet windward sides of the major islands will see an increase in rainfall, while the currently dry leeward sides will experience a decrease. Projected changes in the frequency and magnitude of extreme precipitation events are also uncertain, with some climate models indicating increases and others decreases. The physics of warming suggest that rainfall events are likely to become more extreme because for each 1.8°F (1°C) of temperature increase the atmosphere holds 7 percent more water. Even if average precipitation remains constant, higher temperatures will increase the rate of soil moisture loss during dry periods and potentially increase the intensity of naturally occurring droughts (Stevens et al. 2022).

Kona storms yield disproportionately large amounts of rainfall. Kona storms are cool winter storms associated with a southward shift in the mid-latitude jet stream. They usually affect the state for a week or less and occur, on average, two to three times per year. Kona storms often result in flash flooding and may trigger landslides. Kona storms can produce additional hazards such as hail, heavy mountain snows, waterspouts, and high surf events. Storm tracks are shifting northward due to climate change, which could result in more "noncrossing" (i.e., those that do not cross an island) cold fronts in the future. In addition, warming may also produce fewer cold fronts. On the island of Oʻahu, a study found that Kona storms represent almost 50 percent of total annual precipitation, and that cold fronts that approach but ultimately do not cross the island actually have a drying effect and result in reduced overall rainfall. Because leeward regions are dependent on storm events for much of their rainfall, those areas may be even drier as climate change progresses (Longman et al. 2021).

Hawaiʻi is also susceptible to tropical storms, most often occurring between June and November. Such storms bring heavy rains, high winds, and high waves to the islands. Hurricanes rarely affect the state, with many dissipating into tropical storms or tropical depressions as they approach the islands. Since 1950, 25 hurricanes have affected Hawai'i (passing within 200 miles), with only two making landfall. The annual number of tropical cyclones observed in the Central North Pacific has varied over time, with a greater number forming during El Niño years. The most active hurricane season on record in the Central Pacific was 2015, with eight hurricanes and six additional tropical storms. Future tropical cyclone activity remains uncertain. Modeling points to a northward shift in storm tracks in the Central North Pacific that could yield an increase in the frequency of tropical cyclones reaching Hawai'i, but it has been noted that tropical cyclone frequency around the Hawaiian Islands is still very low in a warmed climate, and that a quantitative evaluation of future change involves significant uncertainties (Kenner et al. 2018).

Sea level rise is another concern. Rates of sea level rise in Hawai'i vary among the islands; it has been 0.6 inch per decade for Kaua'i. By 2100, increases of 1–4 feet in global sea level are very likely, with even higher levels than the global average projected for Pacific Islands including Hawai'i. In fact, the Pacific Basin is likely to experience the highest rates of sea level rise on the planet (Kenner at al. 2018). A Hawaiian assessment of sea level rise concluded that at least 1 foot of rise could be reached by mid-century (Hawai'i Climate Change Mitigation and Adaptation Commission 2017). That same assessment chose 3.2 feet of rise as its high-end planning scenario for the latter half of the 21st century because models suggest an acceleration in sea level rise by the end of the century. The Fourth U.S. National Climate Assessment found that 3.2 feet was an intermediate scenario and one that could be reached as soon as 2060 (Kenner et al. 2018). Sea level science is dynamic and rapidly evolving, and modeling results rapidly become outdated. Sea level rise is projected to cause an increase in tidal floods associated with nuisance-level impacts. Nuisance floods are events in which water levels exceed the local threshold (set by NOAA's National Weather Service [NWS]) for minor impacts on infrastructure, cause road closures, and overwhelm storm drains. Continued sea level rise will also present major challenges to Hawai'i's coastline through coastal inundation and erosion (Stevens et al. 2022).

Pacific climate variability is a governing element that amplifies many aspects of global climate change, such as drought, sea level, storminess, and ocean warming. Overall, there is great uncertainty about how Pacific variability occurring on short timescales, such as El Niño and La Niña, will combine with multidecadal changes in temperature, waves, rainfall, and other physical factors to influence future patterns of climate change (Kenner et al. 2018).

The Fourth U.S. National Climate Assessment summarized its findings as follows (Kenner et al. 2018):

> There is very high confidence in further increases in temperature in the region, based on the consistent results of global climate models showing continued significant increases in temperature for all plausible emissions scenarios.
>
> There is low confidence regarding projected changes in precipitation patterns, stemming from the divergent results of global models and downscaling approaches and from uncertainties around future emissions. However, for leeward areas of Hawai'i, future decreases in precipitation are somewhat more likely, based on greater agreement between downscaling approaches for Hawai'i.
>
> There is very high confidence in future increases in sea level, based on widely accepted evidence that warming will increase global sea level, with amplified effects in the low latitudes.
>
> There is medium confidence in the increasing risk of both drought and flood extremes patterns, based on both observed changes (for example, increasing lengths of wet and dry periods) and projected effects of warming on extreme weather globally.

Thresholds for Changed Circumstances

For the purposes of this HCP, foreseeable frequency thresholds for severe weather events have been estimated based on historic observed rates of each type of severe weather. Based on the discussion above, climate modeling does not provide clear direction regarding the changes in frequency of these events. Instead, thresholds are provided based on historic observed frequencies that already include climate change as explained above. Current scientific understanding of the expected future frequency and intensity of severe weather events in the vicinity of Kaua‘i in a warming climate are provided in each subsection below and summarized in Table 7-1.

Table 7-1. Thresholds of Changed Circumstance for Severe Weather and Natural Hazards (see text for details)

Severe Weather[a]	Annual Average	Foreseeable Frequency	Occurrences During 50-year Permit Term	Dataset Length	Temporal Trend	Extent of Damage	Covered Species Affected
Hurricane (Landfall)	0.028	1 per 35 years	1.4 times	70 years	Stable	Widespread, max	Seabirds, Waterbirds, Green sea turtle (honu)
Hurricane (Close approach[b])	0.028	1 per 35 years	1.4 times	70 years	Stable	Regional, mod	Seabirds, Waterbirds, Green sea turtle (honu)
Hurricane (Distant approach[b])	0.056	1 per 17 years	2.8 times	70 years	Stable	Regional, min	Seabirds, Waterbirds, Green sea turtle (honu)
Tsunami	0.07	1 per 14 years	3.5 times	70 years	Stable	Coastlines, max	Waterbirds, Green sea turtle (honu)
Flooding	see text	see text	see text	14 years	Unknown	Localized or regional	Waterbirds, Seabirds
Landslide	see text	see text	see text	15 years[c]	Unknown	Localized or regional	Seabirds
Sea Level Rise	see text	see text	Gradually over the permit term	2060	Stable	Coastlines, max	Waterbirds, Green sea turtle (honu)

[a] For each type of severe weather considered a changed circumstance, the average rate of occurrence per year is provided (annual average) along with foreseeable frequencies of each event. Dataset length indicates the duration of records used to derived annual averages and foreseeable frequencies.

[b] Close approach is defined as 0–50 miles (0–80.5 kilometers) offshore, distant approach is defined as 50–150 miles (82–241.4 kilometers) offshore. Hurricanes have been divided into these categories due to the differences in the potential damage, in terms of extent and magnitude, that may be expected at conservation sites associated with this HCP. Specifically, damage resulting from hurricanes making landfall or closely approaching the island is presumed to be more severe relative to hurricanes whose center remains at a distance from the island. "Distant" is synonymous with "less severe damage expected", and these distances were based on the extent of damage that resulted from various hurricanes passing at various distances from Kaua'i.

[c] The dataset for landslide frequency was anecdotal, rather than authoritative, and the annual average and foreseeable frequency should be considered minimum estimates. Given the regularity of landslides as well as uncertainty in the exact rate, any landslide that has occurred and is deemed to affect conservation site infrastructure, will be considered foreseeable and addressed with remedial measures.

Frequency threshold calculations for different types of severe weather and hazards are based on various lengths of timeseries, in part due to the rarity of some events and also due to the limitations of historical record keeping. Summarized here is justification for the duration chosen for each type of event (Table 7-1):

- Hurricanes: a timeseries of 70 years (1950–2020) is used for determining the frequency of hurricanes with moderate (i.e., distant approach) to extensive (i.e., close approach and landfalls) damage, due to the infrequent, irregular intervals between such events, as well as the differences in how hurricanes track across the Pacific, causing variation in the frequency and severity of hurricane impacts to different islands.
- Tsunamis: a timeseries of 70 years (1950–2020) is used for determining the frequency of major tsunamis, again due to rarity and the irregular intervals between such events. For example, if the analysis considered only the previous 30 years, then the calculated frequency would be one tsunami expected per 30 years rather than one per 14 years.
- Flooding: a timeseries of 17 years (2004–2021) of flash flood warnings issued by the NWS is used for this assessment because reliable tracking of flash flood warnings did not occur prior to 2004. Also, since flash flooding is frequent on Kaua'i, a shorter timeseries still provides sufficient information to calculate expected frequencies. Given the high foreseeable frequency, any flash flood warning issued by the NWS in the Plan Area would be considered foreseen and addressed with remedial measures if the HCP's minimization measures or conservation measures are compromised.
- Landslides: There is no authoritative database detailing landslide events on Kaua'i at the time of writing. Instead, anecdotal information on landslides for the period 2006–2012—derived from the County of Kaua'i Multi-hazard Mitigation and Resilience Plan (County of Kaua'i 2015)—and for the period 2013–2021—derived from online news outlets—is used to calculate the frequency of known landslides from 2006 to 2021. As noted, this represents a minimum because many areas in the Plan Area, including remote areas where conservation sites are located, are not currently monitored for landslides; an exact rate for landslides cannot be determined, primarily due to a lack of information. Therefore, given the already high foreseeable frequency combined with this uncertainty, any landslide detected in or immediately adjacent to seabird conservation sites should be considered foreseen and addressed with remedial measures if the HCP minimization measures or conservation measures are compromised.
- Sea Level Rise: Sea level rise is predicted to rise by 3.2 feet (0.98 meter) globally by year 2100, however it is projected that this magnitude of sea level rise could occur as early as 2060 (Sweet et al. 2017). Given this uncertainty in the foreseeable frequency, sea level rise in an amount that will affect the lowland covered species may or may not occur during the permit term. If sea level rise does occur there is really no response possible for the loss of green sea turtle (honu) nests due to sea level rise. If nesting habitat lost on the island of Kaua'i, KIUC has no control over these areas, and thus no way to get it back.

The frequency thresholds are calculated as the likelihood of an event happening over a certain amount of time based on multi-year averages, which is not an absolute time-to-event interval. For extreme weather events, there can be great variation in the interval between events and they may not be regularly spaced across the permit term. As an example, if hurricanes may foreseeably make landfall on Kaua'i once every 35 years, then a maximum of two hurricane landfalls would be foreseen over a 50-year permit term. Thresholds are not set for either flooding or landslides because of the difficulty of predicting frequency at a scale meaningful to the 10 conservation sites. Instead, no changed circumstance threshold is set for either flooding or landslides, as described further below.

Hurricanes

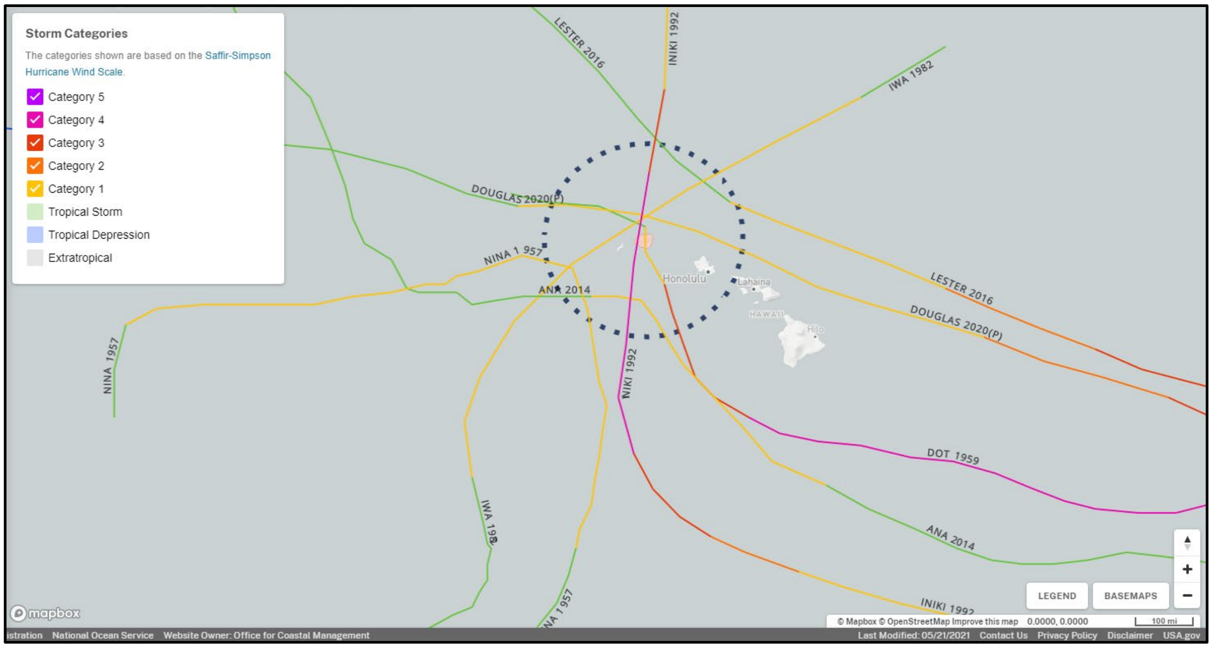
Hurricanes are large weather systems. Hurricane-force winds (i.e., 74 miles per hour [mph] or 119 kilometers per hour [kph]) may extend outward to more than 150 miles (241.4 kilometers [km]) from the center of large (Category 3+) hurricanes (National Oceanic and Atmospheric Administration 1999). At that scale, hurricanes can affect the entirety of Kauaʻi even when they do not make landfall. In the central Pacific, hurricanes generally move from east to west but may also swing northward. As a result, all regions of the island have the potential to be affected by the damaging winds and heavy rains associated with hurricanes.

The National Hurricane Center's Hurricane Database (HURDAT) (National Hurricane Center 2021; National Oceanic and Atmospheric Administration 2021a) contains data from 1950 when record-keeping began. Based on the previous 70 years, an average of five hurricanes form in the central Pacific annually, with two of these being Category 3 or greater.

Rarely do hurricanes make landfall on the Hawaiian Islands (Thompson 2014). However, the extent of hurricane damage is a function of the size of the hurricane and the distance between the hurricane and the island, not whether it makes landfall. To estimate the potential for hurricanes damaging Kauaʻi, we partitioned historical hurricane records into three categories: (1) landfall, (2) close approach (0–50 miles [0–80.5 km] offshore), and (3) distant approach (51–150 miles [82–241.4 km] offshore).

Of all the islands, Kauaʻi has experienced the most direct hits of hurricanes in recorded history (National Oceanic and Atmospheric Administration 2021a; Figure 7-1). Over the last 70 years, two hurricanes have made landfall on Kauaʻi—Hurricane Dot in August 1959 (Category 1 at time of landfall) and Hurricane ʻIniki in September 1992 (Category 4 at time of landfall). This equates to a rate of one landfall every 35 years. Over this same period, an additional two hurricanes made close approaches—Hurricane ʻIwa in 1982 (Category 3) and Hurricane Douglas in 2020 (Category 1); this equates to a rate of one close approach every 35 years. Four additional hurricanes have made distant approaches to Kauaʻi (Figure 7-1); this equates to a rate of one distant approach every 17.5 years. Tropical storms are more frequent and can also have damaging impacts (e.g., rain, flash flooding, storm surge) but with more modest winds that remain below 74 mph (119 kph).

The rate of hurricane formation including formation of major hurricanes has been stable over the last 40 years (1980–2020; Figure 7-2 generated from National Hurricane Center 2021 data using R package HURDAT by Trice 2020). During this more recent period, one hurricane has made landfall and an additional five hurricanes passed within 150 miles (241.4 km) of Kauaʻi, which equates to a rate of one hurricane making landfall every 40 years and one hurricane passing close enough to potentially cause damage to isolated parts of the island every 6 years. These more recent rates of occurrence are similar to the 70-year average indicating that the frequency of impacts due to climate change is undetectable at this point in time.



Source: National Oceanic and Atmospheric Administration 2021a

Figure 7-1. A map of the tracks of all hurricanes within 150 miles (241.4 km) of Kaua‘i (as depicted by the dashed circular outline) between 1950 and 2020, generated using NOAA’s Historical Hurricane Tracks Mapbox interface

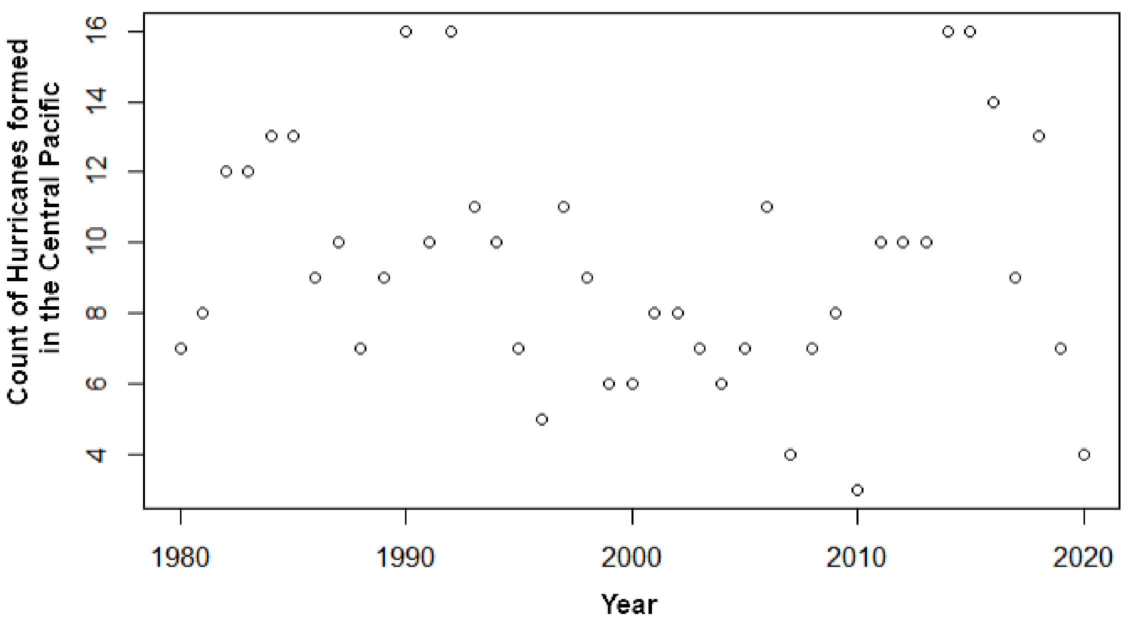


Figure 7-2. Annual count of the hurricanes formed in the central Pacific Ocean based on the National Hurricane Center’s Hurricane Database (National Hurricane Center 2021), which shows no evidence of a directed trend in either increasing or decreasing directions.

Hurricane 'Iniki was the most powerful hurricane to strike the state in recorded history (Central Pacific Hurricane Center 1993). Hurricane 'Iniki made landfall on the south-central portion of Kaua'i at peak intensity and moved across the island in 40 minutes (Central Pacific Hurricane Center 1993). Much of the island experienced sustained winds of 100 to 120 mph (161 to 193 kph), with gusts of 175 mph (282 kph) at landfall along with localized microbursts, sudden downdrafts of wind capable of reaching 200 mph (320 kph). In addition to intense winds, Hurricane 'Iniki created a 13- to 20-foot (4- to 6-meter) storm surge on top of a 17-foot (5.2-meter) swell along the southern Kaua'i coastline. Because the hurricane moved quickly through the island, there were no reports of significant rainfall (National Oceanic and Atmospheric Administration 1993).

Marked declines in populations of the covered seabirds were documented because of Hurricane 'Iniki. "While it is unlikely that the hurricane itself caused direct mortality of adults [on land] given that it struck the island during the day while adults were out at sea" (Raine et al. 2017), it is likely that chicks were still in burrows when Hurricane 'Iniki made landfall. However, the hurricane may have displaced adults at sea, affecting foraging success and chick provisioning (Schreiber 2002). Additionally, damages resulting from this hurricane likely "increased impacts of introduced predators (by opening ingress routes that act as movement corridors), habitat modification (due to erosion and native vegetation removal), and powerline collisions (the removal of considerable vegetation shielding powerlines after large trees were blown over)" (Raine et al. 2017).

Smaller hurricanes that fail to make landfall can also pose threats but have historically resulted in considerably less damage than Hurricane 'Iniki. Hurricane 'Iwa was the second most damaging hurricane to affect Kaua'i, passing within 25 miles (40.2 km) of the shoreline as a Category 3 hurricane. The right semicircle of this hurricane extended across Kaua'i and produced 30-foot (9-meter) swells, an 8-foot (2.4-meter) storm surge, and wind gusts up to 120 mph (193 kph) (Rosendal 1983). The worst damage from Hurricane 'Iwa occurred along the south side of the island, where the rough surf destroyed or severely damaged several exposed luxury hotels, condominiums, and boats (Rosendal 1983). Like Hurricane 'Iwa, the center of Hurricane Douglas passed within 43 miles (69.2 km) of Kaua'i's north shore but, unlike Hurricane 'Iwa, it was a much smaller storm and hurricane-force winds remained offshore. Overall damage was relatively minor with some moderate flooding on Kaua'i due to storm surge and rainfall (Brackett 2020).

In certain situations, described above, hurricanes are expected to have the greatest likelihood of affecting the covered seabirds. In some instances, however, hurricanes may also affect the covered waterbirds and green sea turtle (honu) depending on the severity of the event. Hurricanes may result in life-threatening impacts on adults, juveniles, chicks, and eggs, both on land and at sea of the covered species, and by severely altering vegetation and damaging or destroying nests. Hurricanes have the potential to alter the environment in areas important to the life history of covered species, including altering vegetation in breeding areas and other habitats that affect the ability of covered species to survive and reproduce. Considerable damage or destruction of conservation structures (e.g., powerline collision deterrent devices, predator and ungulate exclusion fences, Save Our Shearwaters [SOS] facilities and operations) because of hurricanes may temporarily reduce the effectiveness of the conservation measures. Additionally, damage resulting from hurricanes may temporarily impede access to the conservation sites to implement remedial measures.

Tsunamis

Tsunamis are potentially destructive waves caused by the displacement of a large volume of water resulting from earthquakes, volcanic eruptions, submarine landslides and other underwater explosions. Tsunamis can travel across the Pacific Ocean basin from the point of origin to remote points of impact in a matter of hours.

Terrestrial areas affected by tsunamis may experience widespread inundation by seawater at otherwise unprecedented distances inland. Tsunamis are life threatening to all life forms that are unable to rapidly relocate and/or tolerate long periods of inundation by rushing seawater. Any structures (e.g., houses, bridges, roads) and sensitive habitats in their pathway are at risk of being destroyed.

Due to the sheer size and destruction that can result from tsunamis, frequencies of these events can be reconstructed from paleotsunami (i.e., tsunami occurring prior to the historical record) deposits. Although there is evidence that Hawai'i was affected by locally generated tsunamis in the distant past (e.g., Moore and Moore 1984; Satake et al. 2002; McMurtry et al. 2004), the most recent event occurred over 10,000 years ago (McMurtry et al. 2004). All recent tsunamis affecting Hawai'i have been generated by remote earthquakes; the Hawaiian Islands' location in the middle of the Pacific Ocean predisposes them to be threatened by tsunamis from great earthquakes in nearly all directions (Butler et al. 2014). Paleotsunami deposits laid down in the in the Makauwahi Sinkhole on the southwest side of Kaua'i between 350 and 575 years ago provide evidence of the largest tsunami to hit the island in geologic history, with seawater traveling 328 feet (100 meters) inland and rising 24 feet (7.3 meters) above sea level (Butler et al. 2014).

In the last 70 years, five major tsunamis have affected Kaua'i. During the 1960 Chilean tsunami, seawater rose a maximum of 10 feet (3 meters) above sea level as measured at the Makauwahi Sinkhole (Butler et al. 2014). The other four major tsunamis that affected Kaua'i occurred in 1952, 1957, 1964, and 2011 (Butler et al. 2014). This equates to an average impact rate of one major tsunami every 14 years.

Because the frequency of earthquake-generated tsunamis is unrelated to climate change and the scale needed to encompass the full range of potential impacts is on the order of centuries, rather than decades, only the 70-year frequencies will be used to set thresholds for what can be reasonably anticipated over the duration of the federal ITP and State ITL for tsunamis.

Tsunami impacts are restricted to lower-elevation coastal areas, most frequently below 10 feet (3 meters) in elevation based on the last 70 years of data from Kaua'i. Conservative estimates of sea level rise could add 1–3 or more feet of height to a tsunami. As a result, green sea turtle (honu) and covered waterbird habitat are at risk of being affected by this type of event. Tsunamis that result in significant coastal flooding may temporarily disturb or destroy active waterbird nests and wetland breeding habitat due to inundation. Green sea turtle (honu) nesting habitat and active nests may be affected by tsunamis that inundate or destroy nesting beach habitat. Furthermore, these events could remove coastal vegetation, coastal beach habitat, or structures near nesting habitat that have the potential to increase the impacts of artificial lights on hatchlings trying to make their way to the ocean. A tsunami that struck a green sea turtle (honu) nesting beach could wash away eggs prior to hatching.

Of all the severe weather and natural hazards accounted for, tsunamis are the least likely to affect the covered seabirds because they do not occur near coastal habitat. Perhaps if a tsunami was powerful enough to trigger landslides in the steep cliff nesting areas high above the ocean then seabirds might be affected.

Flooding

Flooding can result from a body of water overflowing onto land, from heavy rainfall that accumulates on the land surface, and, more recently, from sea level rise that causes "sunny day" tidal flooding associated with "king tides," or the highest tides of the year. Flooding may result from other severe weather events already summarized above (e.g., hurricanes) or may be associated with less severe weather systems (e.g., heavy rainfall events, Kona storms, tropical storms). Rapid rise in water can endanger lives, destroy structures, wash out roads and trails, and promote the occurrence of rainfall-triggered landslides that may impede access by blocking roads and trails.

Flooding risks can be assessed various ways. For planning purposes, NOAA calculates precipitation frequency based on historic data (now through 2010 for Hawaiʻi). The U.S. Geological Survey (USGS) uses its network of streamflow gauges to monitor the flood stage of rivers in real time. The NWS issues flash flood (sudden, violent flooding) warnings using hydrologic tools that are informed by radar-based rainfall rates to forecast the severity, timing, and magnitude of flash flooding.

USGS published updated flood frequency estimates for Hawaiian streams with data through the 2008 water year (Oki et al. 2010). Using 235 gauging stations in unimpacted areas, a trend was detected in only 37 and of those, 27 were downward and 10 were upward. In general, estimated 100-year peak discharges from this study were lower than those from previous studies across all the islands including Kauaʻi. These data are consistent with NOAA's Atlas 14 findings. It should be noted that hydrologic data can be highly variable and the inclusion or exclusion of periods of time can change the outcomes of analysis, sometimes quite significantly.

Unlike the previously described severe weather events, the database that has archived all NWS flash flood warnings issued on Kauaʻi only begins in 1986 and appears unreliable prior to 2004 due to a marked increase in the frequency of warnings issued starting in 2004 (Iowa Environmental Mesonet 2021). According to the NWS, a flash flood warning is "issued when flash flooding is imminent or occurring;" therefore, warnings represent a reliable proxy for the actualized frequency of flooding events that have occurred over the last 17 years (2004–2021) across the entire island. Due to a lack of records for flash flooding events prior to 2004, an assessment of increased flash flooding due to climate change was not possible.

Since 2004, there have been 244 flash flood warnings issued on Kauaʻi, which equates to an average of between 12 and 13 flash floods on the island each year. There is significant interannual variability in flooding, however, and the number of flash flood warnings range from as few as 4 to as many as 58. Within a year, flash flooding can occur in any month but 82.6 percent (n=185) of flash flood warnings issued since 2004 occurred between October and February.

Spatially, some areas are more prone to damage caused by flash flooding due to sloped topography that works to funnel runoff, creating a temporary watercourse or adding to the flow rate of existing watercourses. Areas with this sort of topography are more likely to experience erosion in events of flooding due to fast-moving water flows. Based on the Special Flood Hazard Areas depicted on the Flood Hazard Assessment Tool (State of Hawaiʻi Department of Land and Natural Resources 2021), areas with the greatest risk of flooding are associated with existing watercourses (i.e., rivers, streams, and marshes) and low-lying areas (e.g., Mānā, Hanalei Valley). Although all areas subject to flooding are not identified on this map, and the lack of Special Flood Hazard Areas in the remote interior and along the northwestern coastline are likely because people do not reside in these areas. Given the steep topography and abundant existing watercourses in the remote, uninhabited areas of the island where the seabird conservation sites are located, localized damage caused by flash flooding, particularly in steep valleys and existing waterways, should be anticipated.

On Kauaʻi there have been a few instances in recent history where extensive flooding has occurred in populated areas and has resulted in significant damage to human infrastructure. Four such flooding events have occurred since 1991 (December 1991, October 2006, April 2018, and March 2020; Tetra Tech 2021). The Hanalei National Wildlife Refuge (NWR) on the north side of the island of Kauaʻi has the potential to be affected by extensive damage due to flooding as frequently as once every 10 years if all these storm events are considered. However, locational details provided for three of the four events indicate that worst impacts were at a distance from Hanalei NWR (e.g., Hanalei Bridge, Anahola), so the realized frequency of events causing extensive damage at Hanalei NWR may be more on the order of once every 40 years. In the southern portion of Kauaʻi flooding near the Waimea River mouth and Mānā have been documented in the last 40 years. However, flood events expected to cause extensive damage to Mānā are expected to be relatively rare and are not anticipated at anything less than a 40-year interval.

The covered seabirds and covered waterbirds could be affected by localized flooding that occurs during the nesting season. Large rain events that result in flooding cause the most risk to seabirds. In 2021, a Hawaiian petrel (ʻuaʻu) chick was found in a flooded burrow in the Hono O Nā Pali Natural Area Reserve in late September; the chick was found covered in mud, soaked, and sitting in an inch of water (Archipelago Research and Conservation 2021). Covered seabird eggs and fledglings could also be affected by large rain events. Flooding may also impact the covered waterbird species. It is unlikely that flooding of waterbird wetland and river habitats, even in extreme cases, will result in a mass mortality event of adult waterbirds. However, if it happens to be nesting season for waterbirds when flooding occurs and their nests become inundated, these events could result in temporary reductions in reproductive outputs of affected species (Byrd and Zeillemaker 1981). In April 2018, an historic rain event resulted in 50 inches of rain falling on Kauaʻi in 24 hours, causing the Hanalei River to flood its banks and inundate surrounding low-lying areas, including the wetlands in the Hanalei NWR. Despite this historic flooding, intensive efforts to document impacts on waterbirds located only seven carcasses (based on an interview of K. Uyehara reported by Rogers 2018). Moreover, flooding can create new suitable habitat for the covered waterbird species when properly managed, but these events can also make habitat less suitable or unusable, depending on the water depth and season in which the events occur. Flash flooding can submerge or wash away nests in wetland habitat and can remove nesting substrate. Green sea turtles (honu) do not occur in areas where they are expected to be adversely affected by flooding.

Landslides

Landslides are defined by USGS as the movement of a mass of rock, debris, or earth down a slope. Slope movement occurs when forces acting downslope due to gravity exceed the strength of the earth materials that compose the slope. Landslides can be initiated in slopes already on the verge of movement by rainfall, snowmelt, changes in water level, stream erosion, changes in groundwater, earthquakes, volcanic activity, disturbance by human activities, or any combination of these factors. On land, landslides can endanger lives, destroy structures, and block access to roads and trails. Underwater landslides can generate tsunamis.

Kauaʻi primarily experiences rainfall-triggered landslides (County of Kauaʻi 2015) due to its steep mountainous topography, which focuses rain onto mountain slopes, causing landslides. There is no authoritative database detailing landslide events on Kauaʻi, so generating a robust and long-term average for this type of extreme event and assessing changes in frequency in recent years is not possible. However, the County of Kauaʻi Multi-hazard Mitigation and Resilience Plan (2015) does provide some anecdotal information on landslides. Specifically, this plan notes that flooding and storm events caused landslides affecting highway and coastal roads in 2006, 2008, and 2012. News articles since 2012 indicate additional weather-related landslides occurred in 2014 at Wailua River (Hawaii News Now 2014), in 2018 along the north shore (Parachini 2018), and again in 2021 along the north shore (Bigley 2021). Thus, anecdotal reporting from 2006 to 2021 indicates that landslides are common and landslide-generating events occur at least once every 2.7 years. However, not all landslides are reported, particularly in the uninhabited interior regions of the island, and this is a minimum estimate of landslide frequency rather than an average estimate. Although very little is known about the exact rate of landslides in the uninhabited northwest portions of Kauaʻi where seabird conservation sites are located, landslides do occur frequently in the steep terrain along the Nā Pali Coast and may frequently affect the conservation sites. There are records of landslides affecting the covered seabirds in the Upper Limahuli Preserve, Hanakāpiʻai, and North Bog conservation sites.

The USGS Preliminary Landslide Susceptibility Map for Hawaiʻi depicts areas of steep slopes with moderate, high, and very high risk of landslides across Kauaʻi. These risk categories are based on expert judgement and a slope-stability model applied to digital topography following the methods of Harp et al. (2009). While this information is preliminary or provisional and is subject to revision, it indicates there a risks of landslides throughout the Nā Pali Coast. Each conservation site[5] is primarily designated as the lowest risk category (moderate) with small areas considered to be high risk (Figure 7-3). Generally, areas of very high risk, which are the very steep slopes of the Nā Pali Coast, are outside of the conservation sites, but can overlap slightly with the conservation site boundary, such as is the case along the eastern edge of North Bog.

The location and design of all nine selected conservation sites was informed, in part, by landslide risk. Site locations were chosen, and boundaries were designed to mostly avoid areas with high and very high landslide risk (Figure 7-3). However, a moderate risk of landslides remains throughout all or most the Nā Pali Coast where all the KIUC HCP conservation sites are located. Therefore, landslides are expected to affect the covered seabirds directly and indirectly during the 50-year permit term. Landslides can bury active burrows (including the chicks and any incubating adults inside), remove vegetation and soil, or result in large areas of land breaking off and falling into the ocean. Landslides can also damage or destroy predator fencing, which increases the susceptibility of covered seabirds to predator mortality until the fence can be repaired. Landslides are not expected to affect the covered waterbirds or green sea turtle (honu) because they do not occur in areas susceptible to landslides.

[5] Conservation Site 10 is not shown on Figure 7-3 because it will be selected during the first year of HCP implementation (2023)

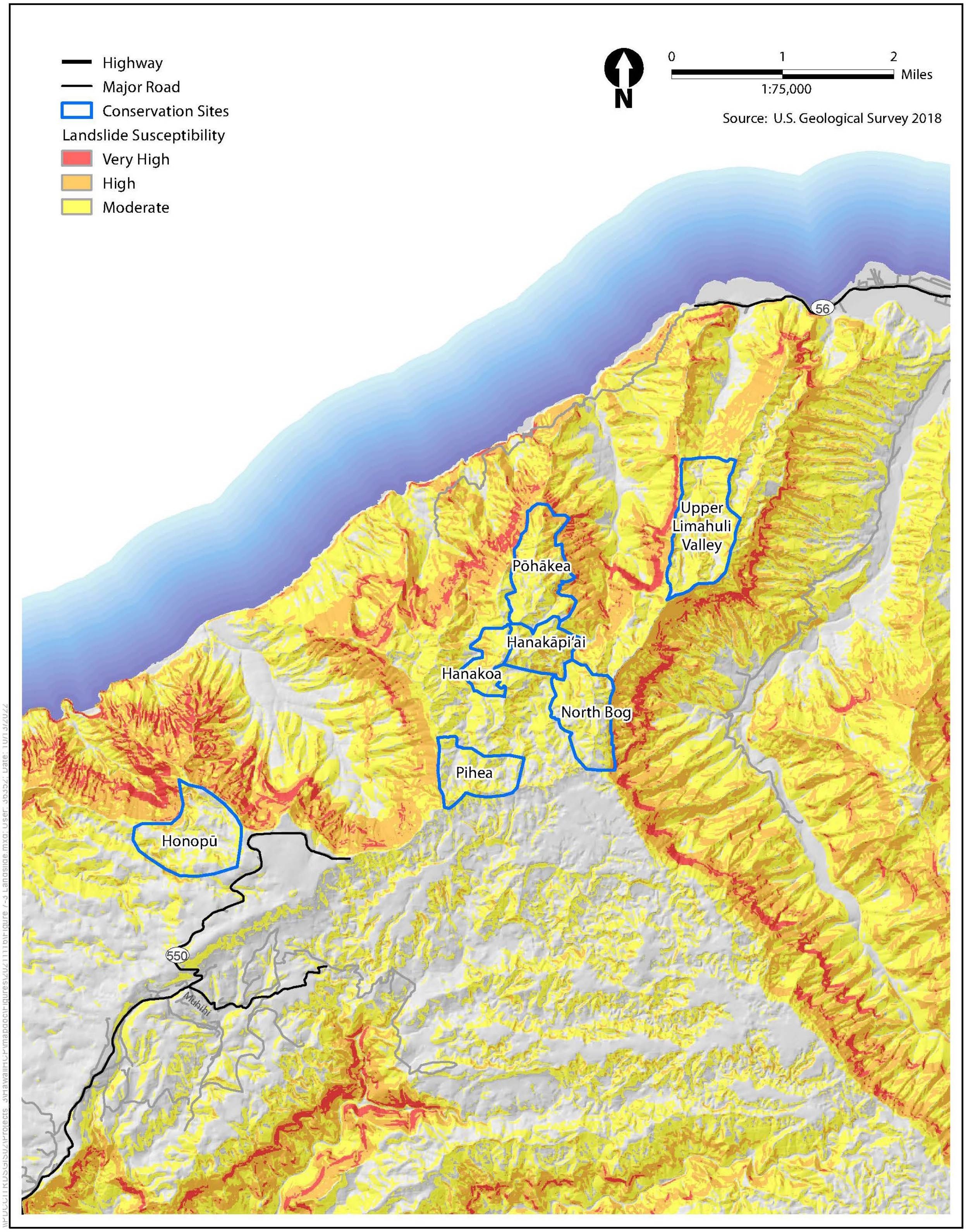


Figure 7-3. Landslide Susceptibility Map for the Conservation Sites

Sea Level Rise

Rising sea levels will both directly inundate areas near shorelines and cause low-lying areas to flood due to the upward displacement of shallow aquifers. Rising sea levels also increase the tendency of large waves to wash inland and flood areas with saltwater, making the soil unsuitable for many plants (Keener et al. 2018).

In addition to water pushing further inland during high tide events, event-based coastal flooding of low-lying areas arising from tropical storms, hurricanes, and tsunamis waves will also be exacerbated by sea level rise. In addition, El Niño and La Niña events affect wave action and model projections indicate changing future wave conditions that will vary in complex ways spatially, by season, and with shoreline exposure and orientation (Kenner et al. 2018).

With 3.2 feet of sea level rise, the level identified by the Hawaiʻi Climate Change Mitigation and Adaptation Commission (2017) as an end-of-century planning target, low-lying coastal areas around the island may become chronically flooded within the mid- to latter-half of this century. This land will become submerged by coastal erosion, direct marine flooding from tides and waves, or become new wetlands behind the shoreline from rising water tables and reduced drainage. Approximately 5,760 acres of land on Kauaʻi is estimated to be vulnerable to 3.2 feet of sea level rise. Some examples of areas that would be exposed to chronic flooding include Kēʻē Beach, Kīlauea, Polihale Beach, and Nāwiliwili Harbor. Seventy percent of Kauaʻi's beaches are subject to chronic erosion and Kauaʻi has lost almost 4 miles of beaches to erosion fronting seawalls and other shoreline armoring (Hawaiʻi Climate Change Mitigation and Adaptation Commission 2017). Nesting waterbirds, turtles and seals, and coastal plants in low-lying areas are expected to experience some of the most severe impacts of sea level rise (Keener et al. 2018).

Preventive Measures

Through implementation of the HCP conservation measures, KIUC will construct and maintain structures in the conservation sites to minimize risks from severe weather events. For example, strong fence construction at the conservation sites will minimize the risk of damage during storm events (Chapter 4, subsection *Predator Exclusion Fencing*, in Section 4.4.4.2, *Management Actions*). In addition, KIUC will proactively clear vegetation and trim trees along a buffer on either side of the fence to protect fences from falling vegetation in strong winds. Remote cameras along the fence line will serve as an early detection monitoring tool to detect fence damage or landslides immediately after storms. For green sea turtle (honu), volunteer monitors will remove shields during a storm to ensure that they are not blown away or damage nests and will visit all potentially suitable habitat on an annual basis to track changes over time (Chapter 4, Section 4.4.5.1*, Nest Detection*).

Changed Circumstance

Given the data regarding annual averages and frequency of occurrence presented in the *Risk Assessment* subsection, a threshold for each changed circumstance has been set for each type of severe weather (Table 7-1). These thresholds indicate the limit of what can be reasonably anticipated in terms of the frequency of occurrence over the 50-year HCP permit term given historical data and long-term trends. Based on the definitions of changed circumstance described above, KIUC would be responsible for remedial measures in the event of damage from severe weather that occurs at or below these frequency thresholds. If the number of occurrences during the permit term exceeds the changed circumstance threshold it becomes an unforeseen circumstance.

KIUC will notify USFWS and DOFAW within 30 days if a severe weather changed circumstance has occurred. Following the occurrence of a severe weather event, KIUC will evaluate the extent of the damage as it pertains to the conservation measures of this HCP, and the resulting impacts on the covered species based on the best available information at that time. Once the extent of the damage has been assessed, KIUC will identify and implement appropriate remedial measures as described below as soon as possible and will notify both agencies of their plans.

Remedial Measures

Damage from severe weather has the potential to be widespread across the island and may affect the success of conservation measures proposed by this HCP. The damage that could result from severe weather types may take various forms that are summarized in Table 7-2. Damages that may affect the success of HCP conservation measures will be remedied using the potential responses in Table 7-2.

Table 7-2. Potential Effects and Potential Responses from Severe Weather

Potential Effect on Covered Species	Potential Response
Damage to powerline minimization devices (e.g., diverters)	KIUC will conduct surveys to assess the damages that may have occurred to powerline minimization devices to determine if repairs/replacement are necessary. Damaged or missing diverters will be replaced; the timing of replacement will be driven by the level of damage and power outages, with first priority being given to restoring power. Power outages from severe weather are often associated with powerlines being down so the potential for take from downed lines is non-existent. Repair or replacement of minimization devices of like kind will be determined by KIUC without consultation. However, if KIUC cannot replace or repair the minimization devices with like kind or KIUC analysis indicates that replacement is not in the best interest of species (e.g., the timing of full replacement/repair), KIUC will consult with USFWS and DOFAW within 30 days to determine an alternative response.
Loss or destruction of entire predator exclusion fence	Should an entire fence be destroyed by severe weather, KIUC will take the following steps within 30 days of the severe weather event: (1) KIUC will analyze damage to the site and determine whether portions of colonies are remaining, whether or not suitable habitat remains, and whether or not fences are replaceable. (2) KIUC will present that analysis to USFWS and DOFAW. (3) KIUC will propose actions to maintain remaining colonies or suitable habitat where fence repair is feasible, and any adjustments needed to ensure HCP goals and objectives are not jeopardized. (4) KIUC will discuss proposed actions with USFWS and DOFAW to verify approach and establish a timeline for implementation.
Temporary loss of accessibility to conservation sites (e.g., damaged helicopters, landing pads, or roads)	KIUC will conduct surveys and confer with appropriate parties (e.g., helicopter operator, Hawai'i Department of Transportation) to determine the extent of access damages. KIUC would be responsible for clearing trails well enough to gain access to conservation sites and repair fences, weatherports, and landing zones. For other damage, KIUC will work with the appropriate party to determine a strategy and timeline for repair.

Potential Effect on Covered Species	Potential Response
Temporary destruction of a portion of a conservation site	Temporary damage to a conservation site (e.g., moderate landslide) will be assessed to determine the extent of damage and implement any remedial measures that can quickly restore some habitat value and speed up the natural recovery of the area (e.g., remove soil and vegetation blocking access to burrow areas).
Permanent destruction of a portion or all a conservation site.	If a portion of or an entire conservation site is permanently lost and unable to be reestablished to provide habitat value (e.g., massive landslide), KIUC will follow the same process as described above under "loss or destruction of entire predator exclusion fence".
Increased accessibility of predators within the conservation sites.	As soon as it is safe to do so following a storm, KIUC will conduct surveys within the conservation sites to determine if increased accessibility (e.g., vegetation removal, erosion) has resulted from storm damage. Depending on the type of damage, responses may include an increased trapping effort, replanting, and/or temporary fencing. KIUC will confer with USFWS and DOFAW to determine the appropriate response and timeline.
Potential escape of domestic animals that are known to depredate covered species (e.g., cats)	KIUC will continue to manage and monitor predators in the conservation sites and regional management sites. If monitoring in the period following severe weather indicates an increase in the presence of domestic animals, KIUC will increase their trapping effort in response to ensure that increased predation on the covered seabirds does not occur. KIUC will work with USFWS and DOFAW to ensure that the level of effort and response timeline is appropriate.
Destruction of green sea turtle (honu) nests	As soon as practically possible following a severe weather event that damages habitat containing active green sea turtle (honu) nests, KIUC monitors will visit the site to determine if any nests remain. KIUC's monitor will document the condition of any remaining eggs and consult with DOFAW, DAR, and USFWS, to determine if they are viable. If they are determined to be viable, KIUC will propose remedial actions on a case-by-case basis (e.g., re-instate KIUC's monitoring and temporary shielding program, collect the eggs for artificial incubation) and discuss proposed action(s) with USFWS, DAR, and DOFAW prior to implementation.
Loss of green sea turtle (honu) habitat due to sea level rise	KIUC will evaluate, in coordination with USFWS, DAR, and DOFAW, where green sea turtle (honu) habitat has been lost due to sea level rise through the HCP's annual nest monitoring program and will adjust the nest detection and temporary shielding program to focus on the remaining suitable habitat.

Given the frequency of widespread hurricane damage, which is expected to occur when hurricanes either make landfall or when their trajectory brings them into close proximity of the island (e.g., within 50 miles [80.5 km]) based on the extent and magnitude of destruction observed to result from all hurricanes passing within 150 miles [241.4 km] of Kauaʻi between 1950 and 2020, it is foreseeable that complete replacement of predator exclusion fence and other conservation infrastructure and equipment may be required up to twice during the permit term. One landfall is expected every 35 years and one close pass is expected every 35 years (see Table 7-1), which equates to the likelihood that two hurricanes with widespread damage will affect Kauaʻi at any point during the next 35 years, which encompasses a 50-year permit term. Minor repairs to infrastructure may be required in any areas that experience severe weather, and infrastructure required for full implementation of the conservation strategy should be inspected as soon as possible following such events.

Unforeseen Circumstance

For each severe weather type, frequencies exceeding the foreseeable frequency presented in Table 7-1 are not anticipated over the permit term of this HCP and are therefore considered unforeseen.

7.3.3.2 New Invasive Species

New invasive species can reasonably be anticipated to become established within the Plan Area over the course of the 50-year permit term. There are many invasive plant and animal species that are already established on Kauaʻi that are known to be significant threats to the covered species, as described in Chapter 3, *Environmental Setting,* and addressed in the conservation strategy for the covered seabird species, as described in Chapter 4, *Conservation Strategy*. In particular, conservation measures for the covered seabirds include monitoring and evaluation of conservation sites for invasive plants and feral honeybees and these monitoring efforts will facilitate detection of additional harmful invasive species if they become established at or near these conservation sites. There is potential that new invasive species, especially those that occur on the other Hawaiian Islands, could become established on Kauaʻi.

Risk Assessment

Invasive species can harm the covered seabirds, covered waterbirds, and possibly green sea turtles (honu). Both lethal and sublethal effects may occur through various pathways—predation (mammals, birds, reptiles), micro-predation (insects), spread of novel pathogens (mammals, insects), and habitat loss (plants). Based on observations from Kauaʻi, other Hawaiian Islands, and Micronesia, it is possible that additional predators that affect covered species, particularly ground-nesting seabirds, could become established on Kauaʻi during the permit term. Specific species of concern include mongoose (*Herpestes javanicus*), brown tree snake (*Boiga irregularus*), and yellow crazy ants (*Anopolepis gracilipes*), all of which may be accidentally introduced to Kauaʻi during the 50-year permit term. Each of these species is described in the following subsections and assessed for their potential threats to the covered species. Other unidentified species of rodents, insects, or plants could also be accidentally introduced over the next 50 years.

The threat of new invasive species is heightened by the challenge of maintaining biosecurity on imports into the Hawaiian Islands (State of Hawaiʻi Division of Forestry and Wildlife 2020). In addition to the specific species discussed below, introductions of other invasive insects, fungus, nematodes, mites, and other plant pests that may adversely affect the covered seabirds, waterbirds, and green sea turtles (honu) are possible.

The KIUC HCP conservation strategy does not require habitat management, including invasive species control, as part of the mitigation for the covered waterbirds or green sea turtle (honu). Habitat management is not required to meet the HCP's biological goal for waterbirds (Chapter 4, *Conservation Strategy*, Goal 4) or green sea turtle (honu) (Goal 5). Actions that facilitate the detection of invasive species in habitats utilized by the covered waterbirds are not planned. As such, invasive species control is beyond the scope of this HCP for covered waterbirds and green sea turtle (honu) and is not required to be addressed by KIUC during the 50-year permit term. These covered species are not discussed further in this section.

Mongoose

Mongoose were brought to the Hawaiian Islands in 1883 to control rats and are known to be established on Hawai'i, O'ahu, Maui, and Moloka'i (Duffy et al. 2015). Mongoose presence has already been documented on Kaua'i; in 1976 a roadkill lactating female was found (Tomich 1986) and three additional individuals were trapped near Līhu'e—two in 2012, one in 2016 (Kaua'i Invasive Species Committee 2021). Despite these rare and intermittent detections of mongoose on Kaua'i, research and trapping efforts to date have yet to confirm an established population (Duffy et al. 2015; Kaua'i Invasive Species Committee 2021).

Mongoose are opportunistic feeders with a varied diet that includes birds, small mammals, reptiles, insects, fruits, and plants; on other Hawaiian Islands, they are known to prey on the eggs and hatchlings of native ground-nesting birds. If mongoose become established, they may depredate seabirds, including the eggs and young. Given what has occurred on other Hawaiian Islands, establishment of mongoose may result in population reductions of the covered seabirds potentially affecting the success of conservation actions proposed for this HCP.

Brown Tree Snake

Brown tree snakes were accidentally introduced to Guam around 1952 and rapidly extirpated most of the native forest vertebrate species, including birds and reptiles (Fritts et al. 2005). Brown tree snakes can depredate seabirds. Because Guam is a major transportation hub in the Pacific, numerous opportunities exist for the brown tree snakes on Guam to be introduced accidentally to other Pacific Islands as passive stowaways on ship and air traffic. Although they are not thought to be present on the Hawaiian Islands, a total of eight brown tree snakes were found in Hawai'i between 1981 and 1998. All snakes were associated with the movement of civilian and military vehicles or cargo from Guam. Special searches are now conducted on any cargo or crafts leaving Guam and entering Hawai'i to minimize the risk of introduction (Hawaiian Invasive Species Council 2021).

Brown tree snakes are primarily arboreal predators that consume many types of small vertebrates (i.e., lizards, birds, and mammals) as well as eggs of an appropriate size, and can eat up to 70 percent of their body weight per day. There are no snakes native to the Hawaiian Islands, so this ecosystem lacks predators that specialize on snakes and the native species have not evolved to defend against snake depredation. Given what has occurred in Guam, the introduction of brown tree snakes to the Hawaiian ecosystem could be potentially devastating in general, but it is unclear to what degree these snakes would affect covered species. Brown tree snakes are primarily arboreal and they target small, tree-nesting forest birds. That said, brown tree snakes have been found on the ground in logs and crevasses, so it is possible that they may encounter and learn to predate the nests and chicks of the covered seabirds and waterbirds in and around forested habitats. If this were to occur, establishment may result in the reductions of covered populations of seabirds and waterbirds, which could affect the success of conservation actions proposed for this HCP.

Yellow Crazy Ant

Yellow crazy ants are originally from Southeast Asia and have been repeatedly transported to various locations throughout the world's tropics by human-assisted dispersal in shipping containers and freight (Queensland Government 2016), including the Hawaiian Islands. They prey on invertebrates and vertebrates, blinding prey by spraying formic acid. In large numbers, they are capable of preying upon relatively large animals (Queensland Government 2016). At Johnston Atoll

NWR these ants nearly extirpated the red-tailed tropicbird (*Phaethon rubricauda*) colony in just a few years. Intensive ant eradication measures were implemented there to eradicate the ants from the atoll (Romo 2021). Based on research grade observations submitted to iNaturalist by citizens, yellow crazy ants have been documented on the Big Island, Oʻahu, Maui, and Kauaʻi. With respect to Kauaʻi, there are 13 research-grade observations of this ant, with the first observations reported in 2015, with an average of two additional observations per year since 2015 (iNaturalist 2021; Global Biodiversity Information Facility 2021). These observations are distributed across the Plan Area, with five from the southeast region, five from the eastern region, and three from the northern region. The northern observations were all located in the vicinity of Kalalau Trail, which leads into the Nā Pali Coast State Wilderness Park, where the majority of covered seabirds nest.

Yellow crazy ants prefer moist lowland forests but can inhabit a diversity of habitats. Where they have been introduced, they can form large-scale super-colonies that extend more than 247 acres (100 hectares) and reach densities of more than 2,000 foraging ants per meter squared. Their impacts vary considerably from site to site and can take decades to manifest (as on Christmas Island) but, in places where yellow crazy ants flourish, not much else does; they decimate insect population and can kill various small animals including seabirds, lizards, crabs, and other sympatric species. Given what has occurred on other islands, including the Hawaiian Islands, establishment of yellow crazy ants in the Plan Area may result in population reductions of the covered seabirds, waterbirds, and green sea turtle (honu), potentially affecting the success of conservation actions proposed for this HCP.

Invasive Plant Species

Highly invasive plant species that currently do not occur or occur in limited distribution on Kauaʻi have the potential to affect the covered seabird burrow habitat or access to their burrows. They can also alter the suitability of covered species habitat by displace native plant species, resulting in habitat loss or degradation from increased erosion and siltation due to shallow root systems, dense vegetation structure limiting burrow density, and loss or alteration of understory vegetation.

Preventive Measures

In the case of introduction of a new mammalian predator (e.g., mongoose), the predator exclusion fencing would prevent access to the social attraction sites for the covered seabirds. In areas where predator exclusion fencing is absent, the high frequency of management and monitoring actions in the seabird conservation sites, including predator control and burrow monitoring (see Chapter 4, Section 4.4.4 and Chapter 6, Section 6.3.4) should be sufficient to allow for early detection of any new invasive species affecting the covered seabirds at the conservation sites.

Similarly, KIUC will monitor the threat posed by new invasive plants in the conservation sites incidentally as other management and monitoring actions are implemented during the seabird breeding season. KIUC will act quickly to remove new invasive plant species that pose a high risk to the covered seabirds. KIUC field staff will continue to implement best management practices to minimize transportation of invasive plants or their seeds into conservation sites (Appendix 4C, *Invasive Plant Species Control Methods*). KIUC will follow the principles of early detection rapid response to ensure that new invasive plants are controlled before they become a problem. KIUC will implement early detection rapid response actions consistent with the current recommended protocols of the Hawaiian Invasive Species Council Prevention/Early Detection Rapid Response Working Group (https://dlnr.hawaii.gov/hisc/meetings/wg/prevention/).

Changed Circumstance

Because mongoose and yellow crazy ants have both been observed on Kauaʻi numerous times over the previous 30 years, it is foreseeable that these species may become established over the next 50 years of the permit term. While less likely, brown tree snakes may also be accidentally introduced and, if so, the effects could be devastating to the covered bird species. Occurrence of any new invasive plant or animal species affecting the success of the conservation strategy for the covered seabirds will be treated as a changed circumstances for this HCP.

KIUC will notify USFWS and DOFAW within 30 days if a new invasive species changed circumstance has occurred. Following this determination KIUC will evaluate the effects and resulting impacts of the new invasive species on the covered species based on the best available information at that time. Once the impacts have been assessed, KIUC will notify both agencies of their plans to implement remedial measures as described below.

Remedial Measures

For conservation sites without predator exclusion fencing, any newly introduced mammalian species will be detected through trapping and camera monitoring. KIUC will consult with USFWS and DOFAW to ensure that the protocols in place are sufficient to control the new mammalian species and will adjust their control techniques as necessary if they are determined to be insufficient. In some cases, this may require new trapping techniques, new equipment, or increased trapping effort.

In addition, if any other types of invasive species are introduced on Kauaʻi (e.g., insects, amphibians, reptiles, fungus, non-native plants), KIUC will employ the following process to identify remedial measures.

1. Evaluate whether the new invasive species has the potential to affect the success of KIUC's conservation measures for the covered seabirds or green sea turtles (honu). This includes review of relevant data collected through the HCP's management and monitoring actions and consultation with USFWS, DOFAW, Hawaiian Invasive Species Council for invasive plants, and species experts. No remedial actions are required if it is determined that the new invasive species is not likely to adversely affect the HCP's conservation measures.
2. If it is determined that the new invasive species is likely to adversely affect the HCP's conservation measures, KIUC will review its existing management and monitoring actions to determine if, as they are currently being implemented, they are sufficient to address the new invasive species.
3. If the HCP's existing management and monitoring actions are determined not to be sufficient to control the new invasive species, KIUC will evaluate whether the existing actions can be adjusted to address the new invasive species.
4. If none of these options are possible, KIUC will propose a new strategy of control specific to the new invasive species, and obtain concurrence from USFWS, DOFAW, and species experts in partnership with other conservation entities on Kauaʻi prior to implementation.

Unforeseen Circumstance

With respect to the covered seabirds and invasive species, there are no unforeseen circumstances. This means that KIUC will evaluate all newly introduced invasive species in the conservation sites to determine if they have the potential to affect the covered seabirds.

7.3.3.3 Disease Outbreak in the Covered Species

Hawaiian endemic species evolved in the absence of various pathogens that have been transported to the islands over the last century because of globalization. Therefore, the exposure of naïve immune systems to novel diseases may have played an important role in the decline of Hawaiian endemic species (e.g., mosquito-borne malaria and Hawaiian honeycreepers; van Ripper et al. 1986; Freed et al. 2005).

Risk Assessment

Disease has not been cited as having long-term population-level impacts on any covered seabirds (Raine et al. 2017), waterbirds (Reed et al. 2011; Underwood et al. 2013; U.S. Fish and Wildlife Service 2021), or sea turtles (Chaloupka et al. 2008; Seminoff et al. 2014). That said, the covered species are all susceptible to various forms of disease and there is potential for disease outbreaks.

With respect to the covered seabirds, Newell's shearwater ('a'o) (*Puffinus auricularis newelli*) fledglings have been found with mild symptoms of mosquito-borne diseases, specifically avian pox (Ainley et al. 2020) and avian malaria (Warner 1968; Raine et al. 2017) but there have been no reports of lethal disease outbreaks in covered seabirds on Kaua'i. Based on studies to date, otherwise healthy seabirds seem to be more resilient to the impacts of avian pox (Young and VanderWerf 2008) and malaria (Quillfeldt et al. 2011) relative to other types of birds.

Avian botulism, a paralytic disease caused by ingestion of a toxin produced by the bacterium *Clostridium botulinum*, is the most significant disease of migratory birds worldwide, especially waterfowl and shorebirds (Rocke and Bollinger 2007). Avian botulism is a chronic issue at the Hanalei NWR since a November/December 2011 epizootic killed hundreds of endangered waterbirds (U.S. Fish and Wildlife Service 2021). Between 2011 and 2018, there were 1,342 cases of avian botulism recorded on the Hanalei NWR (Reynolds et al. 2019). In 2019, the total number of sick and dead native birds affected by avian botulism was 157, with 90 percent of these birds affected between July and December. In 2020, an additional 165 native birds were affected raising the total to 1,664 suspected botulism cases (U.S. Fish and Wildlife Service 2021). These botulism outbreaks have killed individuals of all the covered waterbird species and have been particularly detrimental to the endangered Hawaiian duck (koloa maoli) (*Anas wyvilliana*), which represents 62 percent of birds affected (Reynolds et al. 2019). On Kaua'i, these outbreaks can occur year-round due to lack of seasonal variability in temperatures. An avian botulism task force has been formed and monitoring of birds and water quality has been undertaken to better understand the drivers of the outbreaks in the system (U.S. Fish and Wildlife Service 2021).

Covered sea turtles have primarily been afflicted with a tumor-forming disease called fibropapillomatosis (Chaloupka et al. 2008; Jones et al. 2016). Although this disease is of major concern in some green sea turtle (honu) populations, there is photographic evidence that tumors may spontaneously regress, or increase in size and/or number to the point of debilitation (Herbst 1994; Hirama 2001; Hirama and Ehrhart 2007). The primary impact of fibropapillomatosis is the decrease in ability of sea turtles to forage for food, swim, and avoid predation, affecting the overall survival of affected turtles (Work et al. 2004). Although the primary cause of fibropapillomatosis is unknown (see Blackburn et al. 2021), experts suspect that a herpes virus is the causal agent (Lackovich et al. 1999; Jones et al. 2020). This is reminiscent of human cancers with known viral origins, which, together with other environmental and anthropogenic pressures, have contributed to increases in fibropapillomatosis prevalence (reviewed in Jones et al. 2016). There also is currently no cure (see Blackburn et al. 2021). For sea turtles debilitated by fibropapillomatosis, the current standard of care has been and continues to be preoperative screening to confirm that internal tumors are absent, due to their poor prognosis, followed by surgical excision of external tumors. However, postoperative regrowth is seen in 50 percent of treated turtles and the rehabilitation survival rate of fibropapillomatosis-affected turtles is low (25 percent) (Page-Karjian et al. 2020).

Preventive Measures

Actions to proactively avoid or minimize the impacts of disease outbreaks in the covered species are not planned. The primary preventive measure is monitoring disease outbreaks that are occurring or could occur in birds that are brought into the SOS Program. In addition, KIUC's colony monitoring program would document general deteriorations in health, if observed, while monitoring reproductive success.

Changed Circumstance

One or more of the covered species may be affected by a disease outbreak during the 50-year permit term; therefore, this is considered a changed circumstance. Based on the minor impact disease has had on the long-term population trends of the covered seabirds, covered waterbirds, and green sea turtles (honu), it is foreseeable that disease outbreaks over the next 50 years are expected to be relatively rare and/or inconsequential to the long-term population viability of covered species.

Remedial Measures

In the event of a foreseeable disease outbreak among the covered seabirds or waterbirds, KIUC would cooperate with DOFAW and USFWS and commit to finding a solution within the HCP budget described in this chapter. For example, vaccines could be deployed by the SOS Program consistent with the HCP's estimated budget. The SOS Program will be the likely first line of detection and vaccination for the covered seabirds and covered waterbirds.

There are no remedial measures included in this HCP for disease outbreak for green sea turtle (honu), as fibropapillomatosis is not well understood and there is currently no reasonable remedy (National Oceanic and Atmospheric Administration and U.S. Fish and Wildlife Service 1998; National Oceanic and Atmospheric Administration 2021b). If a remedy for fibropapillomatosis becomes available and the disease outbreak among green sea turtles (honu) directly interferes with the success of biological goal and objectives set forth in this HCP for green sea turtle (honu), KIUC would cooperate with DOFAW and USFWS and commit to finding a solution within the HCP budget described in this chapter.

7.3.3.4 Vandalism

Vandalism is any action involving deliberate destruction of or damage to public or private property. Vandalism can reasonably be anticipated to affect infrastructure associated with Conservation Measure 4 (see Chapter 4, Section 4.4.4, *Conservation Measure 4. Manage and Enhance Seabird Breeding Habitat and Colonies at Conservation Sites*) and Conservation Measure 5 (see Chapter 4, Section 4.4.5, *Conservation Measure 5. Implement a Green Sea Turtle Nest Detection and Temporary Shielding Program*).

Risk Assessment

Over the course of the 50-year permit term, the predator exclusion fence, predator control equipment, social attraction equipment, and wildlife monitoring equipment may be subject to vandalism. It is also possible that the light-proof shields and associated signage for green sea turtle (honu) may be vandalized.

Based on long-term, ongoing predator control and seabird monitoring efforts at the conservation sites associated with this HCP, vandalism is expected to be minimal and infrequent. Over an 8-year period (2012–2020), only one instance of vandalism was reported. In that one instance in 2012, the total cost of damages was estimated to be $1,000[6] (Raine and McFarland 2013; Zito 2013). Details in Zito (2013) indicate that this vandalism was rapidly detected by field crews, with less than 1 week elapsing between vandalism and detection. Importantly, this vandalism occurred at Pihea, which is the easiest conservation site for tourists and locals to access, as this site is in close proximity to the popular Pihea Overlook along the Pihea Trail at Kōkeʻe State Park.

Vandalism of the light-proof fences for green sea turtle (honu) may occur regularly because it has historically occurred on both Kauaʻi and Oʻahu (Jenkins pers. comm.). Vandalism could occur either through individuals dismantling the fences or vehicles driving on the beach running over the structures and the turtle nesting site.

Preventive Measures

Vandalism at active conservation sites has been very rare and has only been reported once since 2012. Further control of vandalism at the conservation sites is difficult because these sites are generally on state lands and/or are in very remote areas where access by field crews is limited to certain times of year. However, certain actions have been implemented following this vandalism event in 2012 that may have hindered subsequent vandalism events, specifically: (1) following the initial occurrence of vandalism at Pihea, ungulate fencing was installed that clearly indicates the end of Pihea Trail and that public access was prohibited; (2) seabird surveillance equipment and mounting gear were camouflaged to minimize visibility to potential vandals; and (3) as cellphone-enabled video and audio surveillance devices have become more affordable, common, and discreet through time, this may deter vandalism due to the potential of being caught on surveillance. Beyond these actions, the primary measure to control impacts from vandalism is to proactively assess the likelihood of occurrence and the expected impacts over the permit term. That way, remedial measures have already been identified and can be swiftly implemented.

With regard to green sea turtle (honu), there are no actions that can prevent vandalism of the light-proof fences. Monitors will be present at the nest site more frequently closer to the estimated time of nest hatching, which helps to reduce vandalism.

[6] The following items were either stolen or damaged beyond repair: one game camera, four cat traps, two water containers, and two tarps.

Changed Circumstance

Based on long-term, ongoing predator control and seabird monitoring efforts at conservation sites associated with this HCP, vandalism is expected to be infrequent and minimal. Only one vandalism event was reported between 2012 and 2020, and the damages were estimated at $1,000. As described earlier, vandalism has been restricted to the most accessible conservation site, Pihea, and occurred before ungulate fencing was installed, which serves to delineate a clear boundary between Kōkeʻe State Park and Hono O Nā Pali Natural Area Reserve. One other conservation site, North Bog, is also in proximity to the popular Alakaʻi Swamp Trail in Kōkeʻe State Park and may be similarly vulnerable to vandalism. For these relatively accessible sites, based on historical rates of vandalism, it is foreseeable to anticipate a maximum of one event of vandalism every 10 years costing approximately $1,000 per event. When vandalism does occur, it is expected to be limited and localized in scope, resulting in relatively minimal damage. Thus, over the HCP permit term, three events of vandalism or any number of events that do not exceed $3,000 is considered foreseeable.

The remainder of conservation sites are in very remote areas of the island that require helicopter access for all but the most intrepid explorers; acts of vandalism have not been documented here to date and are not expected to occur in the future.

However, due to the very accessible and public nature of the location of the green sea turtle (honu) nests and the light-proof fences, it is reasonable to expect that vandalism will regularly occur. Any instance of vandalism of light-proof fences will be considered a changed circumstance and therefore require replacement.

Remedial Measures

In the event of vandalism at conservation sites, KIUC needs the ability to respond quickly and effectively (especially in cases where predator exclusion or ungulate exclusion fencing is damaged). KIUC will assess the situation to determine the appropriate remedial measure and implement then repair as quickly as possible.

Given the low frequency of expected vandalism at the conservation sites (as described under *Risk Assessment* above), it is expected that regular predator fence monitoring already included in HCP (Chapter 6, *Monitoring and Adaptive Management Program*) will facilitate timely detection and repair of breaches in the fence lines. Predator control and seabird surveillance equipment would also be checked frequently enough to facilitate timely detection of vandalism. In the case of equipment damage or theft, full replacement will occur.

Similarly, it is expected that daily and sometimes twice daily monitoring of the green sea turtle (honu) nests prior to hatching will help reduce vandalism of the light-proof fences. However, as described above, when monitors are not present, vandalism incidents may occur. KIUC will fund the repair of all instances of vandalism of light-proof fences to stay within requested take limits for this species and full the conservation objective.

In the event of serious or repeated vandalism, law enforcement may need to be engaged to address these events. In the case of the light-proof fences on beaches, if repeated vandalism occurs, KIUC will confer with DOFAW, DAR, and USFWS to design and implement a solution.

7.3.3.5 Population Declines due to Issues at Sea

Risk Assessment

Globally, seabird populations have been in decline due to multiple threats throughout their range including the covered seabird species. Numerous researchers have identified threats originating at sea that include climate change (especially effects on the distribution of prey species and temperature-mediated changes in ocean chemistry that cause the waters to become more acidic), commercial fisheries (through competition for prey), and ocean pollution (oil spills) (see Croxall et al. 2012 and Díaz et al. 2019). Sea surface temperatures and ocean pH, an indicator of acidity, are now beyond levels seen in the instrument record (Kenner et al. 2018).

For this HCP, KIUC's seabird conservation measures are focused on improving the extent, breeding suitability, and numbers of terrestrial nesting areas. At every conservation site there will be a substantial reduction in land-based predation hazards that affect all seabird individuals, including those transiting between land-based nesting habitats and at-sea foraging grounds. Given the multitude of potential threats to the covered seabirds at sea, in addition to threats being explicitly addressed on land by KIUC, there is a real risk that the efficacy of the proposed conservation strategy could be undermined by ongoing and emerging circumstances that threaten the wellbeing of covered seabirds while they are at sea.

Preventive Measures

While KIUC is actively implementing actions that address terrestrial threats to covered seabirds (e.g., predation, powerline collisions, light attraction), implementing actions that prevent or minimize effects of climate change, commercial fisheries, or ocean pollution is beyond the control of KIUC or this HCP.

Changed Circumstance

Based on current observations and future predictions about changes to the marine system, as summarized above, it is foreseeable that threats to the covered seabirds at sea over the 50-year permit term will increase in extent and severity. However, there is great uncertainty in the timeframe, magnitude, and extent of how covered seabirds will be affected by potential at-sea threats. Thus, setting exact thresholds to define what is expected over the next 50 years (necessary to distinguish between changes that can be reasonably anticipated from changes that are unforeseeable), is not possible at this time.

Instead, the trigger for this changed circumstance will be based on reproductive success across all conservation sites combined dropping below a 5-year rolling average of 87.2 percent for Newell's shearwater ('a'o) or 78.7 percent reproductive success for Hawaiian petrel ('ua'u) and that may be due to declines in at-sea conditions. The word "may" is used deliberately because available data is unlikely to be available to identify a specific cause at sea. However, if causes on land for the decline can be eliminated (e.g., predation, disease, or other factors), then undetermined at-sea causes are a likely culprit. KIUC will coordinate with other HCPs on Kaua'i such as the Kaua'i Seabird HCP and other conservation projects for the same species[7] to consult with species experts, USFWS, and

[7] Other Kaua'i HCPs have or are likely to have similar provisions for a changed circumstance from changes in at-sea conditions. Furthermore, any conservation projects on Kaua'i are likely to be affected by adverse changes in at-sea conditions. Therefore, a coordinated determination and response is likely warranted.

DOFAW to determine if the reduction in reproductive success is likely due to declines in at-sea conditions.

Remedial Measures

While KIUC has no control over events at sea, impacts on seabirds may change the ability of KIUC to offset take, provide a net benefit, and meet HCP biological objectives. KIUC will track the latest research regarding ongoing and new impacts occurring at sea that could potentially cause covered seabird populations to decline. Issues particularly of concern, as summarized above, are population declines resulting from the detrimental effects of marine heat waves and ocean acidification on covered seabirds. However, other issues may arise at sea that could cause declines in covered seabird populations from causes not currently identified.

If the changed circumstance has been determined to occur and more severe at-sea threats are likely to preclude achievement of the biological goals and objectives at the conservation sites for any of the covered seabirds, KIUC will notify USFWS and DOFAW and meet and confer to discuss the addition of one new conservation site that prioritizes the protection of occupied Newell's shearwater (ʻaʻo) burrows, if it is not possible to obtain landowner approval for a location that contains both occupied Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu), if possible. This new conservation site will be managed using predator control but will not include a predator exclusion fence nor a social attraction site. No other remedial actions will be taken beyond the requirement to add one additional conservation site.

7.4 Costs of KIUC HCP Implementation

The cost to implement the KIUC HCP is shown in Table 7-3. Estimating the full costs of the KIUC HCP was an essential step to demonstrate adequate funding to meet regulatory standards. To provide enough funding, all costs associated with the HCP had to be identified. Costs for the KIUC HCP are divided into the following cost categories and summarized in this section.

- Plan Administration
- Powerline Collisions Minimization
- Save our Shearwaters Program
- Manage and Enhance Conservation Sites
- Green Sea Turtle (Honu) Nest Detection and Temporary Shielding Program
- Infrastructure Monitoring and Minimization Program (IMMP; formerly called the Underline Monitoring Program)
- Seabird Colony Monitoring
- Adaptive Management
- Changed Circumstances
- Contingency

These costs are identified for planning purposes only to estimate funding levels needed to implement the KIUC HCP. KIUC will fund the full implementation of the HCP. KIUC is a not-for-profit electric utility governed by a nine-member board and regulated by the Hawai'i Public Utilities Commission (PUC). The KIUC Board will be responsible for reviewing and approving the HCP and the associated funding required to fully implement the HCP each year. Costs associated with the HCP are considered operational costs because they are necessary to KIUC continuing to provide electrical services to Kaua'i. Therefore, the cost of the HCP is considered part of KIUC's overall operating costs paid for by member electric rates. The KIUC Board also reviews and approves Annual Work Plans and associated annual budgets, as part of their annual operational workplan and budget review process.

Table 7-3. Summary of Cost to Implement KIUC HCP

Cost categories	Early HCP implementation cost (2020–2022)	2023	2024	Avg. annual HCP cost (2025–2073)	50-year total HCP cost (2023–2073)	Percentage of 50-year total HCP cost
Plan Administration	N/A	$452,500	$412,500	$412,500	$20,665,000	7.8%
Powerline Collisions Minimization	$19,757,870	$3,885,544	$363,141	$390,791	$23,006,640	8.7%
Save Our Shearwaters Program	$744,344	$300,000	$300,000	$300,000	$15,000,000	5.7%
Manage and Enhance Conservation Sites	$9,015,764	$3,576,627	$3,196,868	$1,538,202	$80,607,204	30.4%
Green Sea Turtle Nest Detection and Temporary Shielding Program	N/A	$158,900	$96,400	$103,119	$5,205,000	2.0%
Infrastructure Monitoring and Minimization Program	$2,746,125	$539,911	$539,911	$539,911	$26,995,544	10.2%
Seabird Colony Monitoring Program	$2,347,023	$952,993	$952,993	$952,993	$47,649,648	18.0%
State Compliance Monitoring	N/A	$50,000	$50,000	$50,000	$2,500,000	0.9%
Changed Circumstances	N/A	$572,934	$572,934	$572,934	$28,646,679	10.8%
Adaptive Management		$394,862	$294,183	$253,744	$12,868,745	4.9%
Contingency	N/A	$145,813	$145,813	$30,378	$1,749,762	0.6%
Total	**$34,611,125**	**$11,030,084**	**$6,924,744**	**$5,144,571**	**$264,894,222**	**100.0%**

7.4.1 Cost Estimate Methodology

To estimate HCP costs, KIUC developed a cost model to identify specific costs in each major cost categories listed above. All potential costs were identified that are expected to be needed to fulfill the requirements of the HCP. The cost model (Appendix 7A, *KIUC HCP Cost Model*) was designed to demonstrate that all HCP-related costs are accounted for and reasonably estimated. The goal of the cost model was to conservatively estimate expenses of KIUC over the permit term so that overall costs are accounted for and understood. During plan implementation, KIUC will update the cost model as needed and as cost assumptions are refined based on actual experience to assist with long-term HCP budget planning.

Model assumptions are summarized in the following sections by cost category. It is assumed that all cost components will increase over time due to inflation. To simplify the presentation, all costs are expressed in current 2021 dollars, allowing comparisons between costs today and costs later in the permit term. KIUC will pay all costs associated with HCP implementation, including inflation, even if those costs are above the costs estimated in Appendix 7A, *KIUC HCP Cost Model*. Average annual costs are based on plan implementation from 2025 to 2073, given that the first 2 years of plan implementation (2023 and 2024) are outlier years associated with the higher on-time costs for installation of powerline minimization and predator exclusion fencing.

Most of the costs in the cost model were based on actual costs to conduct the same or similar action, given that KIUC has been implementing or funding all of the programs in Table 7-3 except for the green sea turtle (honu) nest detection and temporary shielding program. In the case of the management and monitoring of covered seabirds, cost estimates were based on actual costs to date and scaled to new conservation sites. Costs for actions that were not implemented by KIUC during the Short-Term HCP or early implementation of the KIUC HCP (e.g., green sea turtle [honu]) were based on estimates from technical experts and costs incurred by other agencies. Costs for plan administration were estimated by KIUC based on the current costs.

Details of each cost category and the key assumptions that were used to develop the HCP cost estimate are described below. See the cost model in Appendix 7A, *KIUC HCP Cost Model*, for an accounting of all assumptions.

7.4.2 Plan Administration

Plan administration costs are the costs to support staffing, legal defense, and database administration needed by KIUC to carry out the HCP requirements. Plan administration costs are estimated to be $412,500 annually, for a total of $20.6 million over the 50-year permit term (Table 7-4). Costs for plan administration are assumed to be stable throughout the permit term except in the first year. Costs are slightly higher in 2023 ($452,500) due to the need to prepare the first annual report. Once the first annual report is prepared, annual reporting costs are expected to be lower.

Table 7-4. Plan Administration Costs

Program Element	**Estimated Annual Costs**
Plan management staff	$385,000
Legal support	$25,000
Software license fees	$2,500
Total	**412,500**
*Annual report template**	*$40,000*

The cost to establish the annual report template and author the first annual report in Year 1 of HCP implementation is based on the work being contracted to consultants and expected to cost $40,000 dollars. After the first annual report is completed and the template and content are established, the cost estimate assumes that KIUC will prepare the annual report between Years 2 to 50 of the permit term. As such, costs for preparation of the annual report after Year 1 are subsumed under Plan Management Staff.

Staffing constitutes most of the plan administration cost (Table 7-4). Costs for staffing assumes that the KIUC HCP will be implemented by a team of up to three professionals—Program Manager, Data Analyst/GIS Specialist, and Accountant/Budget Analyst (although one person may do two these tasks or all three). It is assumed that the Program Manager will function both as an organizational leader and as a public presence of the implementation effort. For the purposes of the cost estimate, data management and analysis, including GIS work, were based on the work being contracted to consultants.

KIUC may require legal assistance during implementation. For example, legal resources may be needed to draft and review HCP documents or assist with landowner disputes if they occur. Legal costs are based on the billing rate for legal contractors and the estimated time on an annual basis.

7.4.3 Powerline Collisions Minimization

Conservation Measure 1 in Chapter 4, Section 4.4.1, *Conservation Measure 1. Implement Powerline Collision Minimization Projects*, requires KIUC to reduce covered seabird and covered waterbird collisions throughout its powerline system.

In 2020, KIUC began implementing its powerline collision minimization projects. The cost model identifies costs for early implementation of powerline minimization projects to "Plan Year 0" to recognize investments made to reduce take prior to ITP and State ITL issuance. Costs of both completed and planned minimization projects are estimated by applying the average costs per span reported by KIUC to the number of spans for which future minimization projects are anticipated. Between 2020 and 2022, the cost to implement KIUC's powerline minimization projects during early implementation of the HCP exceeded $19 million.

Costs that will be incurred during the 50-year permit term related to implementation of Conservation Measure 1 total $23 million, and an annual average of $363,141 per year. This cost is lower than the early implementation cost given that the cost estimate assumes that only one additional year (2023) is necessary to implement the remaining powerline collision minimization projects. Costs after 2023 are limited to installation of new reflective diverters on new or extended powerlines[8] and replacement of LED and reflective diverters on existing and new powerlines.[9] KIUC assumed a constant rate of diverter installation given that the schedule and location for installation of KIUC's new and extended powerlines is currently unknown. Therefore, the cost estimate assumes an average installation rate of diverters of seven spans per year.

7.4.4 Save our Shearwaters Program

Conservation Measure 3 in Chapter 4, Section 4.4.3, *Conservation Measure 3. Provide Funding for the Save Our Shearwaters Program*, requires KIUC to provide funding to the SOS Program. KIUC has been funding the SOS Program since 2003 and will continue to fund the program with a contribution of $300,000 per year over the 50-year permit term. As shown in Table 7-5, this amount is, on average, approximately $50,000 above KIUC's annual funding contribution over the last 10 years. This amount has proven adequate to operate a functional SOS Program over that time. As such, $300,000 is an appropriate level of funding over the 50-year permit term.

KIUC's funding will address the rehabilitation of the covered seabird and waterbird species, as well as ensure the SOS Program remains functional (e.g., enough funding to cover staff time and materials) over the life of the permit term. This funding amount will increase on an annual basis during the permit term in accordance with an accepted inflation rate index (such as the Consumer Price Index) for the nearest urban area to ensure a consistent funding stream.

7.4.5 Manage and Enhance Conservation Sites

Conservation Measure 4 in Chapter 4, Section 4.4.4, *Conservation Measure 4. Manage and Enhance Seabird Breeding Habitat and Colonies at Conservation Sites*, requires KIUC to manage and enhance covered seabird breeding habitat in all the conservation sites. The costs estimate includes costs related to the following.

- Contractor staff time and training.
- Helicopter leasing and other transportation cost.
- Fencing installation, maintenance, and repair.
- Predator eradication equipment, materials, and contractor time.
- Predator control equipment (e.g., traps), installation, maintenance, and repair.
- Invasive plant species control equipment, maintenance, and repair.
- Social attraction equipment purchase, installation, and maintenance, and repair.

KIUC has been funding habitat management at five of these conservation sites for many years prior to the permit term during implementation of the Short-Term HCP and began managing three additional sites during the HCP's early implementation period (2020–2022). The cost model recognizes early implementation between 2020 and 2022 of conservation site management in the

[8] Reflective diverters are used more widely across KIUC's powerline system (given that LEDs cannot be placed near roads) and are assumed to be representative of the cost that will be incurred by KIUC throughout the permit term to reduce unminimized strikes resulting from new powerlines, even if a small amount of LED diverters are utilized.

[9] Horizontal configuration is not included in the cost estimate because that minimization technique will be part of the project design for new line and rolled up as part of the construction cost, which is not a covered activity under this HCP.

same way as powerline collision minimization (Section 7.4.3, *Powerline Collisions Minimization*), by identifying investments made prior to permit issuance to Plan Year 0. The cost for early implementation of Conservation Measure 4 between 2020 and 2022 was approximately $9 million.

The actual and projected costs from KIUC's contractors during early implementation were used to estimate the cost to manage the conservation sites during the permit term. The total estimated cost to manage and enhance 10 conservation sites throughout the permit term is approximately $80.6 million, and an average annual cost of approximately $1.5 million per year. This is by far the most expensive cost category in the HCP, accounting for a little over 30 percent of all costs. Costs for conservation sites where KIUC has not conducted extensive pre-implementation management were estimated by applying the average actual per-acre management costs and other fixed costs at the other conservation sites to the additional conservation sites (e.g., Honopū) that would be managed during Plan implementation. In addition, costs for Conservation Site 10 were based on the cost of management at Upper Mānoa Valley, assuming that these past costs are a conservative estimate for Conservation Site 10 (Conservation Site 10 must meet or exceed the benefits to the covered species that were expected at Upper Mānoa Valley).

Costs for this conservation measure are greater during the first few years of the HCP implementation at the Upper Limahuli Preserve and Conservation Site 10 conservation sites as predator exclusion fences are built, and predator eradication and social attraction are established. Once these structures and systems are in place, annual costs would be greatly reduced.

7.4.6 Green Sea Turtle (Honu) Nest Detection and Temporary Shielding Program

Conservation Measure 5 in Chapter 4, Section 4.4.5, *Conservation Measure 5. Implement a Green Sea Turtle Nest Detection and Temporary Shielding Program*, requires KIUC to monitor and minimize artificial light disorientation from KIUC streetlights on green sea turtle (honu). As such, KIUC will fund monitoring and light minimization for green sea turtle (honu) to reduce hatchling light disorientation on Kauaʻi's beaches that provide suitable habitat for green sea turtle (honu) and that may be affected by KIUC streetlights. The program is estimated to cost $5.2 million throughout the entire 50-year permit term, and has an average annual cost of $103,119. The cost estimate related to minimizing light effects on green sea turtle (honu) include the following time and materials.

- Project coordinator staff time (12 months per year).
- Data analysis staff time (3 months in Year 1, 2 months in Year 2).
- Additional support staff time (5 months per year).
- Cost to purchase data collection materials (e.g., iPad, software).
- Cost to purchase and maintain fleet vehicle and fuel.
- Cost to purchase light minimization materials (e.g., shade cloth).

The cost to implement the conservation measure is expected to change over time. These costs may increase if green sea turtle (honu) nesting in the Plan Area expands over time or as vegetation or structures are removed, exposing additional beaches to light effects. Conversely, the costs may go down if beach habitat in the Plan Area is lost due to sea level rise, if the green sea turtle (honu) population decreases, or vegetation or structures are installed that screen additional beaches from light effects. Regardless, these changes should not affect the cost estimate in a significant way, given that the monitoring program already assumes that all beaches on Kaua‘i will be monitored for green sea turtle (honu) nesting on an annual basis. Should green sea turtle (honu) nesting increase on new beaches (outside of the beaches identified on Figures 4-10a through 4-10g in Chapter 4, *Conservation Strategy*) where additional minimization and monitoring would be required, this cost would be covered under KIUC’s letter of credit (see Section 7.4.11, *Changed Circumstances and Contingency*).

There is no cost assumed for permanent streetlight minimization for green sea turtle (honu) described in Chapter 4, Section 4.4.6, *Conservation Measure 6. Identify and Implement Practicable Streetlight Minimization Techniques for Green Sea Turtle*. Permanent minimization would replace the temporary shielding. Temporarily shielding costs are assumed to be much higher than the costs to install permanent light shields on streetlights (based on the annual costs for future streetlight shielding), so the temporary shielding costs are assumed to cover the permanent shielding costs in any year in which permanent shielding is implemented.

7.4.7 Infrastructure Monitoring and Minimization Program

The IMMP[10] estimates mortality of the covered seabirds and waterbirds resulting from powerline collisions. This monitoring program is used to determine the efficacy of the KIUC’s powerline minimization projects (Section 7.4.3, *Powerline Collisions Minimization*) and to model take (extrapolating the amount based on monitoring certain spans) that occurs during the permit term. Costs associated with the IMMP include the following:

- Staff wages and per diem.
- Overhead cost and Hawai‘i excise tax.
- Equipment and supplies including song meters, trail cameras, and field gear.
- Transportation via helicopter and vehicles.

The IMMP costs also includes additional costs for specific monitoring equipment such as near infrared lights, generators, light shields, weather station, helicopter sling gear, and other miscellaneous supplies.

During the early implementation period for the KIUC HCP (2020–2022), the IMMP cost $2.7 million dollars over the 3-year period. The total cost of the IMMP over the 50-year permit term is estimated at approximately $27 million, with an average annual cost of $539,911. As stated in Chapter 6, Section 6.4.1.2, *Take Monitoring*, the HCP assumes that KIUC will monitor a subset of its high-risk lines during the permit term to inform trends across the island-wide powerline system. This assumption is reflected in the lower annual cost in comparison to the amount that was spent during the early implementation period. This lower cost is also justified because KIUC completed most of its powerline collision minimization projects during the early implementation period.

7.4.8 Seabird Colony Monitoring

Like conservation site management, covered seabird monitoring has been ongoing for many years, both during and following the Short-Term HCP and within many of the conservation sites proposed for this HCP. As such, costs are based on projected monitoring costs for monitoring activities that

[10] Formerly known as the Underline Monitoring Program (UMP) under KIUC’s Short-Term HCP.

will be conducted in 2022. The cost estimate assumes that contractors will continue to develop and lead the monitoring program throughout the permit term.

The seabird colony monitoring program is estimated to be $47.6 million over the permit term and $952,993 annually, on average. Conservation site monitoring will document status and trends of the covered seabird species to allow adjustments to the conservation strategy and to ensure the biological goals and objectives of the HCP are met. Monitoring is described fully in Chapter 6, *Monitoring and Adaptive Management Program*. Costs associated with covered seabird monitoring include similar items as described above for the IMMP (Section 7.4.7, *Infrastructure Monitoring and Minimization Program*).

7.4.9 Adaptive Management

Adaptive management includes large-scale changes to the conservation measures that go beyond day-to-day minor adjustment that are needed to achieve a biological objective in the event the conservation strategy is not working as intended (Chapter 6, Section 6.2.2, *Adaptative Management*). These changes will be informed by monitoring described in Chapter 6, *Monitoring and Adaptive Management Program*. Adaptive management includes a specific list of actions identified in Chapter 6, Section 6.2.2.2, *Adaptive Management Decisions*.

The adaptive management decision-making process will be a collaborative process between KIUC, USFWS, and DOFAW (see Chapter 6, Section 6.2.2.3, *Adaptative Management Decision-Making Process for this HCP*). Labor costs associated with the adaptive management process are assumed to be part of costs associated with staff time and consultant costs devoted to HCP implementation. It is also assumed that some of KIUC's adaptive management actions will be cost neutral. That is, the cost of the action that is being replaced or altered may be similar to the cost of the new or improved action (e.g., a cost savings realized by a reduction or cessation of ineffective conservation measures). Some adaptive management changes, however, are likely to result in additional costs. Additional costs associated with adaptive management changes (e.g., adding, removing or changing the alignment of predator exclusion fencing) are estimated to cost $12.8 million over the permit term, or an average annual cost of $247,084.

7.4.10 State Compliance Monitoring

As identified in HRS Chapter 195D, Section G.3 "The applicant shall post a bond, provide an irrevocable letter of credit, insurance, or surety bond, or provide other similar financial tools, including depositing a sum of money in the endangered species trust fund created by section 195D-31, or provide other means approved by the board, adequate to ensure monitoring of the species by the State." KIUC will set aside $50,000 annually to fund state monitoring to comply with this requirement. This amount is assumed to be sufficient for state compliance monitoring of KIUC's implementation of the HCP considering that accessibility to most of KIUC's electrical infrastructure is along roadways or at facilities. Because the conservation sites are typically very difficult to access, state monitoring will not likely occur on an annual basis. This funding will also cover coordination meetings by state staff and review of documents by state staff such as the Annual Report and Annual Work Plan.

7.4.11 Other Costs

7.4.11.1 Changed Circumstance

Remedial measure costs are estimated to address responses to the changed circumstances described above in Section 7.3.3, *Changed Circumstances Addressed by this HCP*. The cost estimate for remedial measures is approximately 10 percent of the total 50-year cost to implement this HCP. This amounts to a total of approximately $28.6 million, with an annual amount of $572,934. The cost estimate for changed circumstances assumes the following.

- Due to damage from severe weather (e.g., hurricane, landslide), KIUC may need to do the following.
  - Replace two predator exclusion fences during the permit term.
  - Replace reflective and LED diverters (assuming that over the course of the permit term all diverters will need to be replaced once due to severe weather in different parts of the Plan Area)
  - Address issues with conservation sites such as temporary destruction of a conservation site or escape of domesticated animals.
  - Replace green sea turtle (honu) permanent light shields or temporary light fencing and/or increased monitoring to determine nest outcomes and document habitat loss and alteration.
- Due to new invasive species, KIUC may need to purchase additional predator control equipment to increase trapping efforts.
- Due to vandalism, KIUC may need to replace up to $3,000 worth of damaged predator control equipment (e.g., cameras, fences).
- Due to vandalism, KIUC may need to replace or repair up to two green sea turtle (honu) temporary light-proof shields per year.

7.4.11.2 Contingency

To account for uncertainties in costs, the cost model includes a contingency cost category that amounts to $31.7 million dollars over the 50-year permit term. The contingency is calculated as 3 percent of the total HCP costs for years 2023 through 2042, and then 2 percent thereafter, assuming that cost uncertainty will decrease over time as plan implementation improves and cost estimating becomes more accurate. Contingency costs are expected to be low enough that they can be funded through KIUC's annual operational budget approval process. The contingency costs will be applied to any program costs that are higher than predicted by this HCP in other categories. Contingency funds may be needed, for example, for the following.

- Buy new or repair existing equipment before replacement or repair costs have been budgeted.
- Acquire materials not forecast in the budgets.
- Add temporary staff to address new issues.
- Implement additional or more expensive minimization projects.
- Apply more expensive management techniques.
- Conduct additional monitoring.

- Address unforeseen administrative costs.

7.5 Funding Assurances

KIUC has the financial capacity and commits to fully fund all costs of the KIUC HCP described above. As shown in Tables 7-3 and Table 7-5 below, KIUC has spent an average of $11 million per year over the last 3 years (2020–2022) on early implementation projects and ongoing tasks (Table 7-3). This amount greatly exceeds the average estimated total cost of HCP implementation of $5.1 million annually throughout the permit term (Table 7-3); however, the first 2 years of HCP implementation are estimated to cost $11.0 million and $6.9 million due to KIUC's remaining powerline collision minimization projects (2023) and predator exclusion fence construction (2023 and 2024) (see Chapter 4, *Conservation Strategy*, for details). As stated above in Section 7.4, *Costs of KIUC HCP Implementation*, the KIUC Board reviews and approves HCP funding on an annual basis that is required to implement the HCP in that year, regardless of whether it exceeds the estimated annual average for the permit term. The HCP identifies as annual average cost that excludes 2023 and 2024 since these are outlier cost years.

To ensure funding for adaptive management and for remedial measures should they be needed to address changed circumstances, KIUC will secure a letter of credit in an amount sufficient to fund a reasonable proportion of expected adaptive management or remedial actions in any one year, as described below. A letter of credit is a document that a financial institution issues on behalf of a client to guarantees payment up to a specified amount during a specified period of time. If funds are paid pursuant to the letter of credit, KIUC would owe that amount to the financial institution according to the terms of a loan agreement established to secure the letter of credit. Typically, letters of credit need to be renewed at regular intervals, sometimes as often as annually. The form of the letter of credit will be reviewed and approved by USFWS and DOFAW prior to the issuance of the ITP and State ITL.

To ensure that this letter of credit remains in place for the duration of the permit term, the letter of credit will have a term providing if a replacement letter of credit is not in place before the expiration period of the existing letter of credit, then the letter of credit becomes immediately payable. This means that KIUC's letter of credit cannot be terminated during the permit term without the approval of USFWS and DOFAW. If it becomes apparent the KIUC's letter of credit will not be renewed during the permit term, KIUC will provide another bank for review and approval by USFWS and DOFAW at a minimum of 3 months prior to the expiration of the previous letter of credit.

The letter of credit will fund annually and continually over the term of the HCP $253,744 for adaptive management plus $572,934 for remedial measures for changed circumstances should they occur (Table 7-2), for a total secured funding level of $603,312. KIUC's Annual Work Plan and annual budget process described in Section 7.2.1, *Responsibilities of Kaua'i Island Utility Cooperative*, will include the letter of credit to account for these costs. Any unused funds in the letter of credit for adaptive management and change circumstances remedial actions will be returned after the 50-year permit term is complete. KIUC may request from USFWS and DOFAW an adjustment in the value of the letter of credit at future renewal periods if HCP; however, any changes in funding amounts must be approved by USFWS and DOFAW.

Costs for implementation of the KIUC HCP are part of KIUC's operational costs, which are passed on to ratepayers. KIUC's costs for implementation of the KIUC HCP are anticipated to be fully covered by its revenues received, electricity rates charged, and debt financing. Collection of these funds is anticipated to be authorized by the Hawai‘i PUC for costs associated with the ongoing operation, maintenance, and construction of utility facilities. KIUC will take the appropriate steps to obtain any approvals necessary to obtain sufficient funds for the HCP, including lender approval, regulatory approval, or PUC approval.

KIUC does not anticipate that the PUC will deny any future request for a rate increase because (1) KIUC will already have received approval from the PUC in an adequate amount to provide for expected HCP costs (expected in 2023), and (2) the HCP and its permits will continue to be an obligatory operational cost necessary for KIUC to provide reliable service to its customers. KIUC has applied to the Hawai‘i PUC once in 2009 and successfully adjusted their utility rates to pay for the cost of the Short-Term HCP. KIUC intends to apply to the Hawai‘i PUC for a utility rate increase or to otherwise authorize expenditures necessary to pay for any HCP costs that exceeds current spending capacity.

KIUC has demonstrated its ability to fund HCP implementation since 2011. Table 7-5 documents what KIUC has spent to date on HCP implementation. From 2011 to 2016 KIUC successfully implemented and completed the Short-Term HCP. Since 2016, KIUC has continued to implement many of the same conservation measures in the Short-Term HCP that are now part of this HCP. In addition, KIUC has implemented many powerline minimization projects during both the Short-Term HCP and afterwards, as early implementation actions for this HCP.

Table 7-5. KIUC Spending on Implementation of Measures Similar to those in this HCP (in 2021 dollars, adjusted for inflation[11])

Year	Powerline Minimization	Streetlight Retrofit	Conservation Site Management and Monitoring	Powerline Collision Monitoring	SOS Program	Total
2011[a]	$5,508,552	$0.00	$1,061,303	$264,569	$316,957	$7,151,381
2012[a]	$281,538	$0.00	$592,019	$278,892	$311,144	$1,463,591
2013[a]	$1,110,983	$0.00	$388,998	$115,220	$308,347	$1,923,550
2014[a]	$1,935,685	$0.00	$710,079	$268,715	$295,204	$3,209,682
2015[a]	$1,254,211	$0.00	$826,635	$263,420	$334,084	$2,678,350
2016[b]	$253,353	$0.00	$2,024,525	$1,365,652	$281,064	$3,924,595
2017[c]	$237,863	$0.00	$1,599,058	$662,862	$291,302	$5,370,350
2018[d]	$455,170	$0.00	$1,774,426	$712,823	$294,493	$3,236,912
2019[d]	$75,574	$0.00	$1,290,704	$673,781	$256,259	$2,296,317
2020	$5,448,795	$0.00	$1,516,682	$595,145	$245,028	$7,805,650
2021	$6,307,575	$0.00	$2,418,771	$1,052,501	$300,000	$10,078,847
2022	$8,001,500	$0.00	$7,370,009	$2,075,985	$300,000	$17,747,494
Total[le]	$30,870,799	$2,579,265	$21,573,209	$8,329,564	$3,533,883	$66,886,719

[a] Short-Term Habitat Conservation Plan Kaua‘i Island Utility Cooperative 2015 Annual Report
[b] Short-Term Habitat Conservation Plan Kaua‘i Island Utility Cooperative 2016 Annual Report
[c] Short-Term Habitat Conservation Plan Kaua‘i Island Utility Cooperative 2017 Annual Report
[d] Short-Term Habitat Conservation Plan Kaua‘i Island Utility Cooperative 2018 Annual Report
[e] KIUC funding of the SOS Program dates to 2003. Only funding since 2011 is shown.

[11] U.S. Bureau of Labor Statistics 2021

7.5.1 Funding Adequacy

KIUC has been in existence as a successful electric cooperative since November 2002. In 2020, KIUC received $145.1 million in revenue with expenses that totaled $137.7 million, generating a net margin of $7.4 million (Kaua'i Island Utility Cooperative 2021). Of this total, KIUC spent $20.4 million in 2020 on administrative costs, including regulatory compliance (of which HCP early implementation is a part). KIUC also spent $7.0 million in 2020 to operate and maintain its electric transmission and distribution system. As a non-profit cooperative owned by its member customers, KIUC has access to low-interest loans or loan guarantees provided by the federal government for capital investments through programs such as the U.S. Department of Agriculture Rural Utilities Service. These figures and KIUC's status as a utility cooperative demonstrates that KIUC has the financial ability to pay the HCP implementation costs described in this chapter. The average annual cost of HCP implementation is approximately $5.6 million (Table 7-3). KIUC has equaled or exceeded that level of annual spending on early HCP implementation actions in five of the last 12 years (2011, 2017, 2020, 2021, and 2022 [estimated]) (Table 7-5).

KIUC is solvent and able to meet its current financial obligations, including the conditions and obligations of the KIUC HCP. KIUC will provide adequate resources to fulfill commitments as described in the KIUC HCP. The HCP Accountant/Budget Analyst will forecast anticipated program needs, ensuring that KIUC is able to pay for all conservation measures, monitoring and adaptive management, and HCP administration. The cost estimate for HCP implementation is designed to be conservative; that is, it likely somewhat overestimates future costs. Reasons for this conservative estimate include the following.

- When cost ranges were available, the higher unit cost was chosen as the assumption for the cost model.
- The population dynamics model on which the conservation sites are based (see Chapter 5, *Effects*, and Appendix 5E, *Population Dynamics Model for Newell's Shearwater ('a'o) on Kaua'i*,), is itself conservative. In other words, the conservation sites may produce more covered seabirds than forecast by the current model, allowing KIUC to reduce its level of effort at each conservation site while still meeting or exceeding the biological goals and objectives, saving costs.
- New technologies may be developed during the 50-year permit term that will allow KIUC to achieve the biological goals and objectives of the Plan, or implement the monitoring program, with greater efficiency and lower cost.
- Cost estimates for management of the conservation sites (the largest share of all costs) are based on current KIUC contractor costs that are applied on fewer and smaller conservation sites than will be operational under this HCP. Future unit costs are likely to be lower as KIUC seeks more competitive bids for HCP services and applies them on more and larger conservation sites, realizing more economies of scale.

However, despite the conservative nature of the cost estimate, costs may still exceed predictions. This section describes the safeguards in place if funding needs are greater than those described in this chapter.

7.6 Revisions and Amendments

There are two types of changes that may be made to the HCP: minor modifications or major amendments, each of which is described in the following subsections. All revisions and amendments will be processed in accordance with all applicable legal requirements.

7.6.1 Minor Modifications

Minor modifications are changes to the HCP provided for under the operating conservation program, including adaptive management changes and responses to changed circumstances (Section 7.3.1, *Changed Circumstances*). They also include revisions that do not increase the levels of authorized incidental take and do not materially modify the scope or nature of activities or actions covered by the ITP and State ITL in terms of their effect on the covered species. Minor modifications may include, but are not limited to, the following.

- Correction of any maps or exhibits to correct errors in mapping or to reflect previously approved changes in the HCP.
- Correction of the HCP or its appendices to for any spelling errors or omissions.
- Modifying existing or establishing new conservation measures to further minimize or avoid take of the covered species.
- Modifying reporting protocols for the annual report.
- Minor changes to monitoring or reporting protocols.
- Revising conservation site enhancement and management techniques.

USFWS and DOFAW will confirm receipt of any modification request and will notify KIUC acknowledging the minor modification or determining if such modification request constitutes an amendment as described below.

7.6.2 Major Amendments

Major amendments are changes in the HCP that may affect the impact analysis or conservation strategy. Amendments to the HCP and either the ITP or State ITL follow the same formal review process as the original HCP and permits, including NEPA/Hawai'i Environmental Protection Act (HEPA)[12] review, *Federal Register* notices, an internal Section 7 consultation with USFWS, and approval by the ESRC and BLNR. A major amendment includes but is not limited to the following.

- Adding a new covered species to the HCP and the incidental take authorizations.
- Changes to the covered activities (either deletion or addition) not addressed in the HCP as originally adopted, and which otherwise do not meet the criteria for a minor modification as discussed in Section 7.6.1, *Minor Modifications*.
- Increasing take authorization for any of the covered species.
- Substantial changes to the conservation strategy beyond what is contemplated in the adaptive management process in Chapter 6, *Monitoring and Adaptive Management Program*.

[12] Hawai'i Revised Statute Chapter 343.

- Extending the terms of the ITP or State ITL other than through a permit or license renewal process described below.

A major amendment requires submittal to USFWS and DOFAW of a written application and implementation of all permit processing procedures applicable to an original ITP and State ITL. The specific documentation required to comply with the federal ESA, HRS Chapter 195D, NEPA, and HEPA will vary based on the nature of the amendment.

7.6.3 Permit Suspension or Revocation

USFWS or DOFAW may suspend or revoke their ITP or State ITL if KIUC fails to implement the HCP in accordance with the terms and conditions of the ITP or State ITL or as otherwise provided by law. Suspension or revocation of the ITP or State ITL shall be done in accordance with applicable federal or state law.

7.6.4 Permit Renewal

7.6.4.1 Renewal of Federal Incidental Take Permit

The ITP associated with this HCP is eligible to be renewed before the 50-year permit term expires if it is stated on the original permit. USFWS regulations (50 CFR Section 13.22) allow a permit to remain in effect while USFWS considers a renewal request, but only if the renewal request is received by USFWS at least 30 days before expiration. The permit renewal request will be processed in accordance with federal law applicable at the time the request is made.

7.6.4.2 Renewal of State Incidental Take License

Upon expiration, and to the extent permitted by law, the State ITL may be renewed without the issuance of a new license, provided that the license is renewable, and that biological circumstances and other pertinent factors affecting the covered species are not significantly different than those described in the original HCP. To renew the license, KIUC must submit to DOFAW, in writing, the following.

- A request to renew the ITL.
- Reference to the original license number.
- Certification that all statements and information provided in the original HCP and license application, together with any approved HCP amendments, are still true and correct, or inclusion of a list of changes.
- A description of what take has occurred under the existing license.
- A description of what activities under the original license the renewal is intended to cover.

If DOFAW concurs with the information provided in the request, they will renew the take authorizations consistent with their respective renewal procedures. If KIUC files a renewal request and the request is on file with DOFAW at least 30 days prior to the expiration of the State ITL, the authorizations will remain valid while the renewal is being processed, provided the existing authorization is renewable. If KIUC fails to file a renewal request at least 30 days prior to license expiration, the license will become invalid upon expiration. KIUC must have complied with all annual reporting requirements to qualify for a license renewal.

7.7 Annual Reporting

KIUC will prepare an annual report for each year of the 50-year permit term of the KIUC HCP. The annual reports will summarize implementation activities in the previous calendar year (January 1 to December 31) as well as cumulatively over the permit term. KIUC will submit each annual report by no later than June 1 following the reporting year in order to comply with the reporting deadline established by the Hawai‘i ESA.[13]

Immediately following each calendar year, KIUC's contractors will submit to KIUC technical reports that summarize their activities in the previous calendar year. Once all of the technical reports are available (usually in the spring of each year), KIUC will prepare an annual report and submit it to USFWS and DOFAW, typically by July or August of each year, but no later than September 28 as required by the Hawai‘i ESA.

KIUC's annual reports will include the following information.

- A description of all covered activities implemented during the reporting period categorized by major activity type (per Chapter 2, *Covered Activities*).
- An annual and cumulative summary (i.e., from the start of the permit term) of the amount of take of each covered species (see *Take Monitoring* sections in Chapter 6, *Monitoring and Adaptive Management Program*, for the methods for each covered species).
- An accounting of all minimization actions applied to the covered activities during the reporting period.
- A summary of all conservation actions implemented during the reporting period.
- An annual and cumulative summary of the rescues and releases from the SOS Program (or similar rehabilitation program) of each of the covered seabirds and covered waterbirds.
- A description of the monitoring undertaken for covered seabirds and covered waterbirds during the reporting period and a summary of monitoring results.
- A description of the monitoring undertaken for the green sea turtle (honu) during the reporting period and a summary of the monitoring results, including all the reporting requirements described under Section 4.4.5.5, *Annual Training and Reporting*.
- An assessment of the HCP's achievement to date of each of the biological objectives, including an analysis of the problems and issues encountered in meeting or failing to meet the HCP biological objectives.[14]
- A description of the adaptive management process utilized during the reporting period, including any changes implemented because of that process.

[13] HRS Section 195D-21(f) requires HCP permittees to submit an annual report within 90 days of each fiscal year ending June 30.

[14] As required by HRS Section 195D-21(f).

- A summary of any changes to the monitoring program techniques or protocols including monitoring locations, variables measured, sampling frequency, timing, and duration, and analysis methods, and an explanation for those changes.
- An assessment of the efficacy of the minimization, conservation, and monitoring actions and recommended changes based on interpretation of monitoring results and research findings.
- An assessment of whether any changed circumstances have occurred. If a changed circumstance has occurred, a description of any remedial actions taken or planned.
- A summary of planned actions and management objectives for the next fiscal year, including any proposed modifications to conservation measures (as required by HRS Section 195D-21(f)).
- The status of HCP funding (as required by HRS 195D-21(f)).
- A summary of any administrative changes, minor modifications, or major amendments proposed or approved during the reporting year, as defined in Section 7.6, *Revisions and Amendments*.
- A schedule showing when HCP components will be implemented and when each component is completed.
- A description of data and analyses used to run and update models as conducted for the annual report, cumulative report, or other management summaries and assessments.
- An assessment of new and emerging technology that may be useful to meet HCP objectives.

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Chapter 8
Alternatives to Take

Section 10(a)(2)(A) of the federal Endangered Species Act (ESA) requires applicants to consider alternative actions to the take of covered species and to explain the reasons why those alternatives were not selected. The Endangered Species Habitat Conservation Planning (HCP) Handbook (U.S. Fish and Wildlife Service and National Marine Fisheries Service 2016) identifies several types of alternatives commonly used in HCPs: (1) an alternative that would reduce take below levels anticipated for the proposed project, (2) an alternative that would avoid take and hence not require a federal permit, or (3) an alternative where the proposed project would not occur.

This chapter identifies alternative actions considered by KIUC that would avoid or minimize the potential for take of each covered species in the KIUC HCP. Three alternatives are considered:

1. A “no take” alternative,
2. An undergrounding some transmission lines alternative, and
3. An extensive tree planting alternative.

These alternatives were not selected by KIUC because they were not feasible nor practical, as explained below.

This chapter does not include an alternative to reconfigure, relocate, or modify high-collision powerlines to reduce adult mortality because the KIUC HCP includes these types of minimization measures in the conservation strategy (Chapter 5, *Effects*) to the maximum extent that is economically and technologically feasible (*Chapter 4, Section 4.4.1.2, Powerline Collision Minimization Projects*).

8.1 No Take Alternative

The no take alternative would require KIUC to modify all of its existing and future infrastructure (Chapter 2, *Covered Activities*) to prevent any take of the covered species. As discussed in Chapter 5, *Effects*, certain existing and future KIUC powerlines, streetlights, and facility lights result or are likely to result in take of the covered species. Even with substantial avoidance and minimization measures applied, take would continue to result from collisions with powerlines and fallout due to KIUC-owned and -operated street and facility lighting attraction and disorientation.

The only approaches that KIUC could use to completely eliminate the possibility of take from its infrastructure are to: (1) remove all powerlines on the Island of Kauaʻi that result in take; or (2) move underground all powerlines not completely shielded by topography, vegetation, or other structures; and (3) remove all street and facility lighting that results in take.

These no take alternative approaches are neither feasible nor practicable. KIUC cannot remove all of its powerlines that cause take because it is mandated by state regulations to provide reliable electricity to its customers. Similarly, it is not feasible to eliminate nighttime lighting along state and county roadways and at KIUC production and distribution facilities that operate 24 hours per day, 7 days per week, for reasons of public and worker health and safety.

Undergrounding KIUC lines is not feasible because it is cost prohibitive. The existing KIUC transmission, distribution, and communication system includes roughly 1,000 miles of overhead electrical cables. Given that KIUC already has some of the highest electricity rates in the country and a very small base of ratepayers, and given the financial requirements imposed by its federal and private sector lenders, undergrounding all of its powerlines is not financially feasible. See Section 8.2, *Underground Some Transmission Lines*, for additional information on the prohibitive cost of moving all transmission and distribution lines underground.

8.2 Underground Some Transmission Lines

Under this alternative, KIUC evaluated undergrounding transmission lines that constituted the highest concentration of bird strikes based on past monitoring (Travers et al. 2020). This alternative would target KIUC's cross-island line, which runs from Port Allen across the interior of the island to Wainiha. To evaluate this alternative, KIUC contracted with Electric Power Engineers, Inc. (EPE) for a detailed assessment of the feasibility of undergrounding three transmission line segments.

- 2.5-mile-long (4-kilometer [km]-long) segment across the Powerline Trail
- 1.0-mile-long (1.6-km-long) segment across the ʻEleʻele Coffee Fields
- 0.5-mile-long (0.8-km-long) segment across Lāwaʻi Valley

In its June 11, 2015, report entitled *Assessment of Opportunities for Minimizing Adverse Effects to Seabirds: Wainiha – Port Allen 69 kV Double Circuit Transmission Line*, EPE concluded that while undergrounding the cross-island line segments would eliminate the potential for covered seabird collisions in those areas, it would be very difficult and prohibitively expensive to construct and maintain. In addition, when line failures did occur, they would be very difficult to locate and repair, and this would result in extended circuit outages that increases the risk of a system failure with wide-ranging adverse consequences.

EPE calculated the following costs to move underground the three powerline segments considered, in 2019 dollars.

- The cost to underground the Powerline Trail segment (2.5 miles [4 km]) would be approximately $27 million. The underground route would be approximately twice the length of the overhead route. The cost amounts to approximately $10.9 million per existing overhead alignment mile and $7.2 million per new underground alignment mile.
- The cost to underground the ʻEleʻele Coffee Fields segment (1.0 mile [1.6 km]) would be approximately $6.5 million.
- The cost to underground the Lāwaʻi Valley segment (0.5 mile [0.8 km]) would be approximately $6.3 million or approximately $12.5 million per mile.

Using the per-mile costs noted above, EPE extrapolated the costs to underground all the cross-island line from the Port Allen Generating Station to Wainiha. EPE estimated that undergrounding all 47 miles (75.6 km) of the cross-island line would cost a minimum of $188 million in 2019 dollars, and that the cost could easily be more than twice that amount (over $378 million). The costs to underground powerlines can be highly variable, depending on terrain, access, geological conditions, and physical obstacles such as roads and bodies of water. This cost is prohibitively high given that KIUC's utility operating income for 2019 was approximately $154.9 million and operating expenses over the same time period were approximately $142.9 million (Kauaʻi Island Utility Cooperative 2020). Furthermore, moving underground one 47-mile (75.6-km) line would leave the majority of KIUC's existing overhead electrical powerlines in place. Based on this analysis, KIUC determined that it would infeasible and cost prohibitive to reduce take of the covered birds by moving underground substantial segments of even some of KIUC's high-risk powerlines that cause take.

8.3 Extensive Tree Planting

This alternative would involve extensive tree planting in areas with exposed powerlines, especially in any high-strike locations along perimeter lines. The trees, once tall enough, would shield the powerlines and reduce the risk and incidence of covered species strikes. Fast-growing tall trees, most of which would be invasive, would be most appropriate.

KIUC considered this alternative but determined that extensive tree planting is not a viable alternative. This alternative was not selected because:

- Many interior powerlines are elevated above the existing tree line, even using alternative tree species.
- Vegetation and powerlines are often incompatible, in terms of the cost to maintain powerline clearance and the risk associated with trees falling on the lines, especially during storms. Increasing vegetation biomass immediately adjacent to powerlines would increase the cost of vegetation maintenance and increase the risk of powerline failure during storms.
- Land on either side of the powerlines where trees would need to be planted and maintained is mostly privately owned. It would be infeasible to negotiate with thousands of individual landowners to plant and maintain additional trees on their property.
- Planting tall trees in some areas can have unacceptable visual impacts. While taller trees would shield powerlines from viewsheds, taller trees can also block desirable views of the mountains or ocean from homeowners or recreationalists.

KIUC attempted to promote the ideas to private landowners, including programs to supply plant materials appropriate for the purpose, but was largely rejected by the landowners. Landowners and their neighbors were primarily concerned about the loss of views of the ocean from more and taller trees.

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Chapter 9
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9.6 Chapter 5, *Effects*

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9.10 Chapter 10, *Glossary*

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Chapter 10
Glossary of Terms

active breeding burrow—determined when an adult bird is either observed or when signs of bird presence are documented during the breeding season (e.g., feathers, guano, digging).

adaptive management—a method for examining alternative strategies for meeting measurable biological goals and objectives, and then if necessary, adjusting future conservation management actions according to what is learned (65 *Federal Register* 106 35242–35257, June 1, 2000). Not a strategy to address changed circumstances, but a strategy to address uncertainty associated with an HCP's conservation program, particularly where there is uncertainty posing a significant risk to covered species.

adult—life stage in which a species has reached sexual maturity.

avoidance measures—actions that aim to eliminate all potential take of a covered species, or impacts to a covered species.

baseline conditions—conditions surrounding the presence and/or status of a species or its habitat that exists within the plan area prior to implementation of an HCP.

biological goals—an overarching component of an HCP conservation strategy meant to define what the HCP intends to accomplish for wildlife conservation. Biological goals are descriptive, open-ended, and often broad statements of desired future conditions that convey a purpose, but do not define measurable units. Biological goals lay the foundation from which all conservation activities arise.

biological objectives—the steps that outline how an applicant will achieve biological goals; they provide direction for monitoring; they are specific, measurable, achievable, result-oriented and time fixed.

changed circumstances—changes in circumstances affecting a species or the geographic area covered by the KIUC HCP that can reasonably be anticipated during the permit term and that can reasonably be planned for (e.g., new species listings, or a fire or other natural catastrophic event in areas prone to such events). By identifying a specific response to each changed circumstance, the costs of implementing the response, and the funding assurances for those responses in the HCP, it is possible to facilitate adjustments to the HCP's conservation program without having to amend the HCP. Treated as part of the HCP's operating conservation program.

circuit—completed path for electric current from source to point of use and back.

climate—the average weather over many years.

climate change—a statistically significant change in the state of the climate or its variability that persists for an extended period, typically for decades or longer.

colony—area where birds nest and breed in proximity as a group, often sharing communal behaviors for the benefit of the entire group. The size of the colony can vary from just a few breeding pairs to hundreds or thousands of birds depending on the species and availability of resources, including suitable nest sites and takeoff/landing zones.

communication wire—a wire that delivers information by currents of various frequencies. Telephone conversations, photographs, sound and television broadcasts, and statistical data for computer centers are transmitted through communication wire.

compliance monitoring—process used to verify that KIUC is conforming to permit terms and conditions, including correct implementation of the HCP. Also known as implementation monitoring.

conservation measures—describe the specific actions that KIUC will implement to achieve the objectives in support of the HCP's goals. May be any of the avoidance, minimization, or mitigation actions taken to meet the goals and objectives of the HCP.

conservation sites—specific parcels on Kauaʻi with occupied or suitable breeding habitat for the covered seabird species where some of the HCP's conservation measures will be undertaken.

conservation strategy—the HCP's overall and unified approach for achieving the biological goals and objectives.

construction—making or forming a structure by combining or arranging various parts or elements to serve a particular purpose.

covered activities—the projects or ongoing activities that have the potential to take the covered species for which KIUC is requesting incidental take authorization.

covered seabird—The species are Newell's shearwater (ʻaʻo), Hawaiian petrel (ʻuaʻu), and the Hawaiian distinct population segment of band-rumped storm-petrel (ʻakēʻakē).

covered species—the species covered by this HCP. The species are Newell's shearwater (ʻaʻo), Hawaiian petrel (ʻuaʻu), the Hawaiian distinct population segment of band-rumped storm-petrel (ʻakēʻakē), Hawaiian stilt (aeʻo), Hawaiian duck (koloa maoli), Hawaiian coot (ʻalae keʻokeʻo), Hawaiian common gallinule (ʻalae ʻula), Hawaiian goose (nēnē), and the Central North Pacific distinct population segment of green sea turtle (honu).

covered waterbird—the species are Hawaiian stilt (aeʻo), Hawaiian duck (koloa maoli), Hawaiian coot (ʻalae keʻokeʻo), Hawaiian common gallinule (ʻalae ʻula), and Hawaiian goose (nēnē).

crippling bias—the proportion of birds colliding with powerlines that manage to fly or glide beyond the search corridor before dying. This term is only relevant for monitoring techniques in which the number of injuries or mortalities are estimated through underline searches for dead and injured birds.

crippling rate—the proportion of birds colliding with powerlines that subsequently die due to their injuries. Referred to in Chapter 5 as "mortality rate" for powerline strikes.

distribution wire—the electrical wire that delivers power to neighborhoods, businesses, and other facilities in towns and cities from transmission wire. The voltage of distribution wire is typically 13,000 volts or 13 kilovolts.

effectiveness monitoring—used to determine if KIUC is achieving the stated biological goals and objectives of the HCP. It provides the evaluation of whether the effect of implementing the HCP's conservation program is consistent with the assumptions and predictions made when the HCP was developed and approved.

endangered species—a native species, subspecies, variety of organism, or distinct population segment (DPS) which is in danger of becoming extinct throughout all or a significant portion of its range (16 U.S. Government Code 1532[6]).

enhance—the manipulation of the physical, chemical, or biological characteristics of a land cover type to heighten, intensify, or improve one or more specific existing ecological function(s). Enhancement results in the gain of selected existing ecological function(s), but may also lead to a decline in other ecological function(s).

facility—structure built, installed, or established to serve a particular purpose.

fallout—a phenomenon primarily affecting young seabirds (petrels and shearwaters) that leave their nest for the first time but can also affect adults(e.g., presence of unshielded lights, particularly near breeding colonies). These seabirds use natural lighting such as moonlight to navigate out to sea where they spend their time feeding. They can become disoriented by artificial lighting (e.g., streetlights, building lights) and circle lights repeatedly, become exhausted, and often grounded as a result or collide with structures in the process. Grounded seabirds can suffer injury, starvation, predation, or collision (e.g., with vehicles). Seabirds that collide in flight with structures are commonly injured or killed.

fallout season—September 15th to December 15th, when the majority of Newell's shearwater (ʻaʻo), Hawaiian petrel (ʻuaʻu) are fledging from their burrows.

fledging—the act of leaving the nest/burrow for the first time and migrating to the ocean to begin foraging. After fledging, seabirds will not return to their natal burrow until they are 2–5 years old. See also **sub-adults.**

fledgling—a young bird, typically with fully developed wing muscles and feathers, that leaves the nest for good and can survive away from the nest.

full cutoff shielded fixture—full cutoff shielded fixtures are light fixtures that have no direct uplight (no light emitted above horizontal). These fixtures prevent light from shining upwards by enclosing the bulb and directing it downward. A full cutoff shield also requires luminaries to comply with the glare requirement limiting intensity of light from the luminaire in the region between 80 and 90 degrees.

grounded—a bird on the ground in locations where they normally would not be found, usually because of attraction and disorientation by artificial lights or structure collisions. These birds are unable to get off the ground again naturally. This a term typically used for the covered seabirds.

habitat conservation plan (HCP)— A habitat conservation plan (HCP) must accompany an application for a federal incidental take permit and an application for a state incidental take license. An HCP details, without limitation, all applicant proposed enforceable commitments including take avoidance, minimization, and mitigation actions, and monitoring and ensured funding commitments.

harass—is a component of the definition of "take" under the federal ESA (16 USC 1532). Pursuant to USFWS ESA implementing regulations, *harass* is defined as intentional or negligent acts or omissions that create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt essential behavioral patterns including, but not limited to, breeding, feeding, or sheltering (50 CFR 17.3).

harm—under the federal ESA, *harm* includes significant habitat modification or degradation where it kills or injures wildlife by significantly impairing essential behavioral patterns including, but not limited to, breeding, feeding, or sheltering (50 CFR 17.3).

hatchling—a young animal that has recently come out of its egg. All the covered species emerge from eggs and may be referred to as a "hatchling", but in the KIUC HCP this term is used with reference to green sea turtle (honu).

hurricane—an intense tropical weather system with well-defined circulation and maximum sustained winds of 74 mph (64 knots) or higher.

immediate grounding rate—the proportion of birds colliding with powerlines that are grounded within the search corridor (inverse of crippling rate) or assumed to have lost flight and hit the ground in unsearchable areas.

impact—the effects that covered activities have on the covered species.

impact of the taking—the impacts that result from the taking of the covered species, and described in terms of context, intensity, and duration of the impact. Context is the setting in which the impact of the take analysis occurs and includes consideration of other threats to covered species. Duration of the impact encompasses both current and probable future conditions and trends spanning the entire duration of the requested take. The impact of the taking should be described relative to a species reproduction, numbers, and distribution. The impact of the taking must not appreciably reduce the likelihood of survival and recovery of the species.

inactive burrow—no sign (e.g., bird presence, feathers, guano, digging) that the burrow has been visited during a breeding season.

incidental take—any take otherwise prohibited if such take is incidental to and not the purpose of the carrying out of an otherwise lawful activity (16 USC 1539(a)(1)(B); 50 CFR 17.3).

incidental take license (ITL)—the incidental take license (ITL) is the tool used by the State to authorize incidental take that occurs because of otherwise legal activities (HRS 195D-4(g)). This licensing document must be accompanied with an approved HCP. All qualifying private, non-federal entities, can request an ITL.

incidental take permit (ITP)—pursuant to Section 10(a)(1)(B) of the Endangered Species Act (ESA) of 1973, a permit can be issued by USFWS to non-federal entities, allowing incidental take of an endangered or threatened species when the take is incidental to, and is not the purpose of, carrying out an otherwise lawful activity. This permitting document must be accompanied with an approved HCP.

invasive species—a species that is non-native to the ecosystem and whose introduction causes or is likely to cause economic or environmental harm or harm to human health (Executive Order 13112).

Kona storm—the term was originally applied to the slow-moving subtropical cyclones that occasionally enter the Hawaiian area. Increasingly, this term is now applied by the local public to any widespread rainstorm accompanied by winds from a direction other than that of the trade winds. Kona storms are cool winter storms associated with a southward shift in the mid-latitude jet stream. They are most common during the late fall, winter, and spring and are associated with cold air over the central Pacific Ocean. They bring cloudy wet conditions to the western and southwestern sides of the island.

Kona weather—usually the warmest days in the Hawaiian Islands, when the trade winds, which come from cooler latitudes, fail and air stagnates over the heated islands.

light attraction—disorientation in nocturnal seabirds or green sea turtle (honu) hatchlings caused by attraction toward artificial lighting.

light disorientation—altered behavior in hatchling green sea turtles (honu) that are disoriented by an artificial light source and do not migrate directly to the ocean after emerging from their nest.

land cover type—the dominant feature of the land surface discernible from aerial photographs and defined by vegetation, water, or human uses.

major amendments—changes in the HCP that may affect the impact analysis or conservation strategy. Major amendments require submittal to USFWS and DOFAW of a written application and implementation of all permit processing procedures applicable to an original federal ITP and State ITL.

massif—a block of the earth's crust bounded by faults and shifted to form peaks of a mountain range.

maximum extent practicable—pursuant to section 10 of the ESA, the USFWS must determine that the combination of minimization and mitigation in the HCP leaves no remaining impacts of the taking on the species that could be further mitigated or minimized. Therefore, all impacts of the taking must be either fully offset, or if an applicant cannot fully offset the impacts of the taking, they must demonstrate to the USFWS' satisfaction that it is not practicable to carry out any additional minimization or mitigation.

metapopulation—a group of partially isolated populations belonging to the same species that are connected by pathways of immigration and emigration. Exchange of individuals occurs between such populations, enabling recolonization of sites from which the species has recently become extirpated.

minimization measures—within the context of the HCP, minimization is related to the impacts of the proposed covered activities on the species to be covered. In other words, minimization measures comprise actions that will reduce the impacts of the taking that have been identified during development of the HCP.

minimization efficacy—the desired or intended results from minimization projects on KIUC infrastructure.

minor modifications—changes to the HCP that do not increase the levels of authorized incidental take and do materially modify the scope or nature of activities or actions covered by the federal ITP and State ITL in terms of their effect on the covered species.

monitoring—the systematic surveillance or sampling of air, water, soil, and biota to observe and study the environment, and to derive knowledge from this process. The processes and activities that need to take place to characterize and monitor the quality of the environment or effectiveness of a project.

net benefit—abbreviated reference to "net conservation benefit", a requirement under Hawai'i state law for HCPs to mitigate commensurate for the requested take plus additional mitigation to ensure the likelihood of the survival and recovery of the species in the wild.

nonnative species—species that is not native to the ecosystems in Kaua'i.

"no surprises assurances"—assurances to permit holders that if unforeseen circumstances arise, the USFWS will not require more land, water, or money or additional restrictions on the use of land, water, or other natural resources beyond the level stated in the HCP without the consent of the KIUC (16 CFR 17.22((b)(5); 17.32(b)(5)). This assurance applies as long as KIUC is implementing the terms and conditions of the HCP properly and applies only with respect to species adequately covered by the conservation plan. See also **unforeseen circumstances**. For purposes of this definition, the term "adequately covered" means that a proposed conservation plan has satisfied the permit issuance criteria under Section 10(2)(B) of the ESA for the species covered by the HCP and listed on the ITP, if issued. See 50 CFR 17.3.

open water—aquatic habitats such as lakes, reservoirs, water-treatment ponds, sloughs, and ponds (including percolation and stock ponds) that do not support emergent vegetation.

operation—the fact or condition of a structure being linked to the take of covered species. For powerlines, the wires are operational once they are in place, but those wire do not need to be energized or functional. Streetlights are only operational when the lights are on.

permit area—the geographic area where the ITP applies. It includes the areas under the control of the KIUC where covered activities will occur. The permit area must be delineated in the ITP and be included within the Plan Area of the HCP.

permit term—the period over which KIUC is authorized to incidentally take the covered species in conjunction with implementing the HCP. The permit term for this HCP is 50 years.

Plan Area—the specific geographic area where covered activities and conservation measures described in the KIUC HCP will occur. The KIUC HCP Plan Area covers the full geographic extent of Kaua'i.

predator control—the act of controlling animals defined as predators via a variety of techniques.

predator eradication—complete removal of predators from within a predator exclusion fence.

predator exclusion fence—a fence specially designed to exclude all mammalian predators on Kaua'i from entry, including nonnative rats, feral cats, and ungulates. See **ungulate fence**.

population—a group of individuals of the same species inhabiting a given geographic area, among which mature individuals reproduce or are likely to reproduce. Ecological interactions and genetic exchange are more likely among individuals within a population than among individuals of separate populations of the same species.

powerline—overhead electrical wires strung between supporting structure, including poles, towers, lattice structures, and H-frames. The KIUC HCP covers transmission wires, distribution wires, and communication wires, and associate supporting structures.

range—the geographic area a species currently or historically occupied.

recovery—the process by which the decline of an endangered or threatened species is arrested or reversed or threats to its survival neutralized so that its long-term survival in nature can be ensured. Recovery entails actions to achieve the conservation and survival of a species (U.S. Fish and Wildlife Service and National Marine Fisheries Service 2016), including actions to prevent any further erosion of a population's viability and genetic integrity, as well as actions to restore or establish environmental conditions that enable a species to persist (i.e., the long-term occurrence of a species through the full range of environmental variation). Implementation of an HCP may not impede the ability of a covered species to recover.

reproductive success rate—number of covered seabird burrows that fledged a chick divided by the number of burrows that were confirmed breeding and where an outcome could be determined.

Save Our Shearwaters (SOS)—the SOS Program operates year-round on Kauaʻi rescuing and rehabilitating native Hawaiian birds and the Hawaiian hoary bat. SOS focuses on the rescue and rehabilitation of Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu).

seabird—a bird that frequents coastal waters and the open ocean.

social attraction—a colony creation technique whereby seabirds are attracted to an area to initiate breeding by playing recordings of other seabirds of the same species and installing artificial burrows. This is an effective technique due to the colonial nature of seabirds.

strike reduction—the amount of decrease in avian powerline collisions between the unminimized state and the post-minimization state (e.g., after bird flight diverters are installed).

sub-adult—birds 2–5 years old who have not reached sexual maturity.

suitable habitat—habitat that may be unoccupied or historically or currently occupied that exhibits the characteristics necessary to support a given species. Suitable habitat is used as a criterion for conservation site selection.

take authorizations—the permits that authorize take of species, in this case the federal ITP issued by the USFWS and the state ITL issued by the State of Hawaiʻi Department of Land and Natural Resources, Division of Forestry and Wildlife.

take—under the federal ESA, the term *take* means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect listed species or to attempt to engage in any such conduct (16 USC 1532; 50 CFR 17.3). Under the Hawaiʻi statutes, *take* is defined similarly to the federal ESA as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect endangered or threatened species of aquatic life or wildlife, or to cut, collect, uproot, destroy, injure, or possess endangered or threatened species of aquatic life or land plants, or to attempt to engage in any such conduct.

threatened species—Any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. 16 USC 1532(20).

transmission wire—the electrical wire that delivers power from substations to distribution wire. The voltage of transmission wire is typically 100,000 volts or 100 kilovolts.

triggers—qualitative or quantities thresholds, which can include established schedule milestones, that if not met will initiate adaptive management.

tropical storm—an organized system of strong thunderstorms with a defined circulation (i.e. tropical cyclone) and maximum sustained winds of 39 to 73 mph (62.8 to 117.5 kph).

under-build—distribution wires built on the same pole as transmission wires are always mounted underneath the transmission wires.

ungulate fence—a fence designed to keep out hoofed mammals. On Kauaʻi, existing ungulates that may trample burrows and seabird habitat, or predate on nesting seabirds include feral pigs and goats and deer.

unoccupied habitat—habitat that exhibits all the constituent elements necessary for a species, but which surveys have determined is not currently occupied by that species. The lack of individuals or populations in the habitat is assumed to be the result of reduced numbers or distribution of the species such that some habitat areas are unused. It is possible that these areas would be used if species numbers, or distribution were greater. See also **suitable habitat**.

unforeseen circumstances—changes in circumstances affecting a covered species or geographic area covered by the KIUC HCP that could not reasonably have been anticipated by the plan developers and the USFWS at the time of the HCP's development, and that result in a substantial and adverse change in the status of a covered species. Under the state permit, this refers to changes affecting one or more species, habitat, or the geographic area covered by a conservation plan that could not reasonably have been anticipated at the time of plan development, and that result in a substantial adverse change in the status of one or more covered species.

viable metapopulation—an estimated number of individuals within a metapopulation to persist with high probability in the long term measured by its distribution, population size, age structure, growth rate, and additional demographic variables (e.g., age/cohort survivorship, reproductive success). For the purposes of this HCP 2,500 breeding pairs, and 10,000 individuals, is considered a viable metapopulation.

waterbird—a bird that is found in a variety of wetland habitats including freshwater marshes and ponds, coastal estuaries and ponds, artificial reservoirs, kalo or taro (*Colacasia esculenta*) loʻi or patches, irrigation ditches, sewage treatment ponds, and, in some cases, montane streams and marshlands.

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Chapter 11
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Appendix 1A
Evaluation of Species Considered for Coverage

Pursuant to the federal Endangered Species Act (federal ESA) and Hawaiʻi Revised Statutes, incidental take authorizations may be required for species covered under the KIUC HCP (i.e., covered species) to implement the covered activities over the term of the KIUC HCP. Species KIUC considered for coverage were all state- or federally listed species that could be present in the Plan Area.

Table 1A-1 presents the evaluation process and results of the process for each of the species considered. As a result of this evaluation, KIUC identified nine species as meeting the criteria for inclusion as covered species in the KIUC HCP; Chapter 1, *Introduction and Background*, Table 1-1 lists these species. Attachments 1 and 2 to this appendix provide more detailed rationale for excluding particular species from the KIUC HCP covered species list. Where necessary, the attachments also include avoidance and minimization measures KIUC must implement to ensure take of listed species is avoided.

Attachment 1. Evaluation of Hoary Bat (ʻōpeʻapeʻa) Coverage in KIUC HCP

Attachment 2. Measures to Avoid Adverse Effects on Listed Plant Species

Table 1A-1. Evaluation of Special-Status Animals and Plants for Coverage under the KIUC HCP

Scientific Name/ Common Name/Hawaiian Name[a]	Selection Criteria For Coverage[c]					Comments and Rationale
	Status [b] (Federal/ State)	Likely to Occur in the Plan Area	Potential to Adversely Affect	Sufficient Information	Proposed for Coverage	
Mammals						
Lasiurus cinereus semotu/Hawaiian hoary bat/ʻōpeʻapeʻa	E/E	+	±	+	No	Take unlikely with implementation of the avoidance and minimization measures described in Attachment 1.
Monachus schauinslandi/Hawaiian monk seal/ʻīlio-holo-i-ka-uaua	E/E	+	-	+	No	Take from covered activities unlikely.
Birds						
Puffinus auricularis newelli/Newell's shearwater/ʻaʻo	T/T	+	+	+	Yes	Recommended for coverage under the Plan.
Pterodroma sandwichensis/Hawaiian petrel/ʻuaʻu	E/E	+	+	+	Yes	Recommended for coverage under the Plan.
Oceanodroma castro/band-rumped storm-petrel/ʻakēʻakē	C/E	+	+	+	Yes	Recommended for coverage under the Plan.
Himantopus mexicanus knudseni/ Hawaiian stilt/aeʻo	E/E	+	+	+	Yes	Recommended for coverage under the Plan.
Anas wyvilliana/Hawaiian duck/koloa maoli	E/E	+	+	+	Yes	Recommended for coverage under the Plan.
Fulica alai/Hawaiian coot/ʻalae keʻokeʻo	E/E	+	+	+	Yes	Recommended for coverage under the Plan.
Gallinula galeata sandvicensis/ Hawaiian gallinule/ʻalae ʻula	E/E	+	+	+	Yes	Recommended for coverage under the Plan.
Branta sandvicensis/Hawaiian goose/ nēnē	E/E	+	+	+	Yes	Recommended for coverage under the Plan.

Scientific Name/ Common Name/Hawaiian Name[a]	Selection Criteria For Coverage[c] Status [b] (Federal/ State)	Likely to Occur in the Plan Area	Potential to Adversely Affect	Sufficient Information	Proposed for Coverage	Comments and Rationale
Myadestes palmeri/Kauaʻi thrush/ puaiohi	E/E	+	-	+	No	Take from covered activities unlikely.
Oreomystis bairdi/Kauaʻi creeper/ ʻakikiki	E/E	+	-	+	No	Take from covered activities unlikely.
Loxops caeruleirostris/Kauaʻi akepa/ akekeʻe	E/E	+	-	+	No	Take from covered activities unlikely.
Drepanis coccinea/scarlet honeycreeper/ʻiʻiwi	T/E	+	-	+	No	Take from covered activities unlikely.
Reptiles						
Chelonia mydas/green sea turtle Central North Pacific distinct population segment/honu	T/T	+	+	+	Yes	Recommended for coverage under the Plan.
Eretmochelys imbricata/hawksbill turtle/ʻea	E/E	+	-	+	No	Take from covered activities unlikely.
Lepidochelys olivacea/olive ridley sea turtle	T/T	+	-	+	No	Take from covered activities unlikely.
Caretta caretta/loggerhead sea turtle	T/T	+	-	+	No	Take from covered activities unlikely.
Demochelys coriacea/leatherback sea turtle	E/E	-	-	+	No	Take from covered activities unlikely.
Invertebrates						
Adelocosa anops/Kauaʻi cave wolf spider/peʻe peʻe makaʻole	E/E	+	-	+	No	Take from covered activities unlikely.
Spelaeorchestia koloana/Kauaʻi cave amphipod/ʻuku noho ana	E/E	+	-	+	No	Take from covered activities unlikely.

Scientific Name/ Common Name/Hawaiian Name[a]	Selection Criteria For Coverage[c]: Status [b] (Federal/ State)	Likely to Occur in the Plan Area	Potential to Adversely Affect	Sufficient Information	Proposed for Coverage	Comments and Rationale
Plants						
Adenophorus periens/pendant kihi fern/palai lāʻau	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Astelia waialeale/paʻiniu	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Bonamia menziesii/Hawaiʻi lady's nightcap	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Brighamis insignis/vulcan palm/ʻālula, hāhā	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Canavalia napaliensis/Mākaha Valley Jack-bean/ʻāwikiwiki, puakauhi	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Centaurium sebaeoides/lavaslope centaury/ʻāwiwi	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
*Charpentiera densiflora/*Nā Pali Coast pāpala/pāpala	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Cyrtandra kealiae subsp. *kealiae* (formerly *C. limahuliensis*)/haʻiwale, kanawao keʻokeʻo	T/T	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.

Scientific Name/ Common Name/Hawaiian Name[a]	Selection Criteria For Coverage[c] Status [b] (Federal/ State)	Likely to Occur in the Plan Area	Potential to Adversely Affect	Sufficient Information	Proposed for Coverage	Comments and Rationale
Cyrtandra oenobarba/shaggystem cyrtandra/hāʻiwale, kanawao keʻokeʻo	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Cyanea eleeleensis/hāhā	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Cyanea kolekoleensis/ Kolekole cyanea/hāhā	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Cyanea kuhihewa/Limahuli Valley cyanea/hāhā	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Cyanea recta/upright cyanea/hāhā	T/T	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Cyanea remyi/Remy's cyanea/hāhā	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Cyanea rivularis (listed as Delissea)/ plateau cyanea/hāhā	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Cyrtandra cyaneoides/māpele/ kanawao keʻokeʻo	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
*Delissea kauaiensis/*leechleaf delissea/ ʻoha	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.

Scientific Name/ Common Name/Hawaiian Name[a]	Selection Criteria For Coverage[c] Status [b] (Federal/ State)	Likely to Occur in the Plan Area	Potential to Adversely Affect	Sufficient Information	Proposed for Coverage	Comments and Rationale
Delissea rhytidosperma/Kauaʻi delissea/ʻoha	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Doryopteris angelica/Kauaʻi digit fern	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Dryopteris crinalis var. *podosorus*/ serpent woodfern/palapalai ʻaumakua	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Dubautia imbricata subsp. *imbricata*/ bog dubautia/naʻenaʻe, kūpaoa	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Dubautia kalalauensis/naʻenaʻe, kūpaoa	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Dubautia kenwoodii/Kalalau rim dubautia/naʻenaʻe, kūpaoa	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Dubautia waialealae/Waiʻaleʻale dubautia/naʻenaʻe, kūpaoa	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Euphorbia haeleeleana/Kauaʻi spurge/ ʻakoko	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Euphorbia eleanoriae/Nā Pali sandmat/ʻakoko	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.

Scientific Name/ Common Name/Hawaiian Name[a]	Selection Criteria For Coverage[c] Status [b] (Federal/ State)	Likely to Occur in the Plan Area	Potential to Adversely Affect	Sufficient Information	Proposed for Coverage	Comments and Rationale
Euphorbia remyi var. *kauaiensis*/ Remy's sandmat/'akoko	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Euphorbia remyi var. *remyi*/Remy's sandmat/'akoko	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Exocarpos luteolus/leafy ballart/heau, au	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Flueggea neowawraea/mēhamehame	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Hesperomannia lydgatei/Kaua'i island-aster	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Hibiscadelphus woodii/Wood's hau kuahiwi	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Hibiscus waimeae subsp. *hannerae*/ Hibiscus waimeae/aloalo, koki'o ke'oke'o, koki'o kea	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Ischaemum byrone/Hilo murainagrass, Hilo ischaemum	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Isodendrion longifolium/longleaf isodendrion/aupaka	T/T	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.

Scientific Name/ Common Name/Hawaiian Name[a]	Selection Criteria For Coverage[c]: Status [b] (Federal/ State)	Likely to Occur in the Plan Area	Potential to Adversely Affect	Sufficient Information	Proposed for Coverage	Comments and Rationale
Kadua cookiana/Cook's bluet/ʻāwiwi	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Kadua st-johnii/Nā Pali beach starviolet	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Keysseria erici/Alakaʻi Swamp island-daisy	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Keysseria helenae/Mt. Waiʻaleʻale island-daisy	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Labordia helleri/Nā Pali Coast labordia/kāmakahala	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Labordia lydgatei/Wahiawa Mountain labordia/kāmakahala	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Labordia pumila/Kauaʻi labordia/ kāmakahala	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Lobelia niihauensis/Niʻihau lobelia	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Lysimachia daphnoides/Pacific loosestrife/ehua makanoe, kolokolo kuahiwi, kolekole lehua, kolokolo lehua	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.

Scientific Name/ Common Name/Hawaiian Name[a]	Selection Criteria For Coverage[c] Status [b] (Federal/ State)	Likely to Occur in the Plan Area	Potential to Adversely Affect	Sufficient Information	Proposed for Coverage	Comments and Rationale
Lysimachia scopulensis/ shiny-leaf yellow loosestrife/ehua makanoe, kolokolo kuahiwi, kolekole lehua, kolokolo lehua	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Melicope degeneri/Kōke'e Stream melicope/alani, alani kuahiwi	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Melicope pallida/pale melicope/alani, alani kuahiwi	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Melicope paniculata/Līhu'e melicope/ alani, alani kuahiwi	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Melicope puberula/hairy melicope/ alani, alani kuahiwi	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Myrsine linearifolia/narrowleaf colicwood/kōlea	T/T	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Myrsine mezii/ Hanapēpē River colicwood/kōlea	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Peucedanum sandwicense/makou	T/T	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Phyllostegia renovans/red-leaf phyllostegia	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.

Scientific Name/ Common Name/Hawaiian Name[a]	Selection Criteria For Coverage[c]					Comments and Rationale
	Status [b] (Federal/ State)	Likely to Occur in the Plan Area	Potential to Adversely Affect	Sufficient Information	Proposed for Coverage	
Phyllostegia wawrana/fuzzystem phyllostegia	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Pittosporum napaliense/royal cheesewood/hō‘awa, hā‘awa	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Plantago princeps var. *anomola*/ale/ laukahi kuahiwi	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Plantago princeps var. *longibracteata*/ ale/laukahi kuahiwi	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Plantanthera holochila/Hawai‘i bog orchid	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Platydesma rostrata/pilo kea lau li‘i	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Poa manii/Olokele Gulch bluegrass	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Poa sandvicensis/Hawaiian bluegrass	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Polyscias bissattenuata/‘ohe‘ohe	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.

Scientific Name/ Common Name/Hawaiian Name[a]	Selection Criteria For Coverage[c] Status [b] (Federal/ State)	Likely to Occur in the Plan Area	Potential to Adversely Affect	Sufficient Information	Proposed for Coverage	Comments and Rationale
Polyscias flynii/ʻoheʻohe	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Polyscias racemosum/Munroidendron	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Pritchardia hardyi/Hardy's loulu/loulu	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Pritchardia napaliensis/Nāpali loulu/ kōpiko	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Psychotria hobdyi/Hobdy's wild-coffee/kōpiko	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Pteralyyxia kauaiensis/kaulu	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Remya montgomeryi/Kalalau Valley remya	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Scheidea kauaiensis/Kauaʻi schiedea	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Schiedea lychnoides (listed as *Alsinidendron lychnoides*)/ kuawāwaenohu	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.

Scientific Name/ Common Name/Hawaiian Name[a]	Selection Criteria For Coverage[c]					Comments and Rationale
	Status [b] (Federal/ State)	Likely to Occur in the Plan Area	Potential to Adversely Affect	Sufficient Information	Proposed for Coverage	
Stenogyne kealiae/Keal's stenogyne	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Stenogyne campanulata/Kalalau Valley stenogyne	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Tetraplasandra kavaiensis/ʻoheʻohe	E/E	+	±	-	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.
Wilkseya hobdyi/dwarf iliau	E/E	+	±	+	No	Adverse effects from covered activities, including conservation measures, unlikely with implementation of the avoidance and minimization measures described in Attachment 2.

[a] When available, all three names are listed in order from scientific name, common, and Hawaiian name.

[b] **Federal**

E = listed as endangered under the ESA

T = listed as threatened

C = candidate for listing under ESA

[b] **State**

E = listed as endangered

T = listed as threatened

[c] **Criteria met or not**

\+ = Yes, the species meets the selection criteria

– = No, the species does not meet the selection criteria

U = Uncertain whether species meets selection criteria. More investigation required.

Attachment 1. Evaluation of Hawaiian Hoary Bat (‘ōpe‘ape‘a) Coverage in KIUC HCP

Memorandum

Date:	August 13, 2020
To:	Dawn Huff, Kaua‘i Island Utility Cooperative (KIUC)
From:	Dave Johnston, Paul Conry, Ron Duke, and Scott Terrill (HT Harvey) David Zippin, Torrey Edell, Ellen Berryman (ICF)
Subject:	**Evaluation of Hawaiian hoary bat (‘ōpe‘ape‘a) coverage in KIUC HCP**

The purpose of this memorandum is to document KIUC's evaluation to determine whether listed Hawaiian hoary bats (‘ōpe‘ape‘a) (*Lasiurus cinereus semotus*) should be included as covered species in the KIUC Habitat Conservation Plan (KIUC HCP).

Criteria for Coverage

KIUC used the following criteria to evaluate potential covered species in the HCP. KIUC decided to cover species in the HCP if they met all four of the criteria described below.

1. **Listing status.** The species is currently listed under the federal Endangered Species Act (federal ESA) or the Hawai‘i ESA (Hawai‘i Revised Statute [HRS] 195D-4).
2. **Geographic range**. The species is currently known to occur throughout the Plan Area (Island of Kaua‘i) based on knowledge of the species' geographic range and the presence of suitable habitat.
3. **Effects of covered activities.** The species has a reasonable likelihood of "take" as defined by the federal ESA and Hawai‘i ESA by HCP covered activities that are currently occurring within the Plan Area or are likely to occur over the life of the permits.
4. **Adequacy of existing data on the species.** Sufficient data is available regarding the species' life history, habitat requirements, and presence in the Plan Area to adequately evaluate effects on the species and develop appropriate conservation measures to satisfy the permit issuance criteria of the ESA Section 10 and HRS Section 195D-2.

The Hawaiian hoary bat (‘ōpe‘ape‘a) was state- and federally listed as endangered on October 13, 1970 (U.S. Fish and Wildlife Service 1970). No critical habitat has been designated for the Hawaiian hoary bat (‘ōpe‘ape‘a). This species is widespread on the island of Kaua‘i (U.S. Fish and Wildlife Service 1998). Based on data from the islands of Hawai‘i (Bonaccorso et al. 2015) and Maui (H.T. Harvey and Associates 2019), bat activity occurs in many habitats and females nursing young are generally expected at lower elevations (less than 1,000 feet [304.8 meters] in elevation) during summer months. Thus, the species is expected to raise young throughout much of the lowland areas with appropriate larger trees with dense foliage.

The Hawaiian hoary bat (‘ōpe‘ape‘a) meets the first two criteria described above because it is both listed and known to occur on Kaua‘i. Additionally, the species meets the fourth criteria because sufficient data is available to evaluate effects on the species and develop appropriate conservation measures to satisfy permit issuance criteria. The remainder of this memo focuses on the third criterion: the effects of covered activities on the Hawaiian hoary bat (‘ōpe‘ape‘a) and the likelihood of take, and commitments from KIUC to avoid take of this species.

Effects of Covered Activities

The only KIUC activity with the potential to affect Hawaiian hoary bats (‘ōpe‘ape‘a) is the pruning or removal of trees, but KIUC can avoid take of Hawaiian hoary bats (‘ōpe‘ape‘a) resulting from this activity through the implementation of avoidance measures. While the operation of streetlights may influence Hawaiian hoary bats (‘ōpe‘ape‘a) behavior by attracting bats, no adverse effects of the streetlights are anticipated. Each of these covered activities is detailed below.

Tree Pruning and Removal

Nursing females typically leave their pups in the roost tree while they forage (Barclay 1989), leaving young Hawaiian hoary bat (‘ōpe‘ape‘a) pups unable to leave a tree that is being trimmed or removed. Non-flying pups are therefore vulnerable until they can fly on their own. To avoid and minimize impacts on endangered Hawaiian hoary bats (‘ōpe‘ape‘a), the U.S. Fish and Wildlife Service (USFWS) recommends that projects: (1) do not disturb, remove or trim woody plants more than 15 feet (4.6 meters) tall during the bat birthing and pup rearing season of June 1 through September 15; and (2) do not use barbed wire for fencing (U.S. Fish and Wildlife Service 2020). Similarly, the State of Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife (DOFAW) provides guidance that site clearing should be timed to avoid disturbance during the bat birthing and pup rearing season from June 1 through September 15. However, if site clearing cannot be avoided, including for emergency work, woody plants more than than 15 feet (4.6 meters) tall should not be disturbed, removed, or trimmed without consulting DOFAW (Appendix A; State of Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife 2015, 2020).

Take of Hawaiian hoary bats (‘ōpe‘ape‘a) pups is more likely when dense vegetation is trimmed along lightly traveled roads, because this species is much more likely to use these areas than heavily travelled roadways with sparse vegetation (H.T. Harvey and Associates 2014). Based on recent radio-tracking data from Maui, bats roosted occasionally along quiet neighborhood streets with large densely foliated trees, but did not roost in trees under 15 feet (4.6 meters) tall or in trees that had relatively sparse leaves (e.g., albizia [*Falcataria moluccana*]) (H.T. Harvey and Associates 2019). During 2 years of data collection, on only a single night was a a male bat observed roosting in a tree along a busy two-lane highway (Kula Highway); a Chinese elm (*Ulmus parvifolia*) with large mats of vines making a very densely foliated tree (i.e., a tree with foliage too dense to be able to see light coming through the tree) (H.T. Harvey and Associates 2019). Females, on the other hand, were never observed roosting along busy two-lane highways (H.T. Harvey and Associates 2019).

To evaluate the potential for Hawaiian hoary bats (‘ōpe‘ape‘a) take from vegetation trimming and removal, KIUC commissioned and implemented a pre-trimming bat monitoring program during the bat pup rearing seasons between 2013 and 2015, using thermal imaging. Tree trimmers were trained by KIUC’s consulting biologist on the use and methodology for searching vegetation on a daily basis in areas to be trimmed during the bat pup rearing season prior to vegetation clearing. The tree trimmers were trained using live mice in small cages that were hidden in vegetation along typical line-clearing segments by KIUC and its biologist. Training and blind searcher efficiency trials were conducted each year. During 3 years of monitoring during the bat pup rearing season (June 1 through September 15), KIUC and its contractors failed to find a single bat in over 662 tree-trimming unit-days. Even though no bats had been detected during tree-trimming activities, at the end of the 2015 season KIUC agreed to refrain from trimming in potential habitat during the pup rearing season. USFWS agreed that, with implementation of this measure and additional measures outlined below under *Avoidance Measures,* KIUC will avoid take of Hawaiian hoary bats (ʻōpeʻapeʻa) (Appendix A; U.S. Fish and Wildlife Service 2015).

Street Light Attraction

The Hawaiian hoary bat (ʻōpeʻapeʻa) regularly forages at streetlights (Belwood and Fullard 1984), and concentrations of moths around streetlights likely reduces the foraging time for bats (Acharya and Fenton 1999). Thus, these streetlights concentrate large moths, which also maximizes energy returns for the bats (Acharya and Fenton 1999).

Currently no data exist on the predation of the Hawaiian hoary bat (ʻōpeʻapeʻa) by owls or other predators (State of Hawaiʻi Department of Land and Natural Resources, Division of Forestry and Wildlife 2015). Based on the ecology of other fast-flying open aerial foragers that forage at streetlights (Rydell et al. 1996), predation by owls at streetlights is unlikely. Rydell et al. (1996) found that smaller bats tend to begin foraging later than larger bats, possibly to avoid avian predation that is likely a greater risk with more available light. However, larger and therefore faster flying insectivorous bats, such as the Hawaiian hoary bat (ʻōpeʻapeʻa), start foraging earlier than slower bats, even when differences in diet and foraging habitat are controlled for (Jones and Rydell 1994). Because the Hawaiian hoary bat (ʻōpeʻapeʻa) often begins foraging at or just prior to sunset (Bonaccorso et al. 2015) while light values are relatively high compared to an hour or more later, this species does not appear to be avoiding predation. Therefore, it is unlikely that predation on the Hawaiian hoary bat (ʻōpeʻapeʻa) occurs when light values are high, such as is the case at streetlights.

Even though the Hawaiian hoary bat (ʻōpeʻapeʻa) is widely distributed on Kauaʻi, there are no data suggesting that bats have collided, or will likely collide, with utility structures on Kauaʻi. Currently, the only documented risk to the Hawaiian hoary bat (ʻōpeʻapeʻa) from anthropogenic structures are bats having been caught on barbed wire fencing and colliding with rotating wind turbines.

Avoidance Measures

During the KIUC HCP permit term, KIUC will commit to the following measures to avoid take of Hawaiian hoary bat (ʻōpeʻapeʻa).

1. KIUC will refrain from vegetation trimming or removal during the pup rearing season (June 1 to September 15) where vegetation is over 15 feet (4.6 meters) tall.[1]

2. Based on results from 3 years of comprehensive bat search protocols, vegetation maintenance in areas along heavily traveled roadways that lack vegetation over 15 feet (4.6 meters) tall may be trimmed during the Hawaiian hoary bat (ʻōpeʻapeʻa) bat pupping season (June 1 to September 15) (U.S. Fish and Wildlife Service 2015).

[1] This measures excludes grasses over 15 feet (4.6 meters) tall (i.e., Guinea grass) that are characterized by the lack of overhanging foliage (Willis and Brigham 2005).

3. In the very rare circumstances when removing/trimming/disturbing trees is necessary to correct a location-specific service problem (such as a trouble call reporting that a tree limb had fallen against lines or due to wind repeatedly striking a line, causing light flickering or breaker openings) during the bat pup rearing season, KIUC will only perform the minimum amount of tree trimming absolutely necessary to alleviate the immediate service problem. These very rare situations are not expected to involve take by removing only the minimum amount of vegetation necessary to correct the service problem and avoid imminent danger to lives and property. DOFAW and USFWS will be consulted via email with information on the event (e.g., location, date of removal, type of vegetation) before any vegetation more than 15 feet (4.6 meters) tall is disturbed, removed, or trimmed during the pup rearing season (June 1 through September 15).
4. No barbed wire will be used for conservation fencing.

Conclusion

The Hawaiian hoary bat (ʻōpeʻapeʻa) does not meet all four criteria for coverage under the KIUC HCP. Although the species is federally listed and occurs in the HCP permit area, and sufficient information exists to assess effects on the species and develop a conservation strategy, KIUC activities will avoid take of Hawaiian hoary bat (ʻōpeʻapeʻa). Vegetation trimming or removal will not result in take of Hawaiian hoary bats (ʻōpeʻapeʻa) with implementation of the avoidance measures described above. Furthermore, streetlights are not expected to result in take of Hawaiian hoary bat (ʻōpeʻapeʻa) for the reasons described above. Therefore, the KIUC HCP will not cover Hawaiian hoary bat (ʻōpeʻapeʻa).

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Appendix A. Agency Guidance Regarding Avoidance and Minimization Measures for Hawaiian Hoary Bat (‘ōpe‘ape‘a)

1. U.S. Fish and Wildlife Service December 16, 2015 letter regarding bat monitoring.
2. Division of Forestry and Wildlife August 6, 2020 email regarding guidance on bat take avoidance.

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Pacific Islands Fish and Wildlife Office
300 Ala Moana Boulevard, Room 3-122
Honolulu, Hawai'i 96850

In Reply Refer To:
01EPIF00-2016-TA-0119

DEC 1 6 2015

Mr. Carey Koide
Transmission and Distribution Manager
Kaua'i Island Utility Cooperative
4463 Pahe'e Street, Suite 1
Līhu'e, HI 96766

Subject: Kaua'i Island Utility Cooperative Request to Forego Further Bat Monitoring

Dear Mr. Koide:

This responds to your December 2, 2015 letter requesting to modify avoidance measures to prevent take of the Hawaiian hoary bat (*Lasiurus cinereus semotus*) during Kaua'i Island Utility Cooperative's (KIUC) maintenance operations. The KIUC has implemented comprehensive bat search protocols over the course of three bat pupping seasons (each June through September) in order to prevent the take of bats during tree trimming operations, as a component under KIUC's 2011 Service-approved Short Term Habitat Conservation Plan (ST HCP). The comprehensive bat monitoring protocols, approved by the Service in 2013 (Service File 2013-TA-0306) include the use of thermal imaging devices to scan for the absence of non-volant young in tree canopies prior to trimming, as well as annual field training for all personnel involved and blind searcher efficiency trials to test the ability for tree-trimming crews to accurately detect and avoid take of bats.

The Service received KIUC's 2015 bat monitoring report on December 1, 2015. Reviewing KIUC's monitoring data reports for 2013, 2014, and 2015 indicates that the tree-trimming teams have completed a total of 662 tree-trimming unit-days of monitoring of lowland vegetation clearing without encountering a single bat. Results from the searcher efficiency trials shows that tree-trimming teams have a very high likelihood of detecting a bat, if a bat were present.

Based on this information, the Service agrees with KIUC's decision to modify bat avoidance measures and forego comprehensive bat search protocols and instead limit tree-trimming during the bat pupping season (June through September) to areas along heavily traveled roadways that lack dense vegetation. The rationale behind that decision was based on the concern that in areas of very dense vegetation and along lightly traveled back roads there is a greater likelihood that bats might use that vegetation for roosting, and therefore the KIUC would not perform tree-trimming operations in these areas during the bat pupping season.

This modified bat avoidance measure, supported by three years of monitoring data, should be considered in the development of any new KIUC-proposed habitat conservation plan. If actions proposed by KIUC are reasonably certain to result in any take of a Hawaiian hoary bat, then KIUC is recommended to seek incidental take authorization. We thank you for your efforts to conserve and protect Kaua'i's threatened and endangered species. If you have any questions regarding this letter, please contact Lasha Salbosa, Fish and Wildlife Biologist (phone: 808-792-9400 or email: Lasha-Lynn_Salbosa@fws.gov).

Sincerely,

Aaron Nadig
Island Team Manager:
O'ahu, Kaua'i, Northwestern Hawaiian Islands, and American Samoa

From: Taylor, Lauren
To: Ilana Nimz
Cc: Phil Taylor; Siddiqi, Afsheen A; tkoike@honolulu.gov; Aloha Arborist Association; Angela Liu-kelly; john_vetter@fws.gov; Steve; Dave Johnston; Bookless CIV Lance; william.grannis@us.af.mil; angela.kieranvast@navy.mil; dayna.fujimoto@navy.mil; Matthew Burt; Tyler Bogardus; keith.roberts1@usmc.mil; Stan Oka; kevin_donmoyer@fws.gov; joy_browning@fws.gov; nanea_valeros@fws.gov; Berry, Lainie; Matsuoka, Koa; Montoya-Aiona, Kristina; KAWELO, Hilary K (Kapua) CIV (US); Craig.Gorsuch@colostate.edu; angelia.binder@us.af.mil; matthew.welsh.2.ctr@us.af.mil; Moura, Sean; Katie Temple
Subject: RE: [EXTERNAL] Notes from HHB in Urban Forest meeting
Date: Thursday, August 6, 2020 4:44:09 PM

Aloha all,

Since this meeting DOFAW has had some inquiries about tree trimming during the bat pupping season. I would like to reiterate the State's current guidance on bat take avoidance and am happy for you to disseminate to your colleagues.

The State endangered Hawaiian Hoary Bat or ʻOpeʻapeʻa (*Lasiurus cinereus semotus*) has the potential to occur throughout the islands and roosts in a variety of trees. If any trees must be removed during the bat breeding season there is a risk of injury or mortality to juvenile bats. Site clearing should be timed to avoid disturbance during the bat birthing and pup rearing season (June 1 through September 15). If this cannot be avoided, including for emergency work, woody plants greater than 15 feet (4.6 meters) tall should not be disturbed, removed, or trimmed without consulting DOFAW at (808) 587-0160.

Currently we do not have data or research to support a method for reliably detecting roosting bats in trees. Therefore, to avoid the potential for take, the State recommends avoiding trimming during the pupping season.

Hawaii Revised Statutes Chapter 195D prohibits take of State listed species except when accompanied by an Incidental Take License and Habitat Conservation Plan. Our first priority in all instances is to assist in avoiding take of listed species. For take that cannot be avoided, we will work with the project proponent to minimize and mitigate the impacts of take. For anyone interested in pursuing an Incidental Take License, you may contact Koa Matsuoka (koa.matsuoka@hawaii.gov) or me for a consultation.

Respectfully,

Lauren Taylor
Protected Species Habitat Conservation Planning Coordinator
Endangered Species Biologist
Pacific Cooperative Studies Unit in cooperation with
Department of Land and Natural Resources

Division of Forestry and Wildlife
1151 Punchbowl Street, Room25
Honolulu, HI 96813
(808) 587-0010

Attachment 2. Measures to Avoid Adverse Effects on Listed Plant Species

KIUC will implement the following avoidance measures to ensure the KIUC HCP conservation measures do not adversely affect state- and federally listed plant species.

1. Prior to implementation of covered activities in potentially suitable habitat for listed plant species, including implementation of the conservation strategy minimization and conservation actions, a qualified botantist will conduct a botanical survey for listed plant species within the work area defined as the area where direct and indirect effects are likely to occur. Botanical surveys should optimally be conducted during the wettest part of the year (typically October to April) when plants and identifying features are more likely to be visible, especially in drier areas. If surveys are conducted outside of the wet season, plant presence will be assumed. If observed, listed plant locations will be mapped. The botanist should mark the boundary of the area occupied by listed plants with flagging.
2. KIUC will coordinate with a qualified botanist to implement measures ensuring the covered activities will avoid adverse effects on listed plants. KIUC will time their activities to occur when the listed plant species are less vulnerable to impacts (e.g., after seed has set), to the maximum extent possible. Buffer distances will be implemented for the actions listed in Table A2-1. The buffer distances will reduce direct and indirect impacts on listed plants from management actions. However, where covered activities occur within the recommended buffer distances, additional consultation with USFWS and DOFAW will be conducted. Impacts on the listed plant species within the buffer area may be reduced by placing temporary fencing or other barriers at the boundary of the disturbance, as far from the affected plants as practicable. KIUC may also implement erosion or siltation control measures to ensure listed plants in the vicinity of the management area are not adversely affected.
3. Prior to any work activities within management areas near or within a listed plant species buffer, the qualified botanist will conduct a worker environmental awareness training for all staff. The training will cover the listed plant species and their habitats. The training will cover the natural history, appearance (using representative photographs), and legal status of species, regulatory protections, benefits of compliance, as well as the avoidance and minimization measures that must be implemented to avoid impacts. Participants will be required to sign a form that states they have received and understand the training.
4. All activities, including sureys and monitoring, risk introducing invasive species into work areas. All equipment, personnel and supplies will be properly checked to ensure they are free of contamination (weed seeds, organic matter, or other contaminants) before entering work areas. Quarantines and or management activities occurring on specific priority invasive species proximal to project areas need to be considered or adequately addressed. This information will be obtained by contacting local experts such as those on local invasive species committees (Kaua'i: https://www.kauaiisc.org/). To avoid the potential spread of Rapid 'Ōhi'a Death (ROD), ROD decontamination proctocols will be followed.

Table A2-1. Buffer Distances to Avoid and Minimize Potential Adverse Impacts on Listed Plant Species

Action		Buffer Distance (feet (meters))—Keep Work Activity This Far Away from Listed Plant	
		Grasses/Herbs/Shrubs and Terrestrial Orchids	Trees and Arboreal Orchids
Walking, hiking, surveys/monitoring		3 ft (1 m)	3 ft (1 m)
Cutting and removing vegetation by hand or hand tools (e.g., weeding)		3 ft (1 m)	3 ft (1 m)
Mechanical removal of individual plants or woody vegetation (e.g., chainsaw, weed eater)		3 ft up to height of removed vegetation (whichever greater)	3 ft up to height of removed vegetation (whichever greater)
Removal of vegetation with heavy equipment (e.g., bulldozer, tractor, "bush hog")		2x width equipment + height of vegetation	820 ft (250 m)
Use of approved herbicides (following label)	Ground-based spray application; hand application (no wand applicator; spot treatment)	10 ft (3 m)	Crown diameter
	Ground-based spray application; manual pump with wand, backpack	50 ft (15 m)	Crown diameter
	Ground-based spray application; vehicle-mounted tank sprayer	50 ft (15 m)	Crown diameter
	Aerial spray (ball applicator)	250 ft (76 m)	250 ft (76 m)
	Aerial application – herbicide ballistic technology (individual plant treatment)	100 ft (30 m)	Crown diameter
	Aerial spray (boom)	Further consultation required	Further consultation required
Ground/soil disturbance/outplanting/fencing (hand tools, e.g., shovel, 'ō'ō; small mechanized tools, e.g., auger)		20 ft (6 m)	2x crown diameter
Ground/soil disturbance (heavy equipment)		328 ft (100 m)	820 ft (250 m)
Surface hardening/ soil compaction	Trails (e.g., human, ungulates)	20 ft (6 m)	2x crown diameter
	Roads/utility corridors, buildings/structures	328 ft (100 m)	820 ft (250 m)

Appendix 3A
Species Accounts

3A.1 Newell's Shearwater (ʻaʻo) (*Puffinus auricularis newelli*)

3A.1.1 Listing Status and Taxonomy

The Newell's shearwater (ʻaʻo) (*Puffinus auricularis newelli*), listed as threatened under the federal Endangered Species Act (federal ESA) in 1975, is endemic to the Main Hawaiian Islands (MHI) (Niʻihau, Kauaʻi, Oʻahu, Molokaʻi, Maui, Lānaʻi, Kahoʻolawe, and Hawaiʻi). This species is in the seabird family Procellariidae (Ainley et al. 1997a, 2020). The Newell's shearwater (ʻaʻo) was until recently considered by both the U.S. Fish and Wildlife Service (USFWS) and the North American Classification Committee (NACC) as a *super species* containing the Townsend's shearwater (*P. auricularis townsendi*) and Newell's shearwaters (ʻaʻo) collectively treated as *Puffinus auricularis newelli.* In 2015, NACC decided that both were full species (Chesser et al. 2015), given their non-overlapping breeding and foraging ranges, and morphological and phenological differences (Ainley et al. 2020). USFWS, however, continues to treat both Townsend's shearwater and Newell's shearwater (ʻaʻo) as subspecies of *Puffinus auricularis* (U.S. Fish and Wildlife Service 2016a). Newell's shearwaters (ʻaʻo) and Townsend's shearwaters separate based on breeding phenology and distribution, behavior, and plumage (Ainley et al. 1997a, 2020). The species is also listed as threatened under Hawaiʻi Revised Statutes (HRS), Chapter 195D, Section 195D-4, Endangered and Threatened Species. The species is ranked as critically endangered under the International Union for Conservation of Nature (IUCN) Red List (BirdLife International 2019). No critical habitat has been designated for the Newell's shearwater (ʻaʻo) (50 Code of Federal Regulations 17.11).

3A.1.2 Life History

The Newell's shearwater (ʻaʻo) breeds only in the southeastern Hawaiian Islands (Pyle and Pyle 2017a). As summarized in Ainley et al. (2020), when not at breeding colonies, the Newell's shearwater (ʻaʻo) is highly pelagic, frequenting tropical and subtropical waters overlying depths greater than 6,562 feet (ft) (2,000 meters [m]), mostly east and south of the Hawaiian Islands. It captures prey by pursuit-plunging, an uncommon foraging method among warm-water seabirds (Ainley 1977) and can regularly reach depths of 164 ft (50 m) in pursuit of prey (Ainley et al. 2020). Flight is strong, with rapid wing beats interspersed with short glides, a style requiring predictable prey availability; thus, this flight style is also uncommon among warm-water seabirds (Spear and Ainley 1997a, 1997b). These shearwaters rely heavily on tuna, especially yellowfin tuna (*Thunnus albacares*) and other large, predatory fish that drive prey (predominantly ommastrephid squid) toward the ocean surface (Spear et al. 2007; Ainley et al. 2014).

Newell's shearwaters (ʻaʻo) arrive on colonies in early April, exhibit a pre-laying exodus from late April to mid-May (typical of procellarids), and lay eggs from late May to early June, with chicks fledging late September to mid-November, predominantly in October (Ainley et al. 2020). Females lay a single egg in a chamber at the end of a deep burrow. Incubation is 52–55 days; the chick-rearing period lasts approximately 92 days (Telfer 1986; Ainley et al. 2020).

3A.1.3 Habitat Requirements and Ecology

This species breeds in burrows or deep rock crevices, within dense vegetation at higher elevations, or on sheer coastal cliffs and slot canyons (i.e., long, narrow, deep canyon) (Troy et al. 2016; Ainley et al. 2020; Raine et al. 2021a). On the Island of Kauaʻi, Newell's shearwaters (ʻaʻo) breed at locations between 525 and 3,927 ft (160 and 1,197 m) above sea level (mean 1,509 ft [460 m] ± 394 ft [120 m] SD, *n* = 17; Ainley and Holmes 2011), and in Puna District on Hawaiʻi, at 620–1,083 ft (189–330 m) above sea level (Reynolds and Ritchotte 1997). Newell's shearwaters (ʻaʻo) no longer breed in lowlands, where wedge-tailed shearwaters (ʻuaʻu kani) (*Ardenna pacifica*) are abundant—a species that does not breed at higher elevations (Brattstrom and Howell 1956; Harrison 1990). One exception is a small Newell's shearwater (ʻaʻo) colony established artificially at Kīlauea Point, Kauaʻi, as part of a cross-fostering experiment (Byrd et al. 1984; Telfer 1986; Haber et al. 2010); this population consisted of six to nine breeding pairs in 2017 and nine pairs in 2019 (Raine et al. 2018a, 2020a). While Newell's shearwaters (ʻaʻo) and wedge-tailed shearwaters (ʻuaʻu kani) can co-occur, wedge-tailed shearwaters (ʻuaʻu kani) regularly evict breeding Newell's shearwater (ʻaʻo) pairs (Ainley et al. 2020; Raine et al. 2020a).

The Newell's shearwater (ʻaʻo) is absent in the Leeward Hawaiian Islands where other species of shearwaters, such as the wedge-tailed (ʻuaʻu kani) and Christmas (*Puffinus nativitatus*) shearwaters breed abundantly. These islands, however, are low in elevation, with sparse vegetation, which are factors not typical of Newell's shearwater (ʻaʻo) habitat (Troy et al. 2016; Young et al. 2019).

Due in part to the presence of pigs (*Sus scrofa*), rats (*Rattus* spp.), and cats (*Felis catus*), Newell's shearwaters (ʻaʻo) now nest on steep slopes ranging 28° to 48° on Kauaʻi (median = 39°; Troy et al. 2016), but also on near-vertical volcanic crater walls on Hawaiʻi (Reynolds and Richotte 1997; Ainley et al. 2020). Newell's shearwater (ʻaʻo) usually nest where terrain is vegetated by an open canopy of ʻōhiʻa lehua (*Metrosideros polymorpha*) and other native, wet, montane forest species, with an understory of densely matted false staghorn (uluhe) ferns (*Dicranopteris linearis*) (Troy et al. 2016). Raine et al. (2021a) documented that the three most important microhabitat variables for Newell's shearwater (ʻaʻo) are ʻōhiʻa lehua in the canopy, elevation, and percentage of false staghorn (uluhe) in the understory. The species also breeds, or at least recently bred, in the dry cliff faces of the Waimea Canyon and slot canyons of the Nā Pali Coast, Kauaʻi, both areas of sparse vegetation (Ainley et al. 2020). These birds may occasionally climb nearby trees or rock outcrops to take flight because they have difficultly taking off from flat ground (Telfer et al. 1987; Ainley et al. 2020); however, they have been observed to fly away on flat, unobstructed areas (shopping center parking lots) after becoming grounded when winds were adequately strong (Ainley et al. 1995).

Nesting colonies are situated inland from the coast—as much as 8.7 miles (mi) (14 kilometers [km]) on Kauaʻi. Inland-breeding Newell's shearwaters (ʻaʻo) on Kauaʻi repeatedly use the same routes when flying between breeding areas and the sea. Based on tracking work conducted by Raine et al. (2017a), key features the birds use to route to nesting colonies on Kauaʻi are terrain (specifically ridge tops) and prevailing wind, and while they have a few defined key routes, they appear to choose which route to take depending on prevailing wind direction and wind speed. On the other hand, outbound flights follow a broad swath out to sea, generally using the shortest possible distance between burrow and sea level.

Rainfall in Kauaʻi mountains, where Newell's shearwater (ʻaʻo) nest, is among the heaviest anywhere on Earth. Mean annual rainfall at Mount Waiʻaleʻale is 450 inches (1,143 centimeters [cm]); mean annual rainfall in Puna District and Waipiʻo Valley, on the windward east side of the island of

Hawai'i, is 108–213 inches (274–541 cm) (Encyclopedia Britannica 2020; Carlquist 1980; Giambelluca et al. 2013). Heavy rainfall facilitates dense vegetation growth.

3A.1.4 Distribution and Population Trends

3A.1.4.1 Current and Historic Distribution

As noted in Ainley et al. (2020), Newell's shearwaters ('a'o) occur year-round in the eastern tropical Pacific Ocean, especially in the Equatorial Countercurrent, from equatorial waters lying south of the Hawaiian Islands east to about 120°W and north to the subtropical waters surrounding the MHI (22°N). During breeding season, low densities occur short distances west and north of Hawai'i to about 25°N (King and Gould 1967; Spear et al. 1995a; Joyce et al. 2011). Also, during that time of year, the central part of the marine range projects slightly northward, likely an artifact of more adults and subadults commuting to and from breeding colonies (Ainley et al. 2020). Telemetry work conducted by the Kaua'i Endangered Seabird Recovery Project (KESRP) shows that during the breeding season, Newell's shearwaters ('a'o) predominately use water north of Kaua'i, up to 93.2 mi (150 km), while non-breeding or failed breeders can range more widely (Raine et al. 2021b). Nesting pairs engage in a short-long alteration of foraging trips, with one member of each pair making daily trips while the other is farther at sea for about a week; then they switch routines (Ainley et al. 2020).

Within the Hawaiian Islands, Newell's shearwaters ('a'o) are found in the fossil and subfossil deposits of O'ahu and other islands, and are believed, or are known, to have colonized Hawai'i, Maui, Moloka'i, O'ahu, and Kaua'i Islands (Pyle and Pyle 2017a; Ainley et al. 2020). While the early Hawaiians knew the seabird well, naming it 'a'o after its distinctive call, the species was thought to be extinct after 1908, due largely to habitat loss and predation (Pyle and Pyle 2017a). Since then, Newell's shearwaters ('a'o) have been detected on Kaua'i, O'ahu, Hawai'i, and Maui. Currently, breeding is only known to occur on Kaua'i, Maui and Hawai'i, but song meter recordings made in 2016 and 2017 indicate that a small number of Newell's shearwaters ('a'o) regularly prospect on O'ahu (Young et al. 2019).

3A.1.4.2 Within the Plan Area

The majority of the Newell's shearwater ('a'o) breeding areas are in the northwestern portion of Kaua'i (Figure 1). These breeding populations are found primarily in mountainous areas within deep valleys and along the edges of steep ridges (Ainley and Holmes 2011; Ainley et al. 2020). The only current coastal nesting site, established artificially, is at Kīlauea Point National Wildlife Refuge; as of 2017, a total of 25 burrows have been located at this site; 9 of these burrows were active in 2019 (Raine et al. 2020a). This population is the result of an egg swap project during 1978–1980 when approximately 100 Newell's shearwater ('a'o) eggs from burrows in the Anahola Mountains and Kaluahonu were moved to Kīlauea Point and Moku'ae'ae Islet (Byrd et al. 1984). The current distribution of Newell's shearwaters ('a'o) can in part be explained not only by the birds' preferred locations, but also range restrictions caused by predation by introduced mammals (Ainley et al. 2020) and other factors discussed above and further in Section A.1.5, *Threats*.

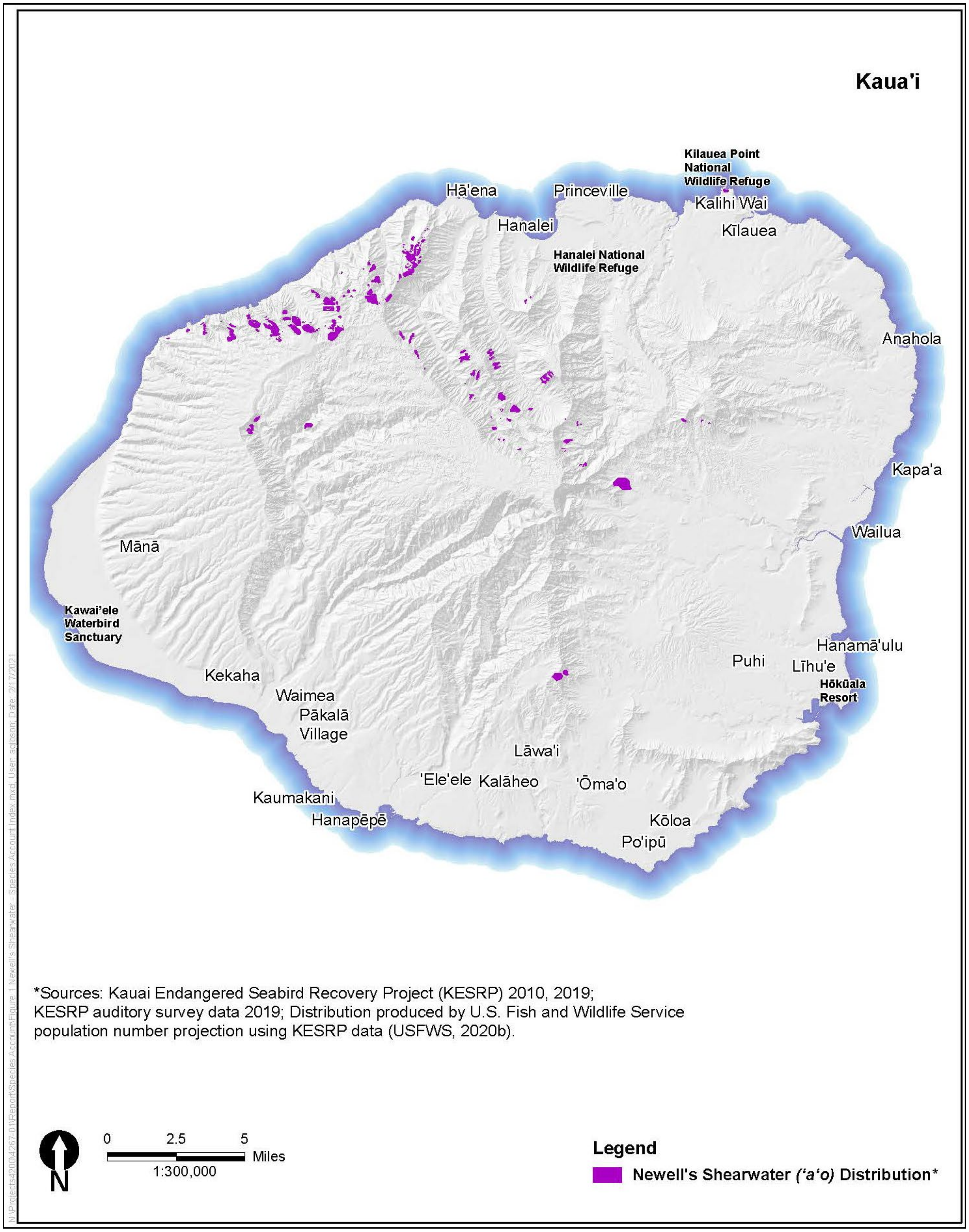

Figure 1. Current Confirmed Distribution of the Newell's Shearwater (ʻaʻo) Based on Contemporary Audio Surveys

Since 2006, KESRP has been using auditory surveys to locate contemporary breeding areas of this species. USFWS has estimated that the suitable breeding habitat range represents roughly 2,634 acres (1,066 hectares; U.S. Fish and Wildlife Service 2016b) that occurs predominantly in the northwestern portion of Kaua'i. Included are Wainiha Valley, Lumaha'i Valley, Hanalei Valley, Upper Limahuli Valley, Upper Mānoa Valley, and in the valleys along the Nā Pali Coast from Hanakāpi'ai to Nu'alolo (Raine et al. 2018b). Habitat suitability modeling by Troy et al. (2014) indicates that a moderate portion of the sloped interior of Kaua'i could potentially be suitable nesting habitat for Newell's shearwater ('a'o); however, in combination with a habitat/threat-isolation index (Troy et al. 2014), is much more restricted to portions of Kaua'i isolated from anthropogenic factors. The bulk of the known active Newell's shearwater ('a'o) burrows are in the Hono o Nā Pali Natural Area Reserve and Upper Limahuli Preserve (Raine et al. 2019a).

3A.1.4.3 Population

Kaua'i supports approximately 90 percent of the known total Newell's shearwater ('a'o) population (Pyle and Pyle 2009; Ainley et al. 2020). An assessment based on at-sea survey data collected by the National Marine Fisheries Service (NMFS) Southwest Fisheries Science Center from 1998 to 2011, estimated the total Newell's shearwater ('a'o) population at 27,011 (95 percent CI = 18,254–37,125), which would include juveniles, sub-adults, and adults (Joyce et al. 2016). An updated assessment by Joyce et al. (2019) largely confirmed the 2016 estimate, concluding there to be 28,779 Newell's shearwaters ('a'o) (95 percent CI = 17,574–43,011) (Joyce et al. 2019). However, these estimates are incomplete because the at-sea survey data analyzed by Joyce et al. (2016, 2019) only partially covered the full oceanic range of the species. Satellite-tagged Newell's shearwaters ('a'o) from Kaua'i have been tracked beyond the two at-sea survey boundaries, and the observed locations of tagged birds indicate that the available at-sea survey effort missed a substantial percentage of the population/at-sea range (Raine et al. 2021b). For example, those surveys did not include Newell's shearwaters ('a'o) seen more than 300 mi (482.8 km) north of Kaua'i (Joyce et al. 2016). Covering approximately the same ocean area, as well as decades earlier, Newell's shearwater ('a'o) population estimates made based on 1986–1998 at-sea surveys are somewhat higher at 16,700–19,300 breeding pairs (Spear et al. 1995a), although as Joyce et al. (2016) stated the two estimates were not directly comparable due to different survey areas and methods. The lower population estimate of Joyce et al., compared to Spear et al., nevertheless is consistent with the decrease seen both by long-term radar studies by KESRP and the Save Our Shearwaters (SOS) fledgling fallout data (Raine et al. 2017b).

Given there is no correction factor to account for the negative bias in the at-sea survey estimates of abundance, Archipelago Research and Conservation (ARC) has developed island-based spatial estimates for the number of Newell's shearwater ('a'o) breeding pairs in different areas of Kaua'i. These estimates expand on previous studies (Raine et al. 2019b), which developed methods to estimate breeding pairs in acoustically monitored conservation sites in northwestern Kaua'i (i.e., Upper Limahuli Preserve, Pihea, Pōhākea, North Bog, Hanakāpi'ai, and Hanakoa). In 2017, arrays of automated acoustic monitoring devices (also known as "song meters") were deployed in these conservation sites in areas where burrow monitoring surveys are also performed. The burrow monitoring surveys provide, among other things, estimates of active nest densities within the study areas. Further, studies within the burrow monitoring areas have demonstrated that the correlation between recorded call rates and active nest densities is highly significant (Raine et al. 2019b). In other words, areas with higher active nest densities have higher call rates, and the relationship between the two has been estimated through regression modeling. This allows the number of breeding pairs to be estimated from call rates measured by acoustic arrays that have been deployed to cover the footprint of monitored conservation sites (Archipelago Research and Conservation 2021). Additionally, this relationship has been used to estimate breeding pairs in other areas where acoustic monitoring data has been collected along the Nā Pali Coast and in the Lumahaʻi and Hanalei Valleys (Raine pers. comm.).

For other areas of Kauaʻi, where acoustic monitoring data are not available, ARC has used alternative methods to estimate breeding pairs, including a modified version of the Troy et al. (2014) habitat suitability model for Newell's shearwater (ʻaʻo) on Kauaʻi. The habitat suitability model was modified in several respects for this purpose, including filtering the estimated suitable habitat to reflect that, in areas without predator mitigation measures, the remaining breeding pairs are currently restricted to nesting in less accessible areas than those found in the conservation sites. Likewise, a correction factor was applied to account for active burrows being more dispersed in unmanaged areas (i.e., a reduction in densities of breeding pairs), due to (1) a lack of invasive predator control, resulting in higher predation rates on nesting birds in colonies outside the conservation sites, and (2) greater vulnerability to powerline collisions and light attraction in areas outside the more remote and undeveloped northwestern region of the island.

This approach resulted in a minimum estimate of 10,186 breeding pairs on Kauaʻi and a minimum island-wide population of 34,546, and as stated above, assuming the Kauaʻi population is 90 percent of the entire population, a minimum total of 11,318 breeding pairs and a minimum population of 38,384 in the State of Hawaiʻi.

3A.1.4.4 Decline/Trend

Based on radar and SOS data collected between 1993 and 2013 the Newell's shearwater (ʻaʻo) population exhibited a significant decline in numbers commuting to and from montane breeding areas (Raine et al. 2017b; Ainley et al. submitted); in the last decade the trend flatlined (Raine and Rossiter 2020; Ainley et al. 2020; Ainley et al. submitted). Ornithological radar was first used to detect prevalence of Newell's shearwaters (ʻaʻo) and Hawaiian petrels (ʻuaʻu) (*Pterodroma sandwichensis*) in the various parts of Kauaʻi during 1992–1993 from May through mid-July (i.e., during the incubation and early chick-rearing stage) (Day et al. 2003a, 2003b). The effort was based on methods developed to monitor marbled murrelets (*Brachyramphus marmoratus*) in the Pacific Northwest (Cooper et al. 2001). The radar effort continued, and Day et al. (2003b) reported a mean annual decrease of 11.2 percent in the Newell's shearwater (ʻaʻo) population between 1993 and 2001.

Updating the analyses presented in Day et al. (2003b), a subsequent study using radar data collected at the same monitoring sites between 1993 and 2013 confirmed the continued decline in the number of shearwaters transiting across eastern and southern Kauaʻi (Raine et al. 2017b). Radar surveys have only been conducted in coastal areas of eastern, southern, and portions of northern Kauaʻi, which are the sections of coast accessible to vehicle-mounted radar equipment. Therefore, these radar data do not apply to the Nā Pali Coast, where the population is now concentrated (Figure 1). The study found an overall decrease in passage rates of 94 percent in 20 years. All the 13 monitored sites showed a substantial decrease in movement rates, with movement rates at 12 (92 percent) of the 13 sites showing statistically significant decreases (Raine et al. 2017b). Based on the radar data as a proxy for the breeding population, the Newell's shearwater (ʻaʻo) population was deemed to have decreased at an annual mean rate of approximately 13 percent over the 20-year period between 1993 and 2013 (Raine et al. 2017b). This updated rate of decrease is comparable to the mean annual rate of 11.2 percent between 1993 and 2001 reported by Day et al. (2003b).

Parallel to the radar data, the number of Newell's shearwater (ʻaʻo) fledglings retrieved by the SOS program on Kauaʻi has also decreased significantly. These fledglings are predominantly grounded due to light attraction, a phenomenon called "fallout", which affects primarily hatch year juveniles. Fledglings may fly into elevated structures (i.e., buildings) or land on the ground. On the ground they have difficulty regaining flight unless the area is open and there is sufficient wind (Section A.1.3, *Habitat Requirements and Ecology*). On the ground they become vulnerable to further injury or death caused by vehicles on roadways, exhaustion and dehydration, and predation by feral animals. Prior to Hurricane ʻIniki in 1992, annual numbers of fledglings collected by SOS were on average 1,511 ± 79, but from 1992 (the year of Hurricane ʻIniki) to 2015, numbers declined strongly, from 955 to 157 annually (Raine et al. 2017b). The order-of-magnitude drop in SOS program retrievals mirrored the decrease observed in radar-based counts of Newell's shearwaters (ʻaʻo) made in the same portion of Kauaʻi monitored by SOS (Raine et al. 2017b). The shearwaters that nest in areas in northern Kauaʻi (Nā Pali Coast) do not appear to be flying where radar (limited to locations accessible by vehicle) would detect them, nor are they flying near civilization where citizens might encounter any that are grounded by light attraction (Raine et al. 2017a). Similarly, the SOS program is concentrated in the same portions of the island that are surveyed by radar. Troy et al. (2011) suggest that there are very few portions of Kauaʻi from which young Newell's shearwaters (ʻaʻo) could successfully fledge without potentially viewing artificial light along their post-natal nocturnal flights to the ocean. And although it is not known how these birds respond to viewing lights on land once they are at sea, studies indicate that the birds can be attracted by light back to shore (Podolsky et al. 1998). Indeed, nesting only along the beach, seaward of any lights or on offshore islets, wedge-tailed shearwaters (ʻuaʻu kani) are attracted back to land from the sea (Urmston et al. 2022).

Raine and Rossiter (2020) and Ainley et al. (submitted) have shown that the trends in both radar and SOS data have leveled out since about 2009, indicating that after a very large population decline the population trend appears over the last decade to be flat. Although data from the most recent radar survey in 2020 did not change the overall significant downward trajectory on Kauaʻi of Newell's shearwater (ʻaʻo) over the entire period since 1993 (93 percent decline in overall numbers with an average rate of 6.9 percent a year), the regression for the last decade (2010–2020) is flat, with no significant change (Raine and Rossiter 2020). It is thought that with the rise in human population, along with its domestic animals added to the rats and pigs already present on Kauaʻi as well as infrastructure collisions, populations of areas surveyable by radar are now much reduced. At the same time, the impact of recent conservation efforts (i.e., reduced coastal lighting) may also have contributed to reducing the rate of decline (Ainley et al. 2020; Raine et al. 2017c; Raine and Rossiter 2020). At conservation sites that have been acoustically monitored, and at which predators have been reduced or eliminated, there have been statistically significant increases in call rates between the first year of monitoring (either 2014 or 2015, depending on the site) and 2020. The rates of increase in call rates range between 8.23 percent at Hanakoa and 18.29 percent at North Bog (Archipelago Research and Conservation 2022).

Consistent with these observations indicating an overall population decrease at least for eastern and southern Kauaʻi, several historical breeding sites have been depleted to the point of extirpation over the past decade (Griesemer and Holmes 2011; U.S. Fish and Wildlife Service 2016b; Raine and Rossiter 2020). The Makaleha breeding site in northeastern Kauaʻi, into which predators have access, has been regularly monitored using auditory surveys performed from an adjacent ridge overlooking the colony. A decade ago, the Makaleha breeding site had high call rates like the Upper

Limahuli Preserve managed breeding site; today, call rates are sporadic at best (Raine pers. comm.). Elsewhere, decreasing numbers have occurred in breeding areas that border, or are contained in, the more urban portions of Kauaʻi. Formerly well-recognized breeding sites at Sleeping Giant, Kāhili/Kalāheo, North Fork Wailua, and Kaluahonu have similarly exhibited reduction to near extirpation levels (Raine pers. comm.).

3A.1.5 Threats

Threats to the Newell's shearwater (ʻaʻo) include collision with powerlines, attraction to artificial lighting and subsequent grounding, predation from introduced species, habitat loss and degradation, and threats at sea which, while poorly known presumably include depletion of predatory fish (e.g., yellowfin tuna), bycatch, ocean pollution, and in general ocean alteration due to climate change. All told, the effects of these various factors have resulted in a significant decline of approximately 13 percent per year over the period of 1993 to 2013 (Raine et al. 2017b; U.S. Fish and Wildlife Service 2017), with a rapid decline of the species from 2003 to 2007 (U.S. Fish and Wildlife Service 2016c). In addition to human-caused factors, stochastic events, such as storms, and ecologically disruptive processes driven by climate change are likely to have an effect on metapopulation numbers (U.S. Fish and Wildlife Service 2016c). The following subsections describe each known threat.

3A.1.5.1 Powerline Collisions

Collisions with utility lines have been shown to have a significant impact on endangered seabirds on Kauaʻi, and data collection since the 1990s has provided robust documentation of the mortality for this species due to powerline collisions in the Plan Area (Cooper and Day 1998; Podolsky et al. 1998; Ainley et al. 2001; Travers and Raine 2016, 2020; Travers et al. 2019). Birds moving to and from the ocean and montane breeding sites in the dark may not see the powerlines and as a result may collide with them (Travers et al. 2014, 2019; Travers and Raine 2020). Extensive studies conducted by KESRP since 2011 as part of the Kauaʻi Island Utility Cooperative (KIUC) Short-Term Habitat Conservation Plan (HCP) using acoustic monitoring devices and direct observations, indicate that every powerline construction type and every region with powerlines on Kauaʻi has resulted in seabird mortality due to collisions (Travers et al. 2020). As a result of collision, seabirds may be killed upon impact or may become grounded with life-threatening injuries. Once grounded, birds can succumb to their injuries and are at risk for vehicular collision, predation, starvation, or dehydration. Collisions with powerlines and their effect on Newell's shearwaters (ʻaʻo) are discussed in detail in Chapter 5, *Effects*, and therefore are only summarized here.

As mentioned above, one method to track powerline strikes is to directly observe nighttime seabird collisions using night vision goggles. Avian powerline morality initially was quantified through ground searches (Podolsky et al. 1998); however, this does not account for birds that become grounded but are not located (whether because they are able to crawl away, they are quickly depredated, or they glide and become grounded later) or are not mortally injured but may also suffer from reduced reproductive success. It is also very difficult to search underneath many powerlines on Kauaʻi due to the rugged terrain (Travers et al. 2020). From 2012 to 2020, Travers et al. (2021) documented 112 Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu) (30 percent/70 percent) collisions, of which 29 percent had negative impacts on flight capabilities.

To better understand strikes from powerlines in remote, unsearchable areas, KESRP developed a novel method to acoustically detect powerline collisions using autonomous recording devices. Increased monitoring coverage resulted in, for the first time, data collection rates that allowed for rapid quantification of the scale of seabird powerline collisions. Several models were then created by KESRP using this data, with the most recent being a Bayesian model (Travers et al. 2020). When seabirds collide with powerlines the grounding rate has been calculated as 28.8 percent (Travers et al. 2021). When this grounding rate is applied to the total number of acoustic strikes, it provides the number of grounded birds. This sampling method provided evidence that powerline strikes represent a serious threat to Newell's shearwater ('a'o) (and other Hawaiian seabirds) on Kaua'i. For more information on KESRP's powerline strike modeling, please see Appendix 5D, *Bayesian Acoustic Strike Model*.

3A.1.5.2 Light Attraction

Newell's shearwaters ('a'o) fly to and from their breeding sites only at night. Artificial lighting causes disorientation, especially in fledglings during their first journey from their breeding site to the sea. They tend to circle lights and, in the process, may collide with structures or may land. This is called *fallout*. Furthermore, some portion of fledglings that successfully reach the sea are attracted back toward land by coastal lights, where they may be then susceptible to fallout (Troy et al. 2013).

Fledglings are the most susceptible to fallout on Kaua'i (Telfer et al. 1987). Attraction to bright lights also occurs inland but seems to have a limited/negligible effect compared to coastal areas (Raine et al. 2019c). Even Newell's shearwaters ('a'o) in northwestern Kaua'i, where there are few lights, can be attracted back to land by bright lights (Troy et al. 2013).

Since the issue was first identified in the 1970s and 1980s, efforts have been implemented on Kaua'i to minimize effects of light attraction–related fallout. Problematic light sources once identified were altered (e.g., Reed et al. 1985). Otherwise, most of the information available on the effect of light attraction on Newell's shearwaters ('a'o) comes from the SOS Program, which was developed to minimize the effects of fallout on Kaua'i's seabird populations through resident collection and delivery of downed birds to SOS stations for rehabilitation and release (Rauzon 1991; Telfer et al. 1987).

During the last 5 years of the SOS Program (2014–2018), SOS received 179 downed Newell's shearwaters ('a'o) annually on average (Anderson 2019), 83 percent of which were released and observed flying to sea. Observations indicate that, in the absence of debilitating injuries or other threats, once grounded, shearwaters may be able to reorient themselves and are able to fly away if there is sufficient slope, sufficient wind to provide lift and an unobstructed pathway (Ainley et al. 1995, 2001). Unfortunately, it is thought that most grounded birds, if not found and recovered, are unable to gain flight and die from predation, vehicle strikes, or starvation and dehydration (Raine et al. 2020b).

Although it is not known what proportion of downed seabirds are discovered and turned in to SOS, or that fly away by themselves, previous studies have used several discovery or detection rates (Podolsky et al. 1998; Travers et al. 2012). The KIUC HCP assumes a detectability rate of 50 percent for areas that are systematically searched (i.e., facilities) (Ainley et al. 2001; U.S. Fish and Wildlife Service 2018a; State of Hawai'i Division of Forestry and Wildlife 2020), and a much lower rate of 10.4 percent for areas that are not systematically searched (i.e., streetlights). Please refer to Appendix 5A, *Light Attraction Modeling*, for a detailed discussion of detectability rates.

To assess whether birds released from SOS survived, a comparison was made using satellite tags affixed to SOS-released shearwater fledglings and those that naturally fledged from the Upper Limahuli Preserve. The results found that some birds that are released after rescue and rehabilitation by SOS do survive (thus highlighting the importance of SOS); however, the survival rates of birds released from SOS were lower than those that fledged naturally and flew directly out to sea (Raine et al. 2020b).

3A.1.5.3 Predation

Predation by introduced predators is likely the most significant threat to the Newell's shearwater (ʻaʻo) and has been since Kauaʻi was first settled by Polynesians (Ainley et al. 2001; Griesemer and Holmes 2011; Raine et al. 2019a, 2019c–g, 2020c). Being burrow nesters, Newell's shearwaters (ʻaʻo) are particularly vulnerable, as eggs, chicks, or adults, to predation by introduced species (Ainley et al. 2019; Raine et al. 2019a, 2019d–h, 2020c). Predation has been documented at all existing management sites (Nagendra et al. 2019; Raine et al. 2019a, 2019d–h). Predation on Newell's shearwaters (ʻaʻo) by feral cats, feral pigs, rats (particularly black rats [*Rattus rattus*]), dogs (*Canis familiaris*), barn owls (*Tyto alba*), and feral honeybees (*Apis* spp.), have all been documented as having serious impacts on this species (Raine et al. 2019a, 2019d–h). Although not confirmed as present on Kauaʻi (U.S. Fish and Wildlife Service 2019), predation by Indian mongoose (*Herpestes auropunctatus*) continues to be an issue on other islands with devastating effects on seabirds in the absence of ongoing predator control (Simons 1985; VanderWerf and Young 2014). Mongoose have been caught on Kauaʻi in recent years (Kauaʻi Invasive Species Committee 2021) and would become a serious threat if they become established. The same would be true of brown tree snakes (*Boiga irregularis*), which are rampant on several Southwestern Pacific islands such as Guam.

Observations made during the implementation of KIUC's Short-Term HCP and early implementation for this HCP have revealed how each predator affects the Newell's shearwater (ʻaʻo) population (see Raine et al. 2020c). Rats mainly target eggs and chicks; cats target chicks, subadults, and adults; and barn owls target subadults and adults. Burrow destruction and depredation by pigs has been documented as a significant source of mortality, including substantial adult mortality at unfenced breeding sites (Raine and McFarland 2014). Predation by owls is also an important issue and likewise particularly difficult to control (Raine et al. 2019c).

Limited research has been conducted on feral cat movement in Hawaiʻi. The Hono o Nā Pali Natural Area Reserve has been the focus of cat tracking efforts (Pias et al. 2017). Frequently, individual cats are detected on multiple camera traps within a monitored seabird breeding site and some cats have been observed on cameras at multiple breeding sites. For example, one cat was detected reliably across three breeding areas, at six camera traps, eight times over 53 days (Pias and Dutcher 2018). Information from studies conducted within Hono o Nā Pali Natural Area Reserve indicate that cats inhabiting the Natural Area Reserve move among adjacent seabird breeding sites and travel over large areas estimated to exceed 1,500 acres (607 hectares).

3A.1.5.4 Habitat Modification

Habitat loss, conversion, and modification historically presumably has had a major negative effect on Newell's shearwaters (ʻaʻo) as civilization has expanded into wild lands where it breeds, along with its accompanying pets, farm animals, vehicles, and other infrastructure (U.S. Fish and Wildlife Service 2016c). Among the MHI, 75 percent of native forest has been lost to agriculture and human growth (Cuddihy and Stone 1990). Human activities associated with agriculture contribute to the exposure and increased predation of ground-nesting birds (Reynolds and Ritchotte 1997). Recently it has become evident that habitat modification via invasive plant species or natural catastrophic events (e.g., hurricane, wildfire) facilitates predation because the reduction in dense native vegetation can provide access for predators into breeding areas (U.S. Fish and Wildlife Service 2016b). Further, pigs and goats modify the habitat by eating and trampling native vegetation and spreading invasive plants (such as guava [*Psidium cattleianum*] and ginger [*Hedychium gardnerianum*]) that modify the habitat, making it impenetrable to breeding seabirds (U.S. Fish and Wildlife Service 2016c). Troy et al. (2014) showed that Newell's shearwaters ('a'o) nesting habitat is covered more by native vegetation than random sites, suggesting invasive vegetation might provide less suitable habitat. Asner et al. (2008) suggest invasive vegetation such as, but not limited to, strawberry guava and ginger, can affect seabird habitat use. Invasive vegetation including young strawberry guava can form nearly impenetrable stands of vegetation, limiting physical access to the ground and to burrows and potential nest sites (Duffy 2010; Van Zandt et al. 2014), and has been associated with at least one abandoned Newell's shearwater ('a'o) colony on Kaua'i (Raine pers. comm.). Extreme weather events such as hurricanes 'Iniki (1992) and 'Iwa (1982) have caused significant disruptions in forest habitat and, coupled with colonization of invasive plants, have resulted in permanent habitat loss for forest birds (Pratt 1994), though the magnitude of these effects on Newell's shearwater ('a'o) have not been documented.

3A.1.5.5 Fisheries

Newell's shearwaters ('a'o) depend on tuna (*Thunnuss* spp.) and other predatory fish to force prey within reach of seabirds (Harrison 1990; Spear et al. 2007; Ainley et al. 2014). The commercial tuna longline fishery is an important economic industry in Hawai'i, as well as in other nations, whose fleets fish within the Newell's shearwater ('a'o) range. Several tuna species are now depleted, with possible secondary adverse effects on Newell's shearwater ('a'o) feeding patterns (Ainley et al. 2014). A particular target of the tuna industry is yellowfin tuna, to which Newell's shearwaters ('a'o) are especially attracted (Spear et al. 2007). More studies are needed to estimate the extent and magnitude of the effect on Newell's shearwater ('a'o). Climate change is expected to shift the migratory home ranges of many tuna and other predatory fish species, which may or may not have additional implications for Newell's shearwater ('a'o) food availability. While bycatch is important to scavenging seabirds, it is likely less of an issue for Newell's shearwater ('a'o) (and other bird species that eat only live prey). Likewise, ingestion of plastics, a significant issue for scavengers and surface-feeding species (see Spear et al. 1995b), is unknown for Newell's shearwaters ('a'o); the inspection of stomachs of downed SOS birds found no plastic (Ainley et al. 2014). Plastic ingestion was found to be the cause of death for three translocated Hawaiian petrel ('ua'u) fledglings (U.S. Fish and Wildlife Service 2022); however, more research is needed to determine if this was an anomaly or a widespread threat.

3A.1.5.6 Stochastic Weather Events

Because many Hawaiian plant and animal species persist in low numbers or in restricted ranges, natural disasters such as hurricanes, volcanic eruptions, or tsunamis can be particularly devastating (Mitchell et al. 2005). Volcanic eruptions, which in 1984 destroyed forest bird habitat on Mauna Loa (Mitchell et al. 2005), occur only on the newer, easternmost islands of the chain (Hawai'i, Maui), and tsunamis would not be an issue given their upland nesting of Newell's shearwater ('a'o). Among the MHI, hurricanes rarely reach Kaua'i. Nevertheless, hurricanes 'Iwa (November 1982) and 'Iniki (September 1992) reached Kaua'i, the last ones to do so, and were implicated in the extinction of several highly endangered forest birds (Pratt 1994). These storms downed a significant number of trees in Kaua'i's forests, likely affecting breeding attempts for Newell's shearwaters ('a'o) (Day and Cooper 1995; Ainley et al. 1997b; Mitchell et al. 2005; Griesemer and Holmes 2011). Raine et al.

(2017b) referred to a drop in the Newell's shearwater (ʻaʻo) population, as indexed by SOS data, after Hurricane ʻIniki, and reasoned that while the hurricane itself caused no direct mortality of adults—because it struck the island during the day while adults were at sea—it caused the removal of considerable amounts of vegetation that, prior to the storm, shielded powerlines, and this reduction in shielding subsequently led to an increase in powerline collisions (and subsequent reduction in Newell's shearwater [ʻaʻo] population). Ainley et al. (2001), on the other hand, also noted the decrease in SOS birds following impacts associated with Hurricane ʻIniki but ascribed the decrease to a documented reduction of human activity on the island, along with a reduction in associated urban lighting, leading to lower rates of fallout. Additionally, many native-dominated areas on Kauaʻi now contain smaller pockets of invasive species that became established following these hurricanes (Mitchell et al. 2005). Given that the majority of the Newell's shearwater (ʻaʻo) population breeds on Kauaʻi, catastrophic events like hurricanes represent a significant threat to the species (Mitchell et al. 2005).

3A.1.5.7 Climate Change

According to the Intergovernmental Panel on Climate Change (IPCC), human activities have caused a 1.8 degrees Fahrenheit (°F) (1 degree Celsius [°C]) increase in tropospheric temperature above pre-industrial levels, and with the current rate of warming, could reach an increase of 2.7°F (1.5°C) by the year 2030 (Intergovernmental Panel on Climate Change 2019).

With increasing atmospheric temperature, the size and intensity of large-scale storms, which differ in many respects from the normal stochastic weather events discussed in Section A.1.5.6, *Stochastic Weather Events*, are expected to increase in coming years in various parts of the globe. Although Kauaʻi is quite used to heavy rainfall, these large-scale storms such as Kona storms may well result in greater landscape-scale damage to habitat (e.g., landslides, flooding) and subsequent loss of burrows/individuals and their future reproductive capacity. In 2021, a Hawaiian petrel (ʻuaʻu) chick was rescued from a flooded burrow in the Natural Area Reserve (Archipelago Research and Conservation 2021). Additional examples include hurricanes ʻIwa and ʻIniki, which devasted forests in 1982 and 1992, dramatically reducing available nesting habitat (Day and Cooper 1995). Large-scale storms also facilitate the incursion of invasive plants and animals (e.g., feral pigs, goats) to native habitat, altering and degrading the forest's ability to support native biota (Mitchell et al. 2005; U.S. Fish and Wildlife Service 2011a). Existing climate zones on high islands are generally projected to shift upslope in response to climate change. Some invasive plants may outcompete native species, as some invasive plants disproportionately benefit from increased carbon dioxide, disturbances from extreme weather and climate events, and an ability to invade higher-elevation habitats as the climate warms (Bradley et al. 2010). Climate change may also result in reduced rainfall that will additionally stress native Pacific Island flora and fauna, especially in high-elevation ecosystems with increasing exposure to invasive species (Leong et al. 2014).

Climate change brings rising sea levels, and this will seriously affect seabirds nesting among the low, northwestern Hawaiian Islands (e.g., Reynolds et al. 2015). However, seabirds confined to nesting in the uplands of coastal environments and mountainous interior of the MHI would not be affected by coastal inundation caused by rising sea levels. Other at-sea issues resulting from climate change that may also arise include effects on the distribution of prey species and ocean acidification due to increased ocean temperatures.

3A.2 Hawaiian Petrel (ʻuaʻu) (*Pterodroma sandwichensis*)

3A.2.1 Listing Status and Taxonomy

The Hawaiian petrel (ʻuaʻu) (*Pterodroma sandwichensis*), is endemic to the MHI, and was listed under the federal ESA as endangered in 1967 (U.S. Fish and Wildlife Service 1967). It is a member the seabird family Procellariidae. The Hawaiian petrel (ʻuaʻu) and Galápagos petrel (*Pt. phaeopygia*) were initially considered to be subspecies of the dark-rumped petrel (*Pt. phaeopygia*), but 20 years ago were split into two separate species, on the basis of differences in vocalizations, morphology, behavior, disjunct nesting and at-sea distributions (Banks et al. 2002; Tomkins and Milne 1991), and genetics (Browne et al. 1997; see also Spear et al. 1995a; U.S. Fish and Wildlife Service 2011b). The species is also listed as endangered under HRS, Chapter 195D, Section 195D-4, Endangered and Threatened Species. No critical habitat has been listed for the Hawaiian petrel (ʻuaʻu) (U.S. Fish and Wildlife Service 2020a). The Hawaiian petrel (ʻuaʻu) is listed as endangered on the IUCN Red List (BirdLife International 2018).

3A.2.2 Life History

Hawaiian petrels (ʻuaʻu) are long-lived, reaching 35 years of age; average age of first breeding is 6 years (Simons and Hodges 1998). In addition to physiological maturation, it is likely that competition for nest sites plays a role when an individual first breeds. It is also likely that nest-site availability can play an important role in the number of breeding birds in a colony, as seen in other burrow and cavity-nesting species—there could be a "floating population" composed of mature birds that have not yet found a nesting cavity (Warham 1997).

The Hawaiian petrel (ʻuaʻu) breeding cycle is synchronous with egg-laying spread over just about a month (Simons 1985). An estimated 89 percent of the adult population breeds in a given year (Simons and Hodges 1998). Phenology differs between the islands, with birds on Kauaʻi, arriving a month later than those on Maui and 2 weeks later than those on Lānaʻi (Judge et al. 2014). On Kauaʻi birds arrive to breeding grounds in mid-March and start pair formation. After pairing, nest building, and burrow maintenance, a distinct pre-laying exodus occurs in April, when breeding adults leave the colony just ahead of egg-laying, presumably to allow females time to acquire the reserves necessary for egg production and males to store energy for incubation. Egg-laying occurs in early May to mid-June. Incubation continues until mid-July. The chick-rearing period runs from mid-July until the end of the September, when the first chicks start to fledge. Fledging peaks in November with the last birds fledging towards the middle of December (Archipelago Research and Conservation 2021). Once the chicks leave they do not return to land again for a few years. Breeding colonies are generally empty by the end of November or early December.

3A.2.3 Habitat Requirements and Ecology

Hawaiian petrels (ʻuaʻu) forage widely in the North Pacific Ocean (Pitman 1986; Warham 1990; Spear et al. 1995a; Adams 2007; Wiley et al. 2012), using a long-trip, short-trip foraging strategy. Satellite-tagged birds from Maui and Lānaʻi have been tracked traveling more than 6,000 mi (10,000 km) on a single foraging trip to and from their breeding colonies, moving northwestward to the Kuroshio Current/Transition Zone then eastward to the California Current before returning to

Hawaiʻi (Adams and Flora 2010). Birds from Kauaʻi follow the same long-trip foraging routes, although for short trips they forage a few hundred kilometers north of Kauaʻi (Raine et al. 2017a). They are among the group of seabirds known as *tuna birds*, owing to their association with tuna that drive prey to the surface. The satellite tracking indicates some affinity to the realm of albacore (*Thunnus alalunga*). Assuming equivalence to the closely related Juan Fernandez petrel (*Pterodroma externa*), whose foraging has been extensively investigated (Spear et al. 2007), Hawaiian petrels (ʻuaʻu) feed mainly during daylight hours, but to a lesser degree at night. In summary, their diet consists of flying squid, flying fish, goatfish, lantern fish, hatchetfish, and similar species (see also Ballance et al. 1997; Simons 1985).

The species' nesting habitat is variable, as described by Simons and Hodges (1998). On Hawaiʻi and Maui, Hawaiian petrels (ʻuaʻu) nest in the cavities of lava flows in xeric conditions at high altitude (summit slopes of Mauna Loa and Haleakalā). On the lower islands of Lānaʻi and Kauaʻi, however, breeding areas are in dense, montane wet forest, mainly along valley headwalls, particularly those of steep slopes covered with uluhe fern (*Dicranopteris* spp.; Troy et al. 2016; see Figure 2). Raine et al. (2021a) documented that the three most important microhabitat variables for Hawaiian petrels (ʻuaʻu) are ʻōhiʻa lehua in the canopy, elevation, and maximum canopy height. Such attributes are consistent with the habitat suitability model of Young et al. (2019) developed to search for potential nesting colonies on Oʻahu, as well as the studies of Van Zandt et al. (2014) on Lānaʻi. Raine et al. (2021) found that Hawaiian petrels (ʻuaʻu) tend to utilize habitat at higher elevations but that were less steep and less vegetated than Newell's shearwater (ʻaʻo).

3A.2.4 Distribution and Population Trends

3A.2.4.1 Current and Historic Distribution

Based on current distribution and subfossil remains, Hawaiian petrels (ʻuaʻu) are thought to have once been prevalent on all of the high islands in the Hawaiian Archipelago including Hawaiʻi, Maui, Lānaʻi, Kahoʻolawe, Molokaʻi, Oʻahu, and Kauaʻi (Ainley et al. 1997c; Olson and James 1982a, 1982b; Telfer 1983; Pyle and Pyle 2017b). Historic accounts reveal abundant Hawaiian petrel (ʻuaʻu) presence on the Hawaiian Archipelago since the late 1800s and/or early 1900s (Banko 1980; Simons and Simons 1980), including on low-elevation coastal plains on Oʻahu, Kauaʻi (e.g., Makauwahi Cave), and other islands (Olson and James 1982a, 1982b). By at least the mid-20th century, Hawaiian petrel (ʻuaʻu) colonies were restricted to high elevations (Pyle and Pyle 2017b).

It appears that the historic decrease in Hawaiian petrel (ʻuaʻu) populations on all of the Hawaiian Islands and the historic extirpation of Oʻahu populations were initiated by Polynesians, especially with the introduction of invasive predatory species they brought to the islands (pigs, rats; Banko 1980; Olson and James 1982a, 1982b; Simons 1985). The Hawaiian petrel (ʻuaʻu) decline was accelerated with the introduction of cats by Europeans (Simons 1985).

Extant Hawaiian petrel (ʻuaʻu) breeding sites are known to exist at five high-elevation regions on Maui, Hawaiʻi, Kauaʻi and Lānaʻi. A large proportion of the Hawaiian petrel (ʻuaʻu) population breeds on the island of Maui within Haleakalā National Park (~27 percent; Pyle and Pyle 2017b). Presence there is aided by a long-standing commitment to predator control by the park. Some fragmented breeding locations with fewer than 10 burrows have been reported in areas outside the main known breeding sites (Simons and Hodges 1998), and radar studies indicate that breeding may occur on Molokaʻi (Day and Cooper 2002). Reportedly, the number of Hawaiian petrels (ʻuaʻu) in breeding areas on Lānaʻi and Maui are significantly greater than previously inferred. Survey work conducted at a rediscovered breeding site on Lāna‘i in 2005 and 2008 indicated that thousands of birds are present, rather than hundreds of birds as first thought (State of Hawai‘i Department of Land and Natural Resources 2015), and in 2019, KESRP and Pūlama Lāna‘i monitored a total of 311 Hawaiian petrel (‘ua‘u) burrows at multiple managed colonies (Raine et al. 2020d). Recent habitat suitability modeling indicates that 8,000–10,000 individuals and 4,000–5,000 breeding pairs reside in Haleakalā National Park (National Parks Service 2021). A recent study based on historical records, acoustic monitoring, and habitat suitability modeling suggests that a small number of Hawaiian petrels (‘ua‘u) may be breeding on O‘ahu (Young et al. 2019).

3A.2.4.2 Within the Plan Area

The current breeding population of Hawaiian petrels (‘ua‘u) on Kaua‘i is confined to higher elevations, especially ridge crests, in the northwest portion of the island (Figure 2).

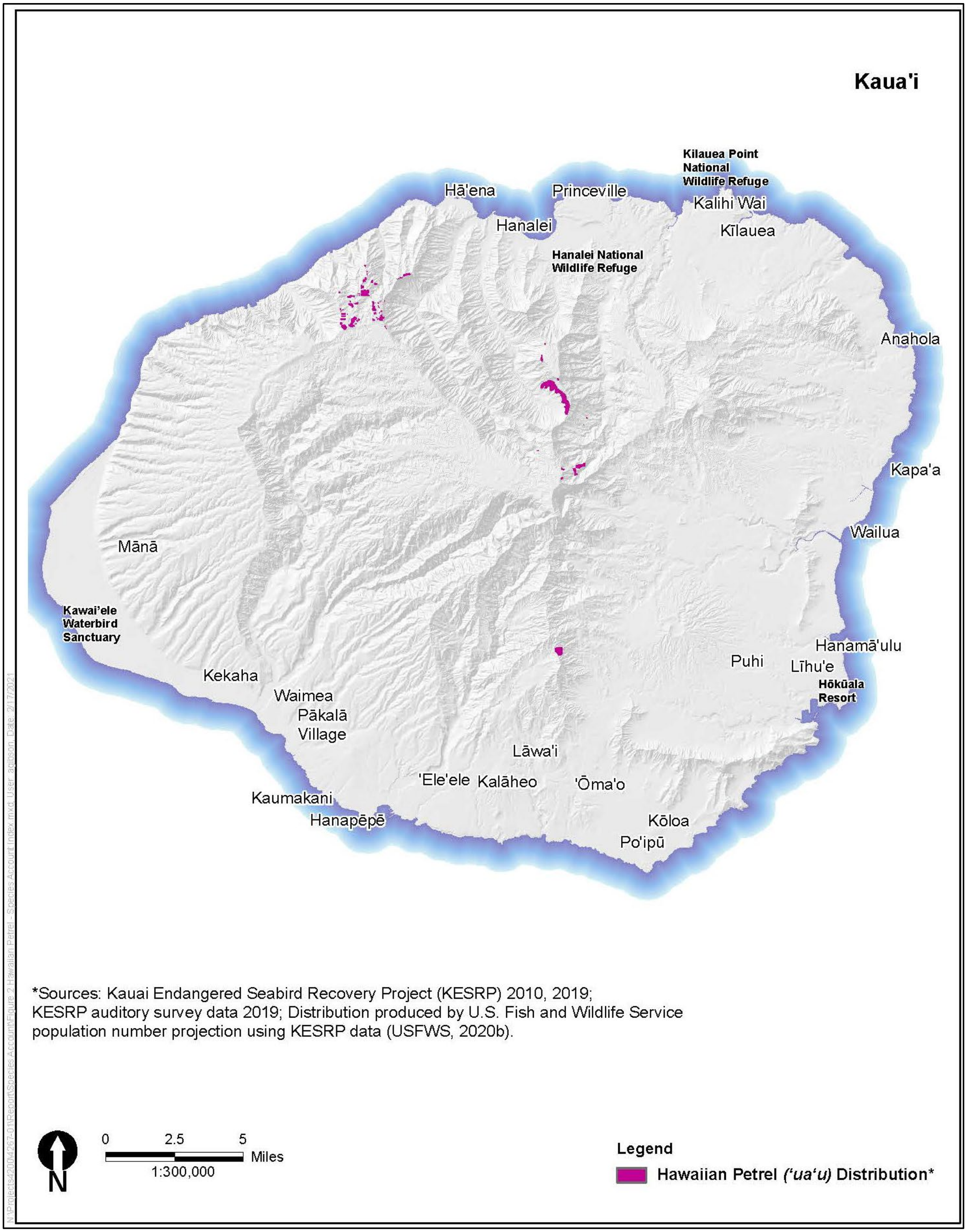

Figure 2. Current Confirmed Distribution of the Hawaiian Petrel (‘ua‘u) Based on Contemporary Audio Surveys

3A.2.4.3 Population

Kauaʻi supports approximately 33 percent of the total Hawaiian petrel (ʻuaʻu) population (Raine pers. comm.). An assessment based on at-sea survey data collected by the NMFS Southwest Fisheries Science Center from 1998 to 2011 estimated the total Hawaiian petrel (ʻuaʻu) population within the study area at 71,496 birds with lower and upper 95 percent confidence intervals of 58,010 and 85,645 (Joyce et al. 2016). The estimate includes juveniles, subadults and adults. More recently, Joyce et al. (2019) estimated the Hawaiian petrel (ʻuaʻu) population to be 65,856 individuals (Bootstrap 95 Percentile, 19,717 to 91,097) also based on surveys at sea. This largely confirmed the estimate from the Joyce et al. 2016 study and is significantly higher than previous assessments based on pelagic surveys in the same general region, where the Hawaiian petrel (ʻuaʻu) population was estimated at 19,000 (95 percent confidence interval = 11,000–34,000) including juveniles, subadults, and adults, and 4,500–5,000 breeding pairs (Spear et al. 1995a). As stated above for Newell's shearwater (ʻaʻo) (Section A.1.4.3, *Population*), the observations of both Joyce et al. (2016, 2019) and Spear et al. (1995a) cover a major portion but not the entire at-sea range and so are underestimates. Further, Ainley et al. (1997b) posited that Spear et al. (1995a) had underestimated the population by about 5 percent due to seasonal patterns of spatial occurrence. Nevertheless, the higher estimate of Joyce et al. (2019), with at-sea surveys conducted a couple of decades later, might well reflect the successful conservation efforts at Haleakalā National Park over the past 40 years.

In 2020, to remedy the gaps in the at-sea abundance data, ARC developed a theoretical population estimate for Hawaiian petrel (ʻuaʻu) that does not rely on the at-sea survey data analyzed by Joyce or Spear. The general approach used for estimating breeding pairs of Hawaiian petrel (ʻuaʻu) follows that used for Newell's shearwater (ʻaʻo)(Section A.1.4.3, *Population*). Briefly, this approach involves a combination of acoustic call rate data (Archipelago Research and Conservation 2021), which has been demonstrated to have a highly significantly relationship with active breeding pairs (Raine et al. 2019b), as well as habitat suitability modeling (Troy et al. 2017), and correction factors to account for lower densities of breeding pairs in colonies outside managed conservation sites (Raine pers. comm.). This approach resulted in a minimum estimate of 8,051 breeding pairs on Kauaʻi, which equates to a minimum island-wide population of 25,277 and, assuming the Kauaʻi population is 33 percent of the entire population, a maximum total of 24,396 breeding pairs and total minimum population of 76,598 in the State of Hawaiʻi.

3A.2.4.4 Decline/Trend

The Hawaiian petrel (ʻuaʻu) population decreased severely over the past few centuries, since the arrival of humans on the islands (Olson and James 1982a). Genetic analysis conducted within the last decade has revealed strong genetic differentiation among Hawaiian populations on separate islands (Welch and Fleischer 2011), underlining the importance of understanding population trends for this species on an island-by-island basis (Stiebens et al. 2013).

As with the Newell's shearwater (ʻaʻo), between 1993 and 2013 the Hawaiian petrel (ʻuaʻu) population declined steeply (Raine et al. 2017b). The study found an overall decrease in passage rates of 78 percent in 20 years, and 62 percent of the 13 sites showed a statistically significant decrease in movement rates over the entire period (Raine et al. 2017b). Based on the radar data as a proxy for the breeding population, the Hawaiian petrel (ʻuaʻu) population has decreased at an annual mean rate of 6 percent over the 20-year period (Raine et al. 2017b).

Radar surveys have only been conducted from May through mid-July, i.e., during the incubation and early chick-rearing stage, in coastal areas of northeastern, eastern, and southern Kauaʻi, or those areas accessible to vehicle-mounted radar equipment. Therefore, these radar data do not apply to the Nā Pali Coast where the Hawaiian petrel (ʻuaʻu) population is concentrated on Kauaʻi (Figure 2).

Following on from the population crash between 1993 and 2013, Raine and Rossiter (2020) and Ainley et al. (submitted) have shown that the trends in both radar and SOS data have been level for approximately the last decade. Although data from the more recent radar surveys through 2020 did not change the overall significant downward trajectory on Kauaʻi of Hawaiian petrel (ʻuaʻu) over the entire period since 1993 (72.8 percent decline in overall numbers with an average rate of 4.7 percent per year), the trend during the last decade (2010 to 2020) has been flat with no significant change (Raine and Rossiter 2020). Similar to Newell's shearwater (ʻaʻo), call rates at acoustically monitored conservation sites in which predators have been excluded or controlled have shown statistically significant increases between the first year of monitoring (either 2014 or 2015, depending on the site) and 2020, ranging from 16.23 percent at Pihea to 26.22 percent at North Bog (Archipelago Research and Conservation 2021).

Unlike Newell's shearwater (ʻaʻo), because so few Hawaiian petrels (ʻuaʻu) are grounded by light attraction on Kauaʻi every year, it is not possible to use SOS data to chart population declines (as was undertaken for Newell's shearwater [ʻaʻo]) (Raine et al. 2017b).

3A.2.5 Threats

Most of the threats facing Hawaiian petrels (ʻuaʻu) are like those faced by Newell's shearwaters (ʻaʻo) and are explained in detail in Section A.1.5, *Threats*. Compared to the Newell's shearwater (ʻaʻo), very few Hawaiian petrels (ʻuaʻu) have been found grounded and turned in to SOS during the fledging season, likely related to a recent historical much lower population size, and long-time relegation to the North Shore away from coast lights in developed areas of Kauaʻi. For example, on average, 9.6 Hawaiian petrels (ʻuaʻu) were received by the SOS Program annually between 2014 and 2018 in comparison to 179 Newell's shearwaters (ʻaʻo) during the same time period on Kauaʻi.

3A.2.5.1 Climate Change

Threats related to climate change would be the same for Newell's shearwaters (ʻaʻo) and Hawaiian petrels (ʻuaʻu), and are discussed in Section A.1.5.7, *Climate Change.*

3A.3 Band-Rumped Storm-Petrel (ʻakēʻakē) (*Oceanodroma castro*)

3A.3.1 Listing Status and Taxonomy

The Hawaiʻi distinct population segment (HDPS) of the band-rumped storm-petrel (ʻakēʻakē) (*Oceanodroma castro*) (hereafter band-rumped storm-petrel), a member of the seabird family Hydrobatidae, was listed as an endangered species under the federal ESA in 2016 (U.S. Fish and Wildlife Service 2016d). The species is also listed as endangered under HRS, Chapter 195D, Section 195D-4, Endangered and Threatened Species. No critical habitat has been designated for the band-rumped storm-petrel (ʻakēʻakē) (U.S. Fish and Wildlife Service 2016d). Recent genetic studies have found that the Hawaiian population of this species is genetically distinct from other populations throughout its global range (Taylor et al. 2019). The band-rumped storm-petrel (ʻakēʻakē) is listed as Least Concern on the IUCN Red List (BirdLife International 2018), as a function of the global occurrence of this species on dozens of nesting islands. However, the IUCN list does not consider the HDPS.

3A.3.2 Life History

On land, at least in the Hawaiian Islands, band-rumped storm-petrels (ʻakēʻakē) are nocturnal. The only nests that have been found are on the Island of Hawaiʻi (Galase 2019; Antaky et al. 2019). Based on auditory data, both on Kauaʻi and offshore Lehua Islet, the species arrives at breeding colonies on Kauaʻi in late May, with birds fledging from late September to mid-November (Raine et al. 2017d). Other information on the breeding biology of this species can only be approximated from the Galápagos Islands, where it has been relatively well studied. The species probably does not breed until 3 years of age, and likely lives to 20 years (Ainley 1984). The nesting season in the Galápagos also occurs during the boreal summer, with adults establishing nesting territories in April or May. A single, white egg is laid. The incubation period averages 42 days (Harris 1969) and the young reach fledging stage in 64–70 days (Allan 1962; Harris 1969). In the Hawaiian Islands evidence of their presence, either vocalizations or specimens, are spread from April to November; calling is most intense at Mauna Loa between June and August (Banko et al. 1991; Galase 2019). On the basis of auditory surveys, it arrives on Kauaʻi in late May and chicks fledge from late September to mid-November (Raine et al. 2017d).

At sea, this species forages at the surface by dipping and surface seizing. Diet consists mainly of small fish, squid, and crustaceans, as well as material scavenged from floating carcasses and surface slicks (Harris 1969; Slotterback 2002, 2020). More so than the above two species, it forages at night (Spear et al. 2007).

3A.3.3 Habitat Requirements and Ecology

The band-rumped storm-petrel (ʻakēʻakē) is a tropical/subtropical species occurring in the Atlantic, Indian, and Pacific Oceans; Pacific populations breed on the Galápagos Islands, Japan, and the Hawaiian Islands (Howell 2012). At sea, the band-rumped storm-petrel (ʻakēʻakē) has been observed off the coast of the Americas from 24.80°N to 23.27°S, but not beyond 1,123 mi (1,807 km) from the mainland (Spear et al. 2007), and birds have been seen 600 mi (966 km) north of Hawaiʻi, 1,000 mi (1,609 km) south of Hawaiʻi, and between Japan and Hawaiʻi (Raine et al. 2017d; U.S. Fish and Wildlife Service 2016d). More specifically, this species has been detected in very low numbers in waters between 10°N and 10°S south and west of Hawaiʻi, particularly during fall (Crossin 1974; Pitman 1986; Spear et al. 1999, 2007). In summer they have been detected in waters immediately south of the Hawaiian Islands (Crossin 1974; Spear et al. 1999; Banko et al. 1991). Banko et al. (1991) reported that early Hawaiians found them common off the windward coasts of the islands.

Nests are placed in crevices, holes, and protected ledges along cliff faces, well above the base and well below the top (Allan 1962; Harris 1969; Galase 2019). As noted by Raine et al. (2017d), breeding colonies on Kauaʻi, based on auditory surveys, are concentrated along the Nā Pali Coast, particularly within canyons from the Kalalau Valley to Polihale, as well as the Waimea Canyon. Habitat consists of sparsely vegetated, very steep cliffs, where the species has been relegated to such habitat by invasive mammalian predators. Small pockets of these birds also occur in some of the wetter and heavily vegetated valleys that contain exposed rocky cliff faces. A large concentration of storm-petrel activity was also recorded on the southeastern slopes of Lehua Islet (Raine et al. 2017d).

3A.3.4 Distribution and Population Trends

3A.3.4.1 Current and Historic Distribution

When Polynesians arrived in Hawaiʻi about 1,500 years ago, the band-rumped storm-petrel (ʻakēʻakē) probably was common on all the MHI (Harrison 1990; Raine et al. 2017d). As indicated by bones found in middens on the island of Hawaiʻi (Harrison 1990) and in excavation sites on Oʻahu and Molokaʻi (Olson and James 1982a, 1982b; Raine et al. 2017d), it appears the band-rumped storm-petrel (ʻakēʻakē) was once numerous enough to be harvested for food and possibly for their feathers (Harrison 1990).

The current distribution of the band-rumped storm-petrel (ʻakēʻakē) in Kauaʻi and the other Hawaiian Islands is poorly known (Raine et al. 2017d; Ainley et al. submitted). Evidence of nesting band-rumped storm-petrel (ʻakēʻakē) is based on detection of adult birds during the breeding season and on retrieval of downed fledglings in the fall, acoustic monitoring, and recovery of carcasses. Potential breeding sites have been recorded on Hawaiʻi (Banko et al. 1991; Galase et al. 2016), Maui (Banko et al. 1991), Kahoʻolawe (Hawaiʻi Heritage Program 1992), Lehua Islet (VanderWerf et al. 2007), and Kauaʻi (Raine et al. 2017d; Wood et al. 2002). Recently, a colony of band-rumped storm-petrel (ʻakēʻakē) was discovered at 6,932.4 ft (2,113 m) elevation on the northern slope of Mauna Loa within the U.S. Army's Pōhakuloa Training Area on the Island of Hawaiʻi (Galase 2019). A breeding population of this species has also been recently identified on the island of Lānaʻi (Raine et al. 2020d). Genetic analysis reveals little differentiation among islands, as judged from specimens obtained historically from various locations (Antaky et al. 2020).

On Kauaʻi, presumed band-rumped storm-petrel (ʻakēʻakē) nesting areas are located predominantly along the northwestern coastal cliffs of the Nā Pali Coast, and in the cliff walls of Waimea Canyon in the southwestern portion of the island (Figure 3). Other small breeding sites are suspected within more vegetated areas in the northern valleys such as Lumahaʻi and Wainiha (Raine et al. 2017d; VanderWerf et al. 2007; Wood et al. 2002).

On Lehua Islet, the band-rumped storm-petrel (ʻakēʻakē) detections over land are mainly concentrated on the southeastern slopes, with very little activity elsewhere (Raine et al. 2017d; VanderWerf et al. 2007). On the Island of Hawaiʻi, presumed nesting birds have been found in the Pōhakuloa Training Area (Galase et al. 2016), and remains of birds have been found along the southwest rift, and in Kūlani (Banko et al. 1991). Vocalizations have been heard in Haleakalā Crater on Maui in 1992 (Wood et al. 2002), on Lānaʻi (U.S. Fish and Wildlife Service 2016d; Raine et al. 2020d), and in Hawaiʻi Volcanoes National Park (U.S. Fish and Wildlife Service 2016d). The band-rumped storm-petrel (ʻakēʻakē) is regularly observed in coastal waters around Kauaʻi, Niʻihau, and Hawaiʻi (Joyce and Holmes 2010; U.S. Fish and Wildlife Service 2016b; Harrison 1990; Spear et al. 1999; Pyle and Pyle 2017c).

3A.3.4.2 Within the Plan Area

The current breeding population of the band-rumped storm-petrel (ʻakēʻakē) on Kauaʻi appears to be confined primarily to steep terrain such as ridge crests in the northwest portion of the island (Figure 3).

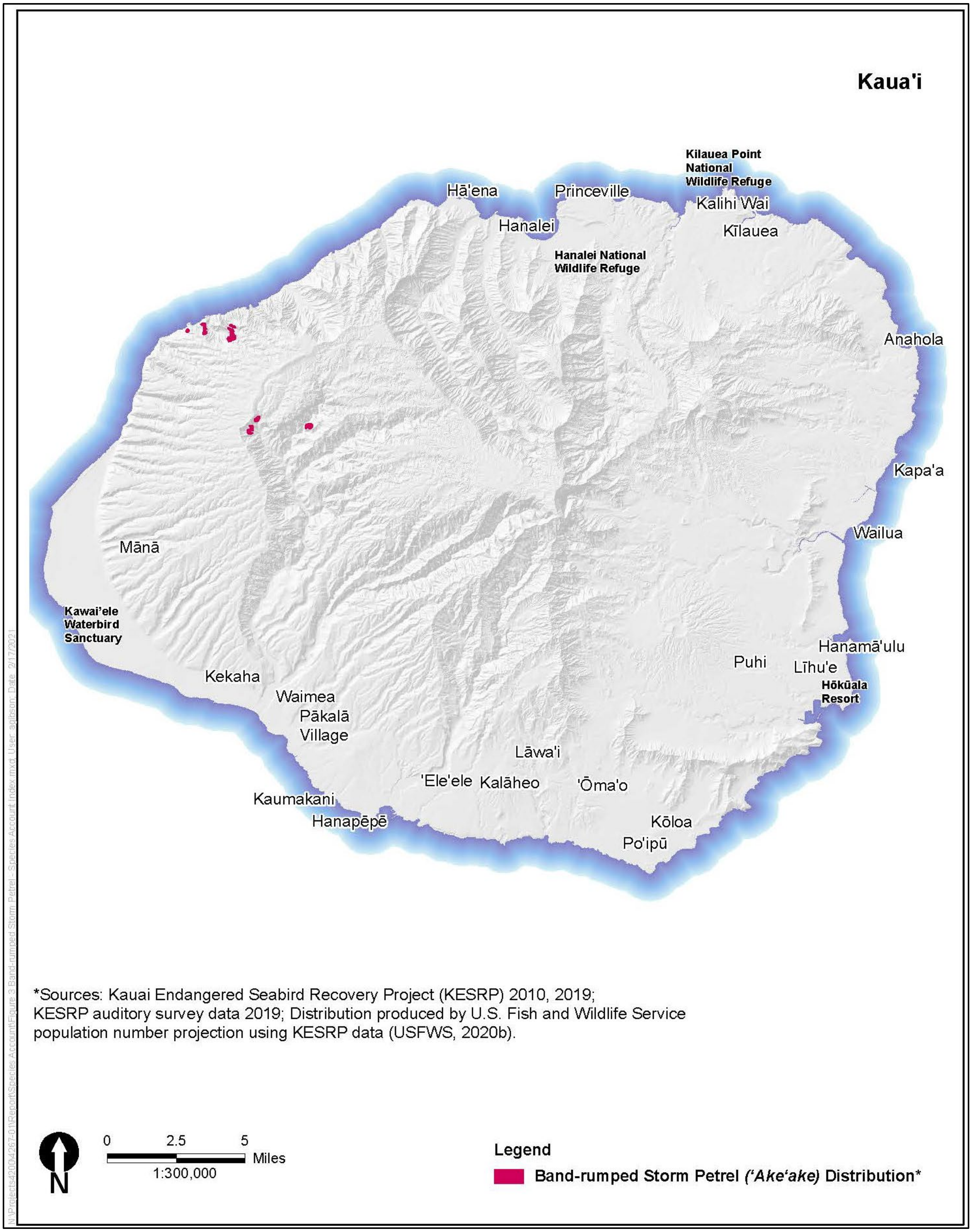

Figure 3. Current Confirmed Distribution of the Band-Rumped Storm-Petrel (ʻakēʻakē) Based on Contemporary Audio Surveys

3A.3.4.3 Population

There are significant differences in the various Pacific populations of band-rumped storm-petrels (ʻakēʻakē). Populations in Japan and the Galápagos are comparatively large, ranging from 30,000 to 50,000 birds, respectively (Coulter 1984; Enticott and Tipling 1997; Hasegawa 1984), while the Hawaiian population size is largely unknown. Extensive at-sea surveys of the Pacific have revealed a broad gap in distribution of the band-rumped storm-petrel (ʻakēʻakē) east and west of Hawaiʻi (Pitman 1986; Spear and Ainley 2007). The worldwide population of the species is uncertain but is most likely around 150,000 birds (Brooke 2004). Recent genetic studies have found that the Hawaiian population of this species is genetically distinct from other populations throughout its global range, hence its classification as the HDPS (Taylor et al. 2019).

3A.3.4.4 Decline/Trend

Based on the scarcity of known breeding sites in Hawaiʻi; the remote, inaccessible locations where they are suspected to occur today; and compared to historic population levels and distribution, the band-rumped storm-petrel (ʻakēʻakē) appears to be significantly reduced in numbers and range compared to before colonization by the Polynesians (Raine et al. 2017d; U.S. Fish and Wildlife Service 2016d).

3A.3.5 Threats

The threats facing the band-rumped storm-petrel (ʻakēʻakē), including environmental stressors associated with climate change, are thought to be comparable to those faced by Newell's shearwaters (ʻaʻo) and are explained in detail in Section A.1.5, *Threats*. However, it is not a "tuna bird" and so changes in the distribution/abundance of tuna would not directly affect it. Also, because it picks at small items floating at the sea surface it is more likely to ingest plastic, which in some storm-petrels has been found to have significant implications (Spear et al. 1995b). As a much smaller seabird species, predation by rats is presumably an even larger problem for this species, and rats are probably capable of taking adult birds as well as chicks and eggs (Raine et al. 2017d).

3A.3.5.1 Climate Change

Threats related to climate change are similar for all three federal ESA–listed seabirds in Hawaiʻi and are discussed in Section A.1.5.7, *Climate Change*.

3A.4 Hawaiian Stilt (aeʻo) (*Himantopus mexicanus knudseni*)

3A.4.1 Listing Status and Taxonomy

The Hawaiian stilt (aeʻo) (*Himantopus mexicanus knudseni*) is a subspecies of the black-necked stilt (*Himantopus mexicanus*). It is a long-legged, slender shorebird (*Charadriiformes*, *Recurvirostridae*), 15 inches (38 cm) in length, with a long, thin beak. It was listed under the federal ESA as an endangered species on October 13, 1970 (U.S. Fish and Wildlife Service 1970). The species is also listed as endangered under HRS Chapter 195D, Section 195D-4, Endangered and Threatened Species. The second revision of the recovery plan for Hawaiian waterbirds was approved in October

2011. A 5-year status review was completed in 2020, at which time USFWS recommended the downlisting of the Hawaiian stilt (aeʻo) to threatened (U.S. Fish and Wildlife Service 2020b). Critical habitat has not been designated.

3A.4.2 Life History

Hawaiian stilt (aeʻo) are semi-colonial nesters, but intensely territorial, with average inter-nest distances ranging from 53 to 262 ft (16–80 m) (Coleman 1981; Robinson et al. 1999). Their loose colonies occur in marshes near mudflats close to the water, especially marsh islands. They are found in that mudflat/marsh habitat year-round. Nests are shallow depressions lined with stones, twigs, and debris; nesting season extends from mid-February through August, with the peak of laying varying among years (Robinson et al. 1999). Hawaiian stilt (aeʻo) usually lay a clutch of three to four eggs incubated for 23–26 days (Coleman 1981; Chang 1990). Both parents take turns incubating day and night (U.S. Fish and Wildlife Service 2011c). Chicks are precocial, and are able to walk and swim within a few hours of hatching (U.S. Fish and Wildlife Service 2011c); they accompany adults on their daily foraging and may remain with both parents as late as February of the year after hatch (Robinson et al. 1999, 2020). Adult Hawaiian stilt (aeʻo) are aggressive against ground predators, as well as other Hawaiian stilts (aeʻo), and routinely approach humans within 15 ft (4.6 m); they use their legs to strike predators (as well as humans) from behind (Robinson et al. 1999, 2020). Adults also feign injury to distract potential predators from their nest sites and young (Dougherty et al. 1978; Robinson et al. 1999).

Stilts most commonly walk or wade over short distances rather than fly. During normal flight, stilts flap their wings continuously with an average wing-beat of approximately 40.8 beats per minute (Hamilton 1975). When flying in flocks, rapid changes of direction with complicated maneuvers are common (Hamilton 1975).

3A.4.3 Habitat Requirements and Ecology

Hawaiian stilt (aeʻo) are opportunistic feeders, and use a variety of aquatic habitats but are limited by water depth (shallow) and vegetation cover. Foraging habitat is early successional marshland or aquatic habitat with a water depth less than 9 inches (22.9 cm) (U.S. Fish and Wildlife Service 2011c). Breeding habitat differs from foraging habitat, and individuals move between the two habitats daily. Movement among wetland habitats in search of food is frequent. Hawaiian stilt (aeʻo) are known to use ephemeral lakes, alkaline ponds, anchialine pools, prawn farm ponds, marshlands, and tidal flats. They eat a wide variety of invertebrates and other aquatic organisms.

3A.4.4 Distribution and Population Trends

No historical estimate of Hawaiian stilt (aeʻo) population size is available, but by the early 1940s, the statewide population was estimated to be between 200 and 1,000 birds (U.S. Fish and Wildlife Service 2011c). These population estimates did not include any Niʻihau populations. Niʻihau can potentially support a large Hawaiian stilt (aeʻo) population when the extensive ephemeral lakes are flooded.

Hawaiian stilt (aeʻo) is currently found in wetland habitats below 660 ft (201 m) elevation on all of the MHI except Kahoʻolawe. Statewide census of the Hawaiian stilt (aeʻo) population shows moderate year-to-year variability (U.S. Fish and Wildlife Service 2020b). Long-term census data indicate that the statewide population has been relatively stable and increasing over the last two decades with an average of ~1,500 birds (U.S. Fish and Wildlife Service 2020b). Surveys of the statewide Hawaiian stilt (aeʻo) population between 2012 and 2016 show the on Kauaʻi resulted in a 5-year minimum average population estimate of 1,932 (1,552–2,385) (Paxton et al. 2021). A population viability analysis has been conducted by Reed and van Rees (2019) to update the findings of Reed et al. (1998) and reassess the population size necessary for long-term viability of the species. Preliminary findings of the population viability analysis indicated an increasing population trend that intermittently exceeds 2,000 individuals statewide but not for 5 consecutive years.

On Kauaʻi, Hawaiian stilt (aeʻo) are numerous in large river valleys such as Hanalei, Wailua, and Lumahaʻi, and on Mānā. Hawaiian stilt (aeʻo) also frequent Kauaʻi's reservoirs, particularly during drawdown periods, as well as sugarcane effluent ponds in Kekaha and Waimea (Figure 4). Considerable movement of the Hawaiian stilt (aeʻo) occurs between Kauaʻi and Niʻihau, apparently in response to rainfall patterns and the flooding and drying of ephemeral lakes on Niʻihau (Engilis and Pratt 1993). From 2008 to 2018, on average, the State of Hawaiʻi Division of Forestry and Wildlife (DOFAW) documented approximately 400 individuals in the Hanalei National Wildlife Refuge and approximately 100 individuals in other wetlands in Hanalei annually during winter counts. During the same time period in Mānā approximately 15 individuals were documented at the Kawaiʻele Sanctuary and approximately 34 individuals annually at other wetlands (State of Hawaiʻi Division of Forestry and Wildlife 2021). Long-term (1986–2016) and short-term (2006–2016) trends indicate increasing population sizes for the Hawaiian stilt (aeʻo) population on Kauaʻi (Paxton et al. 2021).

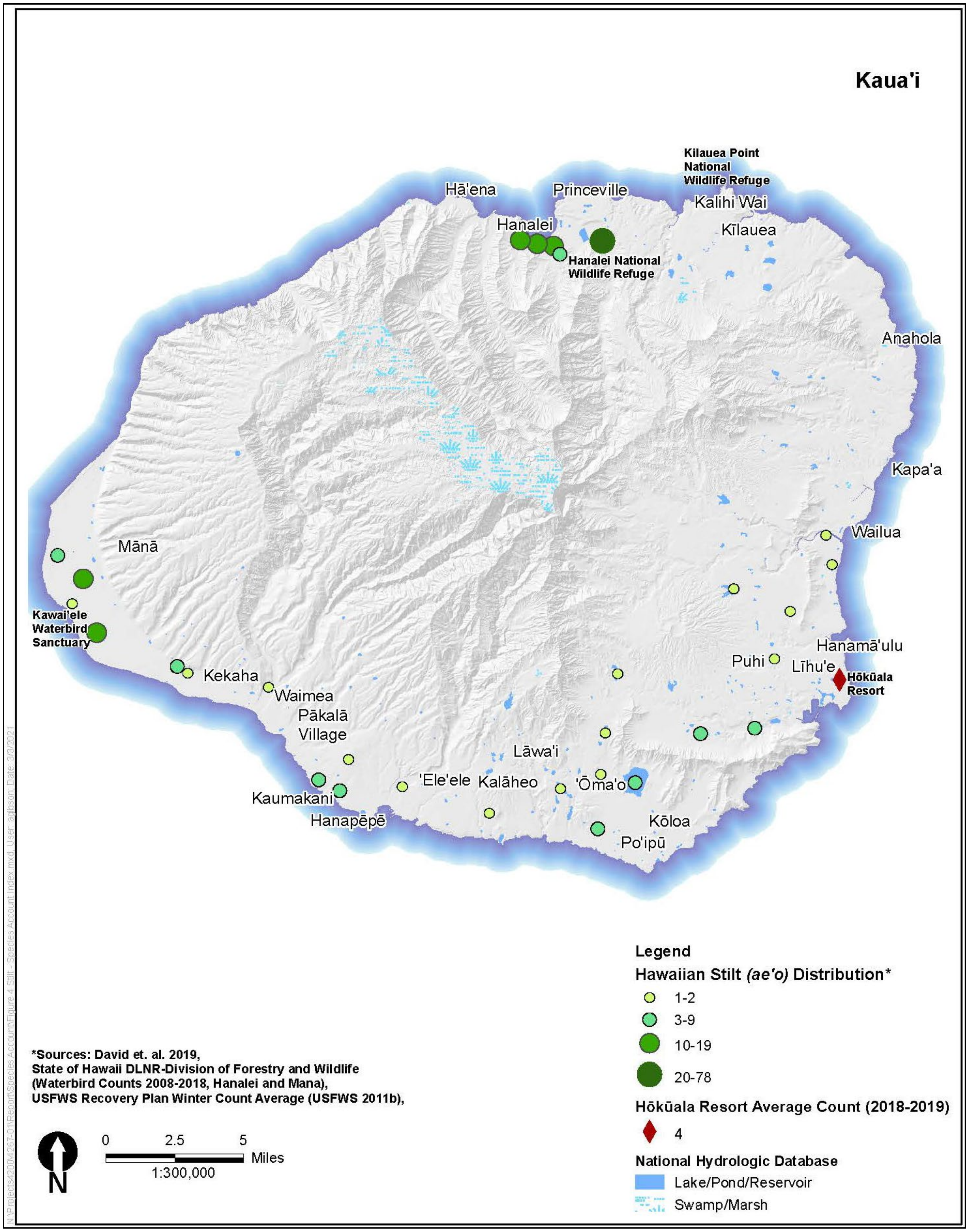

Figure 4. Distribution of the Hawaiian Stilt (ae'o) on the Island of Kaua'i

3A.4.5 Threats

The primary causes of the decline of Hawaiian waterbirds, including Hawaiian stilt (aeʻo), are predation by invasive animals, loss of wetland habitat, disease, and environmental contaminants. Depredation and habitat loss, however, are likely the greatest threats to the species. Human activities have led to the loss of many Hawaiian wetlands through filling and draining for agriculture, housing developments, hotels, and golf courses. Most remaining wetlands are degraded by altered hydrology, invasive species, human encroachment, and contaminants. Hydrologic alterations of wetlands, including flood control and channelization, often make wetland habitat less suitable by altering water depth and timing of water level fluctuations. The depletion of freshwater aquifers can cause saltwater intrusion into coastal groundwater, altering the salinity of associated wetlands, and reducing habitat suitability (U.S. Fish and Wildlife Service 2011b). Predation by invasive animals including rats, feral dogs, feral cats, and bullfrogs (*Lithobates catesbeianus*) also threaten the recovery of the Hawaiian stilt (aeʻo). Rats mainly target eggs and chicks, whereas feral cats and dogs target chicks, subadults, and adults. Other birds such as the black-crowned night heron (aukuʻu) (*Nycticorax nycticora*), cattle egret (*Bubulcus ibis*), Hawaiian short-eared owl (pueo) (*Asio flammeus sandwichensis*), and common mynas (*Acridotheres tristis*) have been observed preying on eggs, chicks, and subadults (U.S. Fish and Wildlife Service 2020b). Although not present on Kauaʻi (U.S. Fish and Wildlife Service 2019), predation by Indian mongoose of waterbirds including the Hawaiian stilt (aeʻo) continues to be an issue on other islands.

The most prevalent avian disease that continues to be a threat to the Hawaiian stilt (aeʻo) and other waterbirds is avian botulism. The disease can reappear annually in wetland habitats with stagnant water. The deadly effect, which includes flaccid paralysis and eventual leg paralysis, is caused by a toxin produced by the anaerobic bacteria known as *Clostridium botulinum* (type C). Wetlands with no prior history of avian botulism are less likely to experience an outbreak due to the low levels or absence of the *Clostridium botulinum* spores in the immediate environment. However, these spores can be introduced into areas with no botulism history by an infected bird (U.S. Fish and Wildlife Service 2020b). Avian botulism has been documented in the following locations: ʻŌhiʻapilo Pond on Molokaʻi, Hanalei National Wildlife Refuge on Kauaʻi, Ōpaeʻula Pond and ʻAimakapā Pond on Hawaiʻi, Keālia Pond National Wildlife Refuge and Kanahā Pond Wildlife Sanctuary on Maui, and at the lake on Laysan Island (U.S. Fish and Wildlife Service 2020b).

Two emerging avian diseases pose significant threats to the Hawaiian stilt (aeʻo): West Nile virus and avian influenza H5N1 or "bird flu". Both diseases have yet to be identified in Hawaiian bird populations (U.S. Fish and Wildlife Service 2011b). A surveillance program for these diseases has been established to identify infected birds; however, eradication measures have not yet been proposed if detection occurs.

3A.4.5.1 Climate Change

According to IPCC, human activities have caused a 1.8°F (1°C) increase in tropospheric temperature above pre-industrial levels, and with the current rate of warming, could reach an increase of 2.7°F (1.5°C) by the year 2030 (Intergovernmental Panel on Climate Change 2019). With increasing atmospheric temperature, the size and intensity of large-scale storms are expected to increase in coming years, and recent data demonstrates Category 4 and 5 hurricanes have increased globally at a rate of 25–30 percent per °C increase in global warming (Holland and Bruyere 2014). Temperature increases may also allow avian disease, pathogens, and vectors to expand their ranges and severity. Changes in temperature, precipitation, and sea level, and the effects of these changes will be greatly exacerbated by existing non-climate-related stressors, such as predation by invasive species, fragmentation of habitat resulting from expanding land uses, and disease. Studies examining the effects of sea level rise on low-lying coastal wetlands in the MHI indicate that increased water levels, erosion, salinity, and unprecedented flooding cycles associated with sea level rise threaten habitats of endangered waterbirds. Hawaiian waterbirds are particularly sensitive to sea level rise due to the proximity of their wetland habitat to the coast and the fact that most Hawaiian Island wetlands are groundwater dependent (Hunt and DeCarlo 2000; U.S. Fish and Wildlife Service 2011c, 2011d in Kane 2014). It is unclear how groundwater flooding will affect endangered waterbird habitat, but reduction of this habitat would negatively affect the species (U.S. Fish and Wildlife Service 2018b). Marine flooding and inundation from storm surge, marine overwash (i.e., waves overtopping sand dunes), and tidal waves, also have the potential to destroy active waterbird nests and their habitat (U.S. Fish and Wildlife Service 2018b). The rate of impact caused by sea level rise–induced flooding is modeled to rapidly accelerate once the height of the sea surface exceeds a critical elevation. Estimating the critical elevation marking the end of slow flooding and the onset of rapid flooding will help wetland decision makers to plan and develop management strategies to meet the challenges presented by climate change (State of Hawaiʻi Department of Land and Natural Resources 2015). In combination with habitat loss and degradation, sea level rise could severely limit available habitat for Hawaiian waterbirds (Clausen and Clausen 2014). In addition to sea level rise, the Hawaiian Islands are projected to experience more severe annual wave-driven flooding events, during which seawater overtops coastal berms, resulting in increased inland flooding (U.S. Fish and Wildlife Service 2018b). Climate change analyses in the Pacific Islands currently lack sufficient spatial resolution to make specific predictions concerning the effects of climate-related changes on waterbirds on Kauaʻi (University of Hawaiʻi at Mānoa 2014). Sea level rise in Hawaiʻi will not be uniform across the island chain due, in part, to local land subsidence resulting from the active growth of the Island of Hawaiʻi (Polhemus 2015).

3A.5 Hawaiian Duck (koloa maoli) (*Anas wyvilliana*)

3A.5.1 Listing Status and Taxonomy

The Hawaiian duck (koloa maoli) (*Anas wyvilliana*) is endemic to the MHI. Taxonomically, Hawaiian duck (koloa maoli) is in the family Anatidae (*Anseriformes*) and closely allied with the mallard (*Anas platyrhynchos*). The Hawaiian duck (koloa maoli) was listed under the federal ESA as an endangered species in 1967 (U.S. Fish and Wildlife Service 1970). The species is also listed as endangered under HRS, Chapter 195D, Section 195D-4, Endangered and Threatened Species. The second revised Hawaiian waterbird recovery plan was approved in October 2011 (U.S. Fish and Wildlife Service 2011c). Critical habitat has not been designated for the Hawaiian duck (koloa maoli).

3A.5.2 Life History

Hawaiian ducks (koloa maoli) tend to congregate in fall and winter in lowland wetlands in flocks of 5 to 15 birds. Pairs usually form in fall and winter but can form at any time of year depending on rainfall and habitat availability. Hawaiian ducks (koloa maoli) breed year-round, with the majority of nesting occurring March–June (Engilis et al. 2002). In the Kauaʻi lowlands, they form pair bonds between November and May, with pairs dispersing to stream and marshland nesting locations (U.S. Fish and Wildlife Service 2011c). Nests are made of vegetation, lined with feathers, on the ground in tall grass. Clutch size averages eight eggs; incubation lasts about 4 weeks. Young take to the water soon after hatching but cannot fly until about 9 weeks old. Offspring become sexually mature enough to reproduce after a year. Hawaiian ducks (koloa maoli) are wary of humans, especially when nesting or during the flightless period while molting, which peaks between June and August. During the winter, Hawaiian ducks (koloa maoli) may gather in larger numbers to exploit abundant food resources, though most typically they are found in pairs (U.S. Fish and Wildlife Service 2011c).

3A.5.3 Habitat Requirements and Ecology

Hawaiian ducks (koloa maoli) are found from sea level to 9,900 ft (3,017.5 m), in a wide variety of natural and artificial wetland habitats including freshwater marshes, flooded grasslands, montane stock ponds, streams, forest swamplands, taro patches, lotus (*Nelumbo nucifera*) farms, irrigation ditches, reservoirs, and mouths of larger streams. Hawaiian ducks (koloa maoli) typically forage in water less than 6 inches (15.2 cm) deep and are opportunistic feeders, having a diet including snails, fish, aquatic insects, earthworms, grass seeds, green algae, and seeds and leaves of wetland plants (U.S. Fish and Wildlife Service 2011c). They are strong flyers and usually fly at low altitudes. Birds on open wetlands are particularly skittish, and when flushed readily burst from water's surface making sharp turns, flying within 50 m of the ground and circling the disturbance before moving off (Engilis et al. 2020). Flight speed has been clocked from a moving automobile at approximately 44–50 miles per hour (72–80 km per hour) for over a third of a mile (half a kilometer) (Swedberg 1967). Hawaiian ducks (koloa maoli) are non-migratory, although some seasonal, altitudinal, and inter-island movements occur, the timing and mechanics of which are not well understood (Engilis and Pratt 1993). On Kauaʻi, seasonal movement of birds occurs from lowland wetlands to more secluded habitats in summer (U.S. Fish and Wildlife Service 2011c). In addition, there is evidence they may travel between Kauaʻi and Niʻihau in response to above-normal precipitation, and the flooding and drying of Niʻihau's ephemeral lakes (Engilis and Pratt 1993).

3A.5.4 Distribution and Population Trends

Hawaiian ducks (koloa maoli) were historically common across most of the Hawaiian Islands. Factors such as predation, agricultural and urban development, hybridization with feral mallards, and overhunting caused a decrease in the population in the early 20th century. At that time, Hawaiian ducks (koloa maoli) were common in the coastal marshes of all the MHI except for Lānaʻi and Kahoʻolawe (Pyle and Pyle 2017d). By the mid-20th century, the species had been reduced to 500 birds on the island of Kauaʻi, and a few isolated pairs on other islands (Schwartz and Schwartz 1953). Starting in the mid-1950s and continuing to 1990, the State of Hawaiʻi began a captive propagation and release program. During that time period, 757 captive-bred Hawaiian ducks (koloa maoli) were released on the islands of Oʻahu (326), Maui (12), and Hawaiʻi (419).

Since the species' listing under the federal ESA in 1967, the population has increased on Kauaʻi, though it is declining on other islands. The Hawaiian duck (koloa maoli) population was estimated in 2002 to be about 2,200 individuals, with 2,000 true (non-hybrid) Hawaiian ducks (koloa maoli) on Kauaʻi and Niʻihau, and 200 on the Island of Hawaiʻi (Engilis et al. 2002). The Hawaiian duck (koloa maoli) population on Kauaʻi is substantially larger than on all other islands combined. Surveys of the Kauaʻi Hawaiian duck (koloa maoli) population between 2012 and 2016 estimated a population of 947 (751–1,185) individuals (Paxton et al. 2021). This comparatively large population size on Kauaʻi is probably due to the lack of an established population of mongooses and low occurrence of hybridization unlike the other Hawaiian Islands (U.S. Fish and Wildlife Service 2011c).

Hawaiian duck (koloa maoli) survey counts on Oʻahu, Maui, and Hawaiʻi are confounded by the difficulty in distinguishing Hawaiian duck (koloa maoli) from mallards and hybrids in the field. Populations on Kauaʻi have remained relatively free of mallard genes (Pyle and Pyle 2017d).

The State's biannual surveys typically do not include remote wetlands and streams (Engilis et al. 2002), where an estimated 50 to 80 percent of Hawaiian ducks (koloa maoli) are believed to reside on Kauaʻi (Schwartz and Schwartz 1953). Therefore, because DOFAW's biannual counts only provide estimates for lowland wetlands (Figure 5), they are useful for long-term trends analysis but are not used as an estimate for the Hawaiian duck (koloa maoli) population. Global long-term (1986–2016) and short-term (2006–2016) trends indicate increasing population sizes for the Hawaiian duck (koloa maoli) population on Kauaʻi (Paxton et al. 2021).

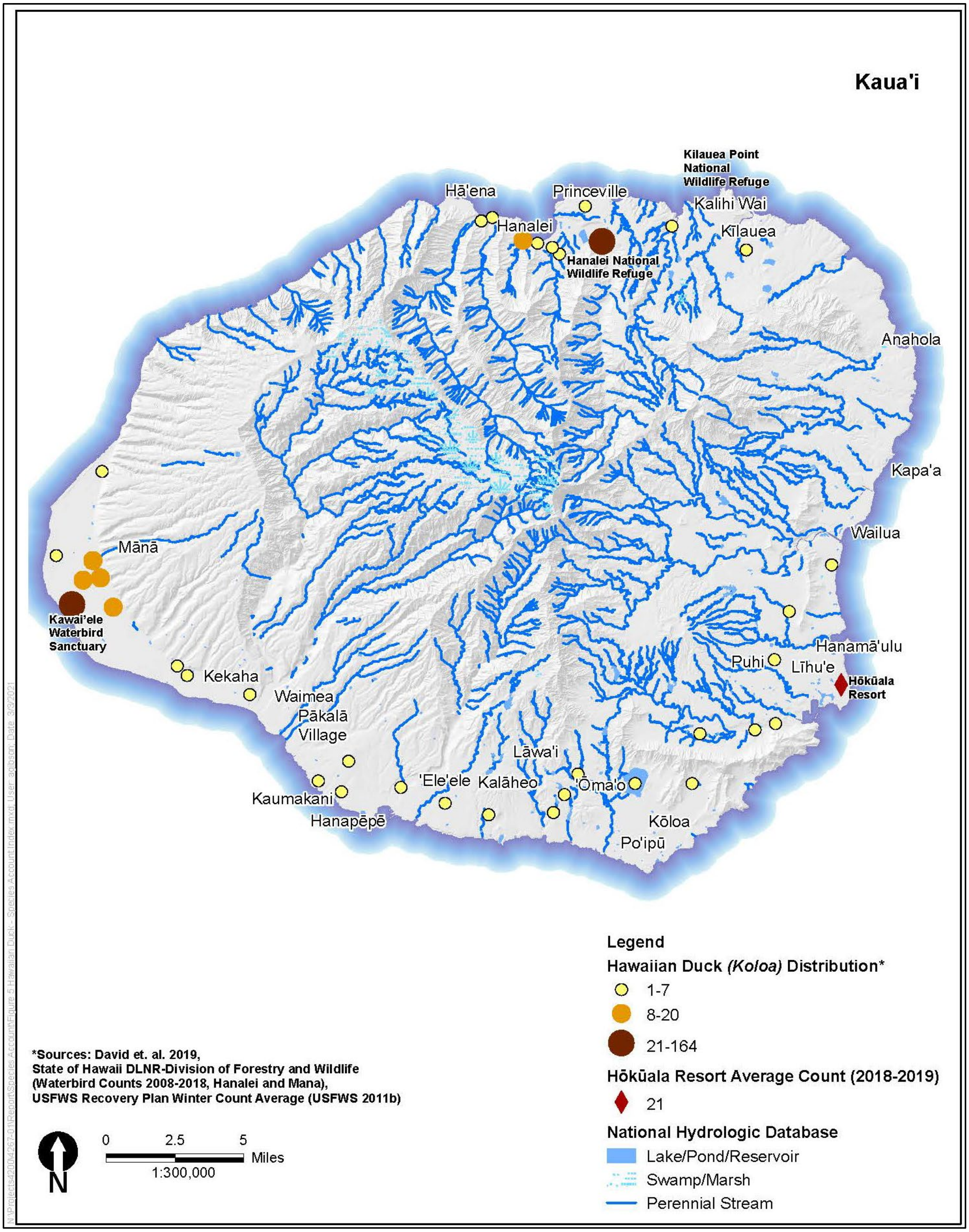

Figure 5. Distribution of the Hawaiian Duck (koloa maoli) on the Island of Kaua'i

3A.5.5 Threats

Threats to the Hawaiian duck (koloa maoli) are generally the same as those for other Hawaiian waterbirds—loss of wetland habitat, predation by invasive animals, disease, and environmental contaminants. In addition, threats to Hawaiian duck (koloa maoli) include hybridization with invasive mallards that were introduced to Hawaiʻi for farming, sport hunting, and pond beautification (Uyehara et al. 2007; U.S. Fish and Wildlife Service 2011c). Hybridization is considered the largest threat to the species (U.S. Fish and Wildlife Service 2011c). This is especially problematic on the islands of Oʻahu and Maui where most of the individuals are now mallard-Hawaiian duck (koloa maoli) hybrids (U.S. Fish and Wildlife Service 2011c; Pyle and Pyle 2017d). Although instances exist of ducks, geese, and rails colliding with powerlines (Bevanger 1998; Travers et al. 2019), there is little evidence that collisions with utility structures are having a large impact on Hawaiian waterbirds on Kauaʻi. During the period of 2007 to 2019, one Hawaiian duck (koloa maoli) turned into the SOS Program (Bache 2020) was found in the vicinity of powerlines, but the cause of death was unknown.

3A.5.5.1 Climate Change

Threats related to climate change are similar for all Hawaiian waterbirds and are discussed in Section A.4.5.1, *Climate Change*, for Hawaiian stilt (aeʻo). Climate change analyses in the Pacific Islands currently lack sufficient spatial resolution to make specific predictions concerning the effects of climate-related changes on Hawaiian duck (koloa maoli) on Kauaʻi (University of Hawaiʻi at Mānoa 2014).

3A.6 Hawaiian Coot (ʻalae keʻokeʻo) (*Fulica alai*)

3A.6.1 Listing Status and Taxonomy

The Hawaiian coot (ʻalae keʻokeʻo) (*Fulica alai*), is a member of the rail family, Rallidae, and is endemic to Hawaiʻi. It is 13–16.1 inches (33–41 cm) in size, and plumage is similar to the American coot (*Fulica america*). The Hawaiian coot (ʻalae keʻokeʻo) was listed as endangered under the federal ESA in 1967 (U.S. Fish and Wildlife Service 1970). The species is also listed as endangered under HRS, Chapter 195D, Section 195D-4, Endangered and Threatened Species. The latest recovery plan for the species was published in 2011 (U.S. Fish and Wildlife Service 2011c). The last 5-year review was published in 2015. Critical habitat has not been designated for the Hawaiian coot (ʻalae keʻokeʻo).

3A.6.2 Life History

Hawaiian coot (ʻalae keʻokeʻo) are mostly sedentary, making localized flights around existing wetland habitats based on rainfall (Pratt and Brisbin 2020). Their flight is strong and direct, requiring an extended period of running along the water's surface to become airborne (Brisbin and Mowbray 2020). Flight height is typically ≤16 ft (5 m) above the water surface except over land when additional altitude is needed to clear obstacles such as trees (Brisbin and Mowbray 2020). At times, the species travels long distances, including between islands, when local food sources are depleted (Engilis and Pratt 1993). Floating nests are constructed of aquatic vegetation, and found in open water or anchored to emergent vegetation (Byrd et al. 1985). Open water nests usually consist of mats of water hyssop (*Bacopa monniere*) and Hilo grass (*Paspalum conjugatum*) (Byrd et al. 1985; Pratt and Brisbin 2020). Nests in emergent vegetation are typically platforms constructed from buoyant stems of species such as bulrush (*Scirpus* spp.) (Byrd et al. 1985). Average depth of water at Hawaiian coot (ʻalae keʻokeʻo) nest sites was 13 inches (33 cm) in natural habitats (Byrd et al. 1985).

Hawaiian coot (ʻalae keʻokeʻo) are somewhat gregarious and non-breeding birds may form large flocks. Nesting occurs primarily March through September, although some nesting occurs in all months of the year (Shallenberger 1977; Pratt and Brisbin 2020). The timing of nesting appears to correspond with seasonal weather conditions (Byrd et al. 1985; Engilis and Pratt 1993). Nest initiation corresponds to rainfall, as appropriate water levels are critical to nest success. Clutch size ranges from one to ten eggs, and young hatch after a 25-day incubation period (Byrd et al. 1985). Chicks swim from the nest soon after hatching, remaining close to parents; immature birds have been seen with parents several weeks after hatching (Pratt and Brisbin 2020). There is no information on the lifespan and survivorship of this species; however, banding records indicate the oldest American coot was at least 22 years old (Klimkiewicz and Futcher 1989).

3A.6.3 Habitat Requirements and Ecology

Hawaiian coots (ʻalae keʻokeʻo) generally occur within wetland habitats having emergent plants interspersed with open water, especially freshwater wetlands, freshwater reservoirs, cane field reservoirs, sewage treatment ponds, taro loʻi, and brackish wetlands; they exhibit limited use of saltwater habitats (Shallenberger 1977; Byrd et al. 1985; Pratt and Brisbin 2020). Ephemeral wetlands support large numbers of Hawaiian coots (ʻalae keʻokeʻo) during the non-breeding season. Habitat elevation ranges from the coastal plains at sea level to 850 ft (259 m), rarely to 3,500 ft (1,067 m) (Byrd et al. 1985). On Kauaʻi, however, some birds occur in plunge pools above 4,900 ft (1,493.5 m) and on Hawaiʻi, birds occur in stock ponds at 6,600 ft (2,012 m) in elevation (U.S. Fish and Wildlife Service 2011c).

Hawaiian coots (ʻalae keʻokeʻo) are generalists and feed on land, grazing on grass adjacent to wetlands, or in the water (U.S. Fish and Wildlife Service 2011c). The species typically forages in water less than 12 inches (30.5 cm) deep, but dives in water up to 48 inches (121.9 cm) deep. Hawaiian coots (ʻalae keʻokeʻo) prefer to forage in water that is somewhat open (U.S. Fish and Wildlife Service 2011c). They use logs, rafts of vegetation, narrow dikes, mud bars, and artificial islands for resting. Food items include seeds and leaves, snails, crustaceans, insects, tadpoles, and small fish (U.S. Fish and Wildlife Service 2011c; Pratt and Brisbin 2020).

3A.6.4 Distribution and Population Trends

The Hawaiian coot (ʻalae keʻokeʻo) population was estimated to be 1,500–2,800 birds (U.S. Fish and Wildlife Service 2011c). The survey data from the biannual waterbird counts imply that the population has an overall slightly increasing trend (U.S. Fish and Wildlife Service 2011c). Surveys of the statewide Hawaiian coot (ʻalae keʻokeʻo) population between 2012 and 2016 Kauaʻi resulted in a 5-year minimum average population estimate of 1,815 (1,248–2,577) (Paxton et al. 2021).

The Hawaiian coot (ʻalae keʻokeʻo) historically occurred on all of the MHI except Lānaʻi and Kahoʻolawe. Hawaiian coots (ʻalae keʻokeʻo) have historically been most numerous on the islands of Oʻahu, Maui, and Kauaʻi (U.S. Fish and Wildlife Service 2011c). Approximately 80 percent of the current population occurs on Kauaʻi (Hanalei, Hulēʻia, ʻŌpaekaʻa), Oʻahu, and Maui (U.S. Fish and Wildlife Service 2011c). The remaining 20 percent occurs in coastal ponds and playa wetlands, including breeding populations on the islands of Hawaiʻi, Lānaʻi, Molokaʻi, and Niʻihau (U.S. Fish and Wildlife Service 2011c).

Surveys indicate that migration events between Kauaʻi and Niʻihau occur only when annual precipitation is above normal and ephemeral lakes on Niʻihau become flooded (Engilis and Pratt 1993). Numbers of Hawaiian coots (ʻalae keʻokeʻo) counted on Niʻihau during wet winters include 949 birds in 1986 and 803 birds in 1996, but Niʻihau has not been surveyed since 1999 (U.S. Fish and Wildlife Service 2005). Population trends specific to Kauaʻi have been monitored by annual surveys of Mānā from 1986 to 2004 and monthly counts in the Hanalei National Wildlife Refuge in 2010 through 2015. Between 0 and 87 Hawaiian coots (ʻalae keʻokeʻo) were observed each year in Mānā, whereas 45 to 641 individuals were detected in Hanalei (State of Hawaiʻi Division of Forestry and Wildlife 2021). Trend data collected over three decades (up to 2008) show that Hawaiian coots (ʻalae keʻokeʻo) are either stable or increasing statewide. Distribution of the Hawaiian coot (ʻalae keʻokeʻo) on Kauaʻi is shown in Figure 6. Global long-term (1986–2016) and short-term (2006–2016) trends indicate increasing population sizes for the Hawaiian coots (ʻalae keʻokeʻo) population on Kauaʻi (Paxton et al. 2021).

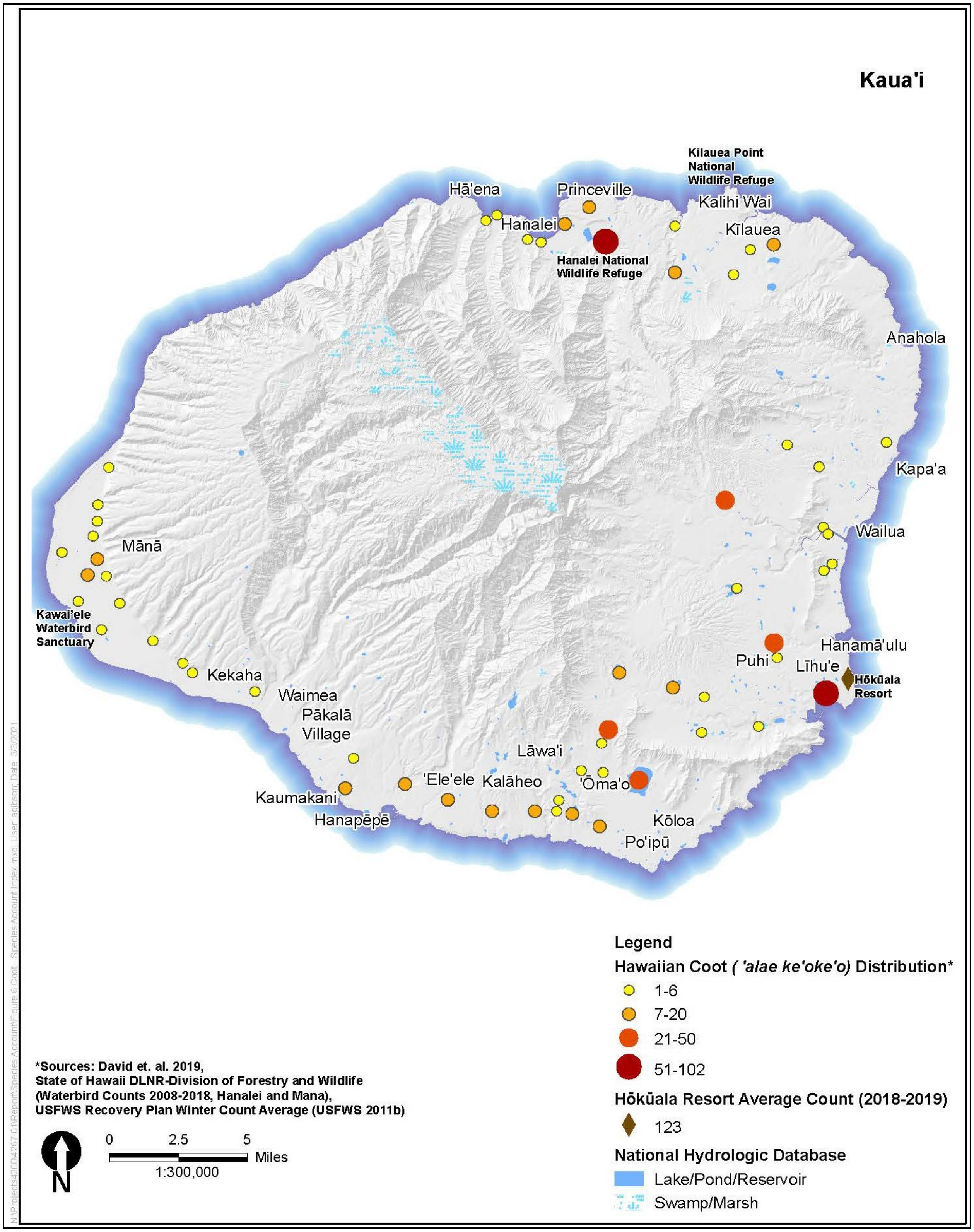

Figure 6. Distribution of the Hawaiian Coot ('alae ke'oke'o) on the Island of Kaua'i

3A.6.5 Threats

Threats to Hawaiian coots (ʻalae keʻokeʻo) are generally the same as those outlined in the Hawaiian stilt (aeʻo) account (Section A.4.5, *Threats*). In addition, Hawaiian coot (ʻalae keʻokeʻo) nest and forage at wastewater treatment plants across the islands, increasing their exposure to toxins. Bumblefoot (ulcerative pododermatitis), a bacterial infection that causes foot inflammation and swelling in birds, may be a chronic condition in the population. This infection has been found on 45 percent of the Hawaiian coot (ʻalae keʻokeʻo) banded at the Kaunakakai Wastewater Reclamation Facility on Molokaʻi (U.S. Fish and Wildlife Service 2011c). The incidence in birds on Kauaʻi is unknown.

There is no indication that this species interacts to a great extent with powerlines. However, studies in Europe have shown members of the Rallidae to be susceptible to high numbers of casualties in sensitive habitats where there are thin, low-hanging lines (Haas et al. 2005). During the period of 2007–2019, five individuals were turned into the SOS Program, reportedly found under powerlines. The precise cause of death is unknown but is assumed to be powerline collisions (Bache 2020).

3A.6.5.1 Climate Change

Threats related to climate change are similar for all Hawaiian waterbirds and are discussed in Section A.4.5.1, *Climate Change*, for Hawaiian stilt (aeʻo). Climate change analyses in the Pacific Islands currently lack sufficient spatial resolution to make specific predictions concerning the effects of climate-related changes on Hawaiian coot (ʻalae keʻokeʻo) on Kauaʻi (University of Hawaiʻi at Mānoa 2014).

3A.7 Hawaiian Common Gallinule (ʻalae ʻula) (*Gallinula galeata sandvicensis*)

3A.7.1 Listing Status and Taxonomy

The Hawaiian common gallinule (ʻalae ʻula) (*Gallinula galeata sandvicensis*), previously called the Hawaiian common moorhen and the Hawaiian gallinule, is a subspecies of the common gallinule (Griiformes, Rallidae). Hawaiian common gallinule (ʻalae ʻula) was listed as endangered under the federal ESA in 1967 (U.S. Fish and Wildlife Service 1970). The species is also listed as endangered under HRS, Chapter 195D, Section 195D-4, Endangered and Threatened Species. The latest recovery plan for the species was published in 2011 (U.S. Fish and Wildlife Service 2011c). The last 5-year review was published in 2015. Critical habitat has not been designated for the Hawaiian common gallinule (ʻalae ʻula).

3A.7.2 Life History

Hawaiian common gallinules (ʻalae ʻula) are non-migratory and it is unknown whether they are capable of inter-island movement. They characteristically swim or walk on aquatic vegetation or soil and are seldom seen flying (Bannor and Kiviat 2020). They nest year-round, though concentrated nesting is March–August (Shallenberger 1977; Byrd and Zeillemaker 1981; Chang 1990). Nesting phenology appears to be related to wetland late-succession vegetation and water levels. The Hawaiian common gallinule (ʻalae ʻula) clutch averages five to six eggs (Byrd and Zeillemaker 1981;

Chang 1990); incubation ranges from 19 to 22 days (Byrd and Zeillemaker 1981). Re-nesting and multiple broods during one season often occur (Byrd and Zeillemaker 1981). Platform nests are constructed in dense vegetation over water or near the edge of a marsh. Hawaiian common gallinule (ʻalae ʻula) hatchlings are precocial; chicks are covered with down and are able to walk but are dependent on parents for several weeks (U.S. Fish and Wildlife Service 2011c). Hawaiian common gallinule (ʻalae ʻula) are secretive, preferring to forage, nest, and rest in dense wetland vegetation. When feeding along the water's edge or in open water, they quickly seek cover when disturbed.

3A.7.3 Habitat Requirements and Ecology

Hawaiian common gallinules (ʻalae ʻula) predominantly occur in wetlands below 410 ft (125 m) in elevation on Kauaʻi and Oʻahu, with a few observations reported from Keʻanae Peninsula, Maui, and also from the Island of Hawaiʻi. The preferred habitat is low-elevation freshwater marshes (Engilis and Pratt 1993). Key habitat features include scattered dense stands of robust vegetation near open water, floating or barely emergent mats of vegetation, and water depth less than 3 ft (0.9 m). Hawaiian common gallinules (ʻalae ʻula) are opportunistic feeders and their diet varies with habitat, but includes algae, grass seeds, insects, snails, fish, crustaceans, mollusks, grasses, and wetland plants (U.S. Fish and Wildlife Service 2011c).

3A.7.4 Distribution and Population Trends

No historical population estimates are available prior to the first biannual waterbird count by DOFAW in 1977. It is believed that in the 19th century Hawaiian common gallinule (ʻalae ʻula) were common on all of the Hawaiian Islands, except Lānaʻi and Kahoʻolawe. The population exhibited a precipitous decline in numbers through the mid-20th century. Currently Hawaiian common gallinules (ʻalae ʻula) are only known to inhabit the islands of Kauaʻi and Oʻahu. Surveys of the statewide population between 2012 and 2016 were small but relatively stable, with a minimal 5-year average of 927 (678–1,235) individuals (Paxton et al. 2021).

On Kauaʻi, the largest populations occur in the Hanalei and Wailua River valleys, Waiakalua Reservoir, and Wilcox Ponds. However, they also occur in low numbers within the irrigation canals in Mānā in western Kauaʻi and in taro fields (Figure 7) (U.S. Fish and Wildlife Service 2011c). Between 2008 and 2018, DOFAW conducted monthly counts at Hanalei National Wildlife Refuge and other wetlands in Hanalei and observed approximately 648 individuals and 100 individuals, respectively, on an annual basis (State of Hawaiʻi Division of Forestry and Wildlife 2021). Annual counts in Mānā at the Kawaiʻele Waterbird Sanctuary averaged approximately 18 individuals and in other Mānā wetlands 34 individuals, on an annual basis (State of Hawaiʻi Division of Forestry and Wildlife 2021). While these surveys provide an estimation of population status, the methodology for the counts may be flawed and final totals are thought to be underestimated because of the species' secretive behavior (U.S. Fish and Wildlife Service 2011c). Global long-term (1986–2016) and short-term (2006–2016) trends indicate increasing population sizes for the Hawaiian common gallinules (ʻalae ʻula) population on Kauaʻi (Paxton et al. 2021).

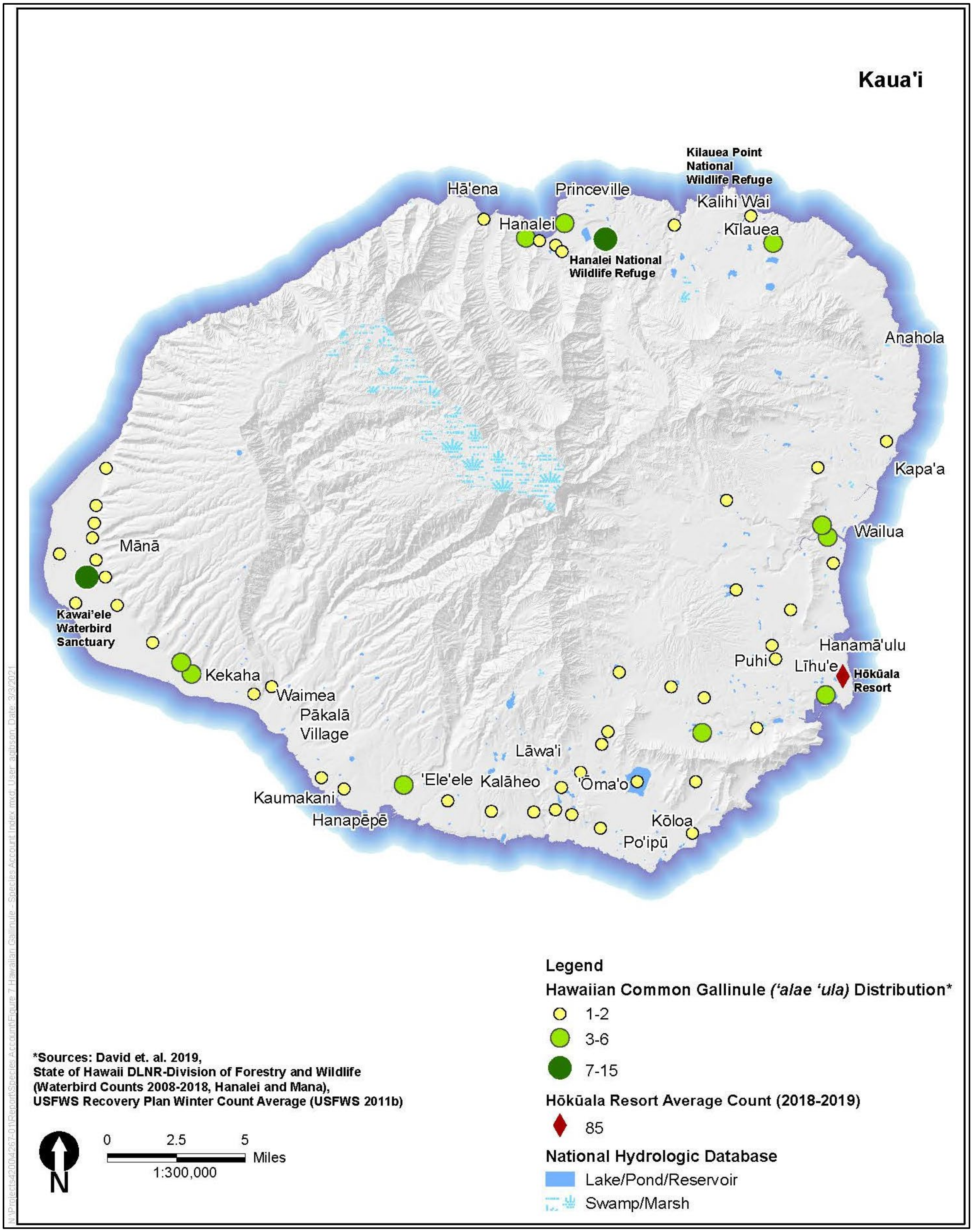

Figure 7. Distribution of the Hawaiian Common Gallinule ('alae 'ula) on the Island of Kaua'i

3A.7.5 Threats

Most of the threats to the Hawaiian common gallinule (ʻalae ʻula) are also common to the other Hawaiian waterbirds. See the discussion of threats for these species in Section A.4.5, *Threats*. Habitat loss and degradation and predation are likely the main threats to an increasing or stable population of Hawaiian common gallinule (ʻalae ʻula). There is no indication that Hawaiian common gallinules (ʻalae ʻula) interact with powerlines, although instances exist of ducks, geese, and rails colliding with powerlines (Bevanger 1998; Travers et al. 2019), particularly in sensitive habitats (Haas et al. 2005). During the period of 2007 through 2019, three Hawaiian common gallinule (ʻalae ʻula) were found in the vicinity of powerlines but the cause of death was unknown (Bache 2020).

3A.7.5.1 Climate Change

Threats related to climate change are similar for all Hawaiian waterbirds and are discussed in Section A.4.5.1, *Climate Change*, for Hawaiian stilt (aeʻo). Climate change analyses in the Pacific Islands currently lack sufficient spatial resolution to make specific predictions concerning the effects of climate-related changes on Hawaiian gallinule (ʻalae ʻula) on Kauaʻi (University of Hawaiʻi at Mānoa 2014).

3A.8 Hawaiian Goose (nēnē) (*Branta sandvicensis)*

3A.8.1 Listing Status and Taxonomy

The Hawaiian goose (nēnē) (*Branta sandvicensis*) is a medium-sized goose (16.1 inches [41 cm] tall) and a member of the avian family Anatidae. The Hawaiian goose (nēnē) was listed as endangered under the federal ESA in 1967. The species is also listed as endangered under HRS, Chapter 195D, Section 195D-4, Endangered and Threatened Species. In 2019, USFWS downlisted Hawaiian goose (nēnē) from endangered to threatened (83 *Federal Register* [FR] 13919). This change went into effect on January 21, 2020 (U.S. Fish and Wildlife Service 2019). Critical habitat has not been developed for this species by USFWS.

3A.8.2 Life History

The Hawaiian goose (nēnē) is non-migratory with daily, local flights typically in early morning and late afternoon, between nesting and feeding areas. Although they are capable of interisland flight, their wings are reduced in size and they are non-migratory. When taking off and landing, their long, low flight path makes them vulnerable to collisions with stationary structures and moving objects such as vehicles and aircraft (Banko et al. 2020). Historically, flocks moved between high-elevation feeding habitats and lowland nesting areas. Hawaiian geese (nēnē) reach sexual maturity after 1 year, but usually do not form pair bonds until the second year. Females are highly philopatric and nest near their natal area, while males more often disperse (U.S. Fish and Wildlife Service 2018c). Today, many Hawaiian geese (nēnē) nest in mid- and high-elevation sites, although it is believed that they once nested primarily in leeward lowlands (Banko et al. 1999; U.S. Fish and Wildlife Service 2004). Lowland areas are used by Hawaiian goose (nēnē) populations on Kauaʻi year-round (Banko et al. 1999; U.S. Fish and Wildlife Service 2004, 2019).

Hawaiian geese (nēnē) nest on the ground in a shallow scrape, shaded by shrubs or other vegetation. They have an extended breeding season, laying eggs from August to April, peaking in December (October–March); the majority of eggs hatch in December and January (Banko et al. 1999; U.S. Fish and Wildlife Service 2004, 2018c). A Hawaiian goose (nēnē) clutch typically contains three to five eggs, and incubation ranges from 29 to 32 days. Once hatched, the young may remain in the nest for 1–2 days; all hatchlings depart the nest after the last egg is hatched (U.S. Fish and Wildlife Service 2004, 2018c). Goslings are flightless for 10–12 weeks and adults are flightless (owing to wing molt) for a period of 4–6 weeks, at about the same time. During June to September, after molting and fledging, family groups congregate in post-breeding flocks, often far from nesting areas (U.S. Fish and Wildlife Service 2004, 2018c). Hawaiian geese (nēnē) are highly social within their family units and moderately social with other geese, typically associating in small local flocks that are limited in size because of small population sizes (Banko et al. 2020).

3A.8.3 Habitat Requirements and Ecology

Hawaiian geese (nēnē) exhibit seasonal movements to grasslands when the production of fruiting bodies associated with shrubland foraging habitat is low, and when wet conditions produce grass with a high water and protein content. Hawaiian goose (nēnē) grazing is opportunistic, with variation in their grazing allowing the species to survive in marginal habitats (Banko et al. 1999). Historical reports from the Island of Hawai'i indicate that Hawaiian geese (nēnē) bred and molted primarily in the lowlands during winter and moved upslope in the hotter and drier summer (U.S. Fish and Wildlife Service 2004, 2018c). Reproductive success is relatively low in highland habitats on Hawai'i and Maui, and higher in lowland habitat on Kaua'i (Banko et al. 1999).

On Kaua'i, where the largest population now occurs, Hawaiian geese (nēnē) typically use lowland habitats including golf courses, coastal wetlands including taro lo'i (ponds), farmlands, pastures and fallow grassy and shrubby fields; they are also found along roadsides, and in established and maintained Hawaiian goose (nēnē) release sites and wildlife sanctuaries (Banko et al. 1999). Most Hawaiian geese (nēnē) on Kaua'i occur in coastal wetlands at Hanalei and Hule'ia National Wildlife Refuges, along the Nā Pali Coast, and in maintained wetlands and water features at resorts and golf courses in and around Līhu'e. The range has expanded considerably as the population has increased, and Hawaiian geese (nēnē) have adapted to many urban settings (U.S. Fish and Wildlife Service 2004; David et al. 2019).

3A.8.4 Distribution and Population Trends

Hawaiian geese (nēnē) were once widely distributed among the MHI (Ni'ihau, Kaua'i, O'ahu, Moloka'i, Maui, Lāna'i, Kaho'olawe, and Hawai'i); for a detailed history, see Pyle and Pyle (2017e). Before 1778, the distribution of Hawaiian goose (nēnē) was much broader than what it became after colonization by Europeans (Banko et al. 1999). However, estimating the population size both pre-Polynesian and pre-European contact is difficult because of limited understanding of species composition or even the gross structure of the vegetation before human occupation (U.S. Fish and Wildlife Service 2004). By 1952, the world population totaled 30 Hawaiian geese (nēnē), confined to the Island of Hawai'i (Smith 1952). It is thought that Hawaiian goose (nēnē) populations on the higher islands, Hawai'i and Maui, persisted longest owing to those islands' remote rugged upland areas, where hunting and predation by introduced mammals were less intense (Banko et al. 1999).

In 2020 statewide population estimate for the Hawaiian goose (nēnē) was 3,865 individuals, with 1,099 on Hawai'i; 477 on Maui; 23 on Moloka'i; 2,266 on Kaua'i; and 0 on O'ahu (Nēnē Recovery

Action Group 2020). Kauaʻi has the greatest amount of lowland habitat available, and it is believed that this, in combination with the lack of an established mongoose population, has resulted in the largest population of Hawaiian geese (nēnē) among the MHI (Banko et al. 1999; U.S. Fish and Wildlife Service 2004).

There are currently four areas on Kauaʻi where Hawaiian geese (nēnē) are concentrated. The current distribution of birds on all islands, including Kauaʻi, is largely due to the locations captive-bred or translocated birds were released (Banko et al. 1999). With the exception of the Nā Pali Coast population, all Kauaʻi populations occur at low elevations, ranging from sea level to 600 ft (182.9 m). Approximately 25 captive Hawaiian geese (nēnē) were released by Kīpū Kai Ranch in 1985 on the southeast coastline of Kauaʻi. These birds were originally obtained from the Shipman Estates on Hawaiʻi in the late 1960s. Another 38 captive-bred Hawaiian geese (nēnē) were released at the Kīlauea Point National Wildlife Refuge located on the northeast coastline of Kauaʻi beginning in 1991. These birds have bred successfully, and together these two populations increased to more than 350 birds (U.S. Fish and Wildlife Service 2004). In 2012, it was estimated that 650 Hawaiian geese (nēnē) occurred on lands between Hanalei and Mōkōlea Point at Kīlauea Point. This was significantly higher than the record count of 91 individuals observed at the Kawaiʻele wetlands of Mānā along the southwestern coastline of Kauaʻi that same year. A third population was initiated on the Nā Pali Coast with the release of 62 captive Hawaiian geese (nēnē) in 1995–1996. Release was at 330 ft (100.6 m) elevation with the birds subsequently moving to breed at 1,650 ft (502.9 m). This population numbered about 61 birds in 2004 (U.S. Fish and Wildlife Service 2004). Twenty-four Hawaiian geese (nēnē) were introduced to the Hanalei National Wildlife Refuge in April 2000 (U.S. Fish and Wildlife Service 2004). Monthly counts at the Hanalei National Wildlife Refuge ranged between 40 and 211 Hawaiian geese (nēnē) from 2010 to 2015 (State of Hawaiʻi Division of Forestry and Wildlife 2021).

In 2011, an increase to 400 Hawaiian geese (nēnē) at Kauaʻi Lagoons (now Hōkūala Resort) along the southeast coast of Kauaʻi adjacent to Līhuʻe International Airport prompted DOFAW to initiate a translocation plan to reduce risk to aircraft operations (State of Hawaiʻi Division of Forestry and Wildlife 2012). Between 2011 and 2016, 652 birds were translocated to Maui and Hawaiʻi (U.S. Department of Agriculture-Wildlife Services 2019). Since 2016, Hawaiian geese (nēnē) resumed nesting at the resort, and in 2019, over 100 Hawaiian geese (nēnē) were recorded at the facility (David et al. 2019). Even with the translocation of birds to Maui and Hawaiʻi, Hawaiian goose (nēnē) are increasing on Kauaʻi (Figure 8; Nēnē Recovery Action Group 2017, 2022).

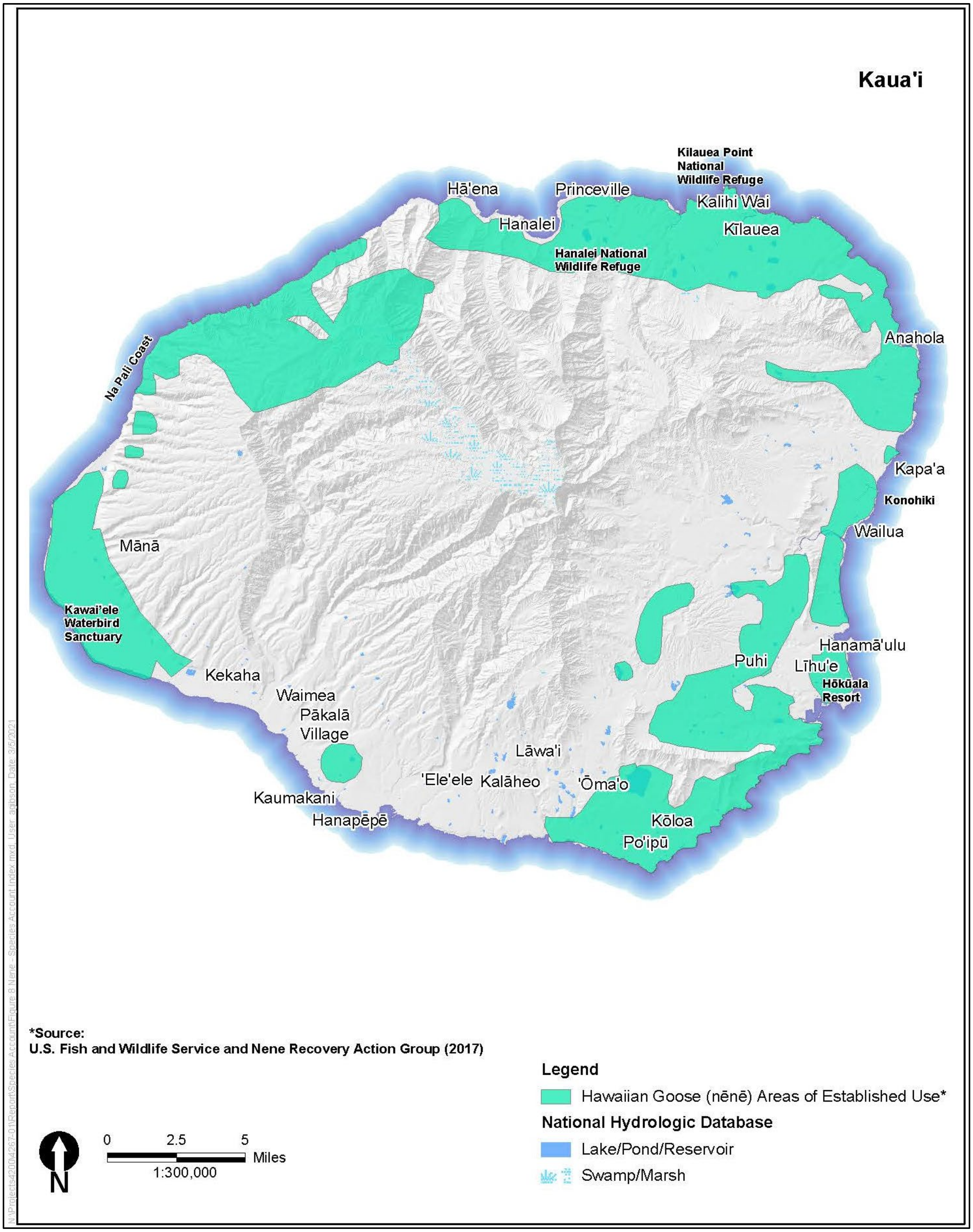

Figure 8. Hawaiian Goose (nēnē) Established Use Areas

3A.8.5 Threats

As with the other Hawaiian waterbirds, the primary causes of the decline of the Hawaiian goose (nēnē) are predation by introduced animals, loss of habitat, over-hunting in the late 19th century and early 20th century, disease, and environmental contaminants (U.S. Fish and Wildlife Service 2011c). During periods of flightlessness (while growing flight feathers and molting; February–May), Hawaiian goose (nēnē) goslings and adults are both extremely vulnerable to predation by invasive mammals. Introduced predators such as dogs, cats, and, on other islands, mongoose pose a serious threat to the Hawaiian goose (nēnē) by taking eggs, young birds, and even adults (U.S. Fish and Wildlife Service 2011c; State of Hawaiʻi Division of Forestry and Wildlife 2012).

Human activities have led to loss of lowland habitat for development of cultivated agriculture, housing developments, hotels, and golf courses. Habitat loss has also resulted from ungulate grazing and browsing, increased frequency of fire, and invasive plant species invasion (U.S. Fish and Wildlife Service 2004, 2019). However, palatable grasses and other plants in some pastureland, golf courses, lawns, and roadsides allow Hawaiian goose (nēnē) to forage and nest where it otherwise could not (Banko et al. 1999). In light of this information and the fact that the Hawaiian goose (nēnē) population in the lowland Kauaʻi sites have been the most successful, managers have expanded efforts to find lowland areas for potential Hawaiian goose (nēnē) reintroduction (U.S. Fish and Wildlife Service 2004). The threat of destruction and modification of habitat, particularly in lowland areas, by urbanization and land use conversion, including agriculture, is ongoing and expected to continue to limit the amount of Hawaiian goose (nēnē) foraging and nesting habitat, which may lead to reduced reproductive success and population declines (U.S. Fish and Wildlife Service 2019).

Increased use of urban, agricultural, and human built environments exposes Hawaiian geese (nēnē) to injury or death from collisions with vehicles, aircraft, construction or agricultural equipment, and golf balls or golf carts (Banko et al. 1999; David et al. 2019; U.S. Fish and Wildlife Service 2004). Although instances exist of ducks, geese, and rails colliding with powerlines (Bevanger 1998; Travers et al. 2019), there is little evidence that collisions with utility structures are having a large impact on Hawaiian geese (nēnē) (or other waterbird species) on Kauaʻi. During one seabird season of powerline monitoring, KESRP reported bird collisions that involved two cattle egrets, one black-crowned night heron (aukuʻu), and one Hawaiian goose (nēnē) (Travers and Raine 2020). During the period from 2007 to 2019, five Hawaiian geese (nēnē) were turned in to the SOS Program, found in the vicinity of powerlines, but the cause of death was not determined (Bache 2020).

Diseases could also render local habitats unsuitable for sustaining life history requirements. Avian botulism type C, introduced by humans, is the most prevalent disease affecting all Hawaiian waterbirds (U.S. Fish and Wildlife Service 2011c). It is caused by a neurotoxin produced by a common bacterium (*Clostridium botulinum*). Normally dormant, avian botulism spores only release toxins when certain conditions occur, including warm temperatures, high pH, low dissolved oxygen, and stagnant waters. By eating invertebrates containing the toxin, birds can be infected. The disease causes flaccid paralysis, the eventual loss of use of legs, and death (U.S. Fish and Wildlife Service 2011c). Since 2013, avian botulism outbreaks have been documented at 10 locations on Kauaʻi (Pratt and Brisbin 2020). Omphalitis, an infection of the umbilical stump, has been found to cause mortality in both wild and captive Hawaiian goose (nēnē) goslings (U.S. Fish and Wildlife Service 2004).

The possibility of West Nile virus or avian influenza reaching the Hawaiian Islands from the U.S. mainland or Asia currently is not a concern, but the potential for the future introduction of this pathogen in the Hawaiian waterbird populations remains a concern.

3A.8.5.1 Climate Change

Threats related to climate change that are discussed in Section A.4.5.1, *Climate Change*, for Hawaiian stilt (aeʻo) are similar for the Hawaiian goose (nēnē), including habitat loss due to flooding and sea level rise, the spread of invasive plant species, and disease. Climate change analyses in the Pacific Islands currently lack sufficient spatial resolution to make specific predictions concerning the effects of climate-related changes on Hawaiian goose (nēnē) on Kauaʻi (University of Hawaiʻi at Mānoa 2014).

3A.9 Central North Pacific Distinct Population Segment of the Green Sea Turtle (honu) (*Chelonia mydas)*

3A.9.1 Listing Status and Taxonomy

The green sea turtle (honu) is the largest marine turtle in the family Cheloniidae, second in maximum size only to the leatherback sea turtle (*Dermochelys coriacea*), and the sole species within the genus *Chelonia*. Green sea turtles (honu) grow to have a carapace length of 4 ft (1.2 m) and to weigh more than 400 pounds (181 kilograms). Its carapace has an olive-to-black color pattern and is composed of five scutes (or plates) running down its center, with four on either side. Other notable morphological distinctions are the species' yellow undersides and the two scales between its eyes. This species and other members of the Cheloniidae inhabit tropical and subtropical seas around the world.

All green sea turtles (honu) were listed under the federal ESA on July 28, 1978 (43 FR 32800). At that time, breeding populations in Florida and along the Pacific Coast of Mexico were listed as endangered and all other populations were listed as threatened. Major factors contributing to its status included human encroachment and associated activities on nesting beaches; commercial harvest of eggs, subadults, and adults; predation; lack of comprehensive and consistent protective regulations; and incidental take in fisheries. The federal recovery of the species is administered jointly between USFWS and NMFS (collectively referred to as "the Services") (U.S. Fish and Wildlife Service and National Marine Fisheries Service 2015).

On February 16, 2012, the Services received a petition from the Association of Hawaiian Civic Clubs to identify the Hawaiian green sea turtle (honu) population as a distinct population segment (DPS) and delist it. On August 1, 2012, NMFS—with USFWS concurrence—determined that the petitioned action might be warranted, on the basis of the substantial information presented (77 FR 45571). After conducting a status review, the Services determined on April 6, 2016, that the Hawaiian population of the green sea turtle (honu) met the definition of threatened and identified it as the Central North Pacific distinct population segment (CNPDPS) (81 FR 20057). The status review analysis determined there were 11 DPSs for the species globally. All other green sea turtle (honu) populations remain federally protected, with three DPSs listed as endangered and eight DPSs listed as threatened, including the CNPDPS. Critical habitat for the CNPDPS of the green sea turtle (honu) has not been designated; however, the Services have agreed to identify and propose critical habitat for the five DPSs (including the CNPDPS) within U.S. jurisdictional lands and waters by 2023.

The CNPDPS of the green sea turtle (honu) is also protected by Chapter 195D of the HRS and Section 13-124 of Hawai'i Administrative Rules. Both adopt the same definitions, status designations, and prohibitions as the federal ESA, with the exceptions of some additional critical habitat designations and protections under the federal ESA, and additional penalties for violations at the state government level.

3A.9.2 Life History

Seminoff et al. (2015) published the status review as a NOAA Technical Memorandum entitled *Status Review of the Green Turtle (*Chelonia mydas*) under the U.S. Endangered Species Act*. This work serves as the most contemporary and comprehensive published repository of information for the species globally. As such, it forms the basis for most of the detail in this section.

Green sea turtle (honu) is migratory, and requires shoreline, neritic (nearshore), and oceanic habitats to satisfy different parts of its life cycle. Green sea turtles (honu) become sexually mature at 25–35 years. During the nesting season (April through September), females come ashore to lay eggs within a few weeks of mating. After making their way above the high-tide line, they use their front flippers to dig a large depression called a *body pit*. Females then use their back flippers to dig a smaller hole at the posterior end of the body pit called an *egg chamber*, into which they deposit between 50 and 200 soft-shelled eggs. After refilling and covering their nests with sand, they return to the ocean to forage before returning to shore approximately 14 days later to nest again. The female will nest approximately three to four times in a nesting season. Upon laying the final nest, the female returns to the ocean, taking up to several months to reach marine foraging grounds in the MHI. Females return to these specific, generally neritic feeding areas, to replenish energy stores for the next reproductive season. This typically takes more than a year; while males can mate annually, on average, females mate every 2 to 4 years to accommodate the energetic requirements of reproduction.

After about 2 months, hatchlings break through the eggshell and slowly dig their way to the surface, typically en masse, and head to the ocean. This movement generally occurs at night or in the early predawn hours to avoid detection on the beach or in nearshore waters by predators. Hatchlings initially orient to the brightest horizon, naturally occurring over the moonlit ocean, in areas devoid of artificial lighting (Daniel and Smith 1947; Limpus 1971; Salmon et al. 1992; Witherington and Martin 1996; Witherington 1997). After reaching the water, hatchlings exhibit a multi-day *swimming frenzy*, during which they swim almost continuously, fueled only by leftover egg yolk, to reach deeper water away from shore.

Young turtles are transported by strong currents to oceanic habitats, where they live among flotsam, such as Sargassum (brown algae) and flotsam mats. During this part of the green sea turtle's (honu) life cycle, which can last years to decades, the animals are omnivorous. This period is often referred to as "the lost years." Because it is difficult to study the turtles during this period, relatively little is known about this phase of the turtle's life cycle. Once juvenile turtles reach a certain size and age range, around 10 to 15 years old, the animals return to the highly productive neritic feeding areas to finish growing, a process that can take as little as a few years and as long as a few decades.

Adult turtles also occupy neritic foraging areas while traveling between nesting and breeding locations. After acquiring sufficient resources, adult males and females migrate to breeding areas to mate and, in the case of females, to nest. Females exhibit strong natal homing, meaning that to lay their own eggs, they return to the coastline where they had hatched. The distance between feeding and breeding areas can be hundreds to tens of thousands of miles.

3A.9.3 Habitat Requirements and Ecology

Seminoff et al. (2015) state that most green sea turtles (honu) spend most of their lives in neritic foraging grounds. These areas of shallow waters include both open coastline and protected bays and lagoons. While in these areas, green sea turtles (honu) rely on marine algae and seagrass as their primary food, although some populations also forage heavily on invertebrates during different parts of their life cycle. This is the case for the CNPDPS during its oceanic life stage as detailed below. These coastal habitats are often highly dynamic with annual fluctuation in salinity and air temperature, which can cause the distribution and abundance of potential green sea turtle (honu) food items to vary substantially between seasons and years (Carballo et al. 2002). Conditions at coastal foraging areas have been shown to affect the timing of green sea turtle (honu) reproduction (Limpus and Nicholls 1988; Solow et al. 2002). Therefore, even though foraging areas are usually separated from nesting areas by hundreds to thousands of miles, they have a profound influence on population dynamics. Annual and decadal oscillations in marine climate likely play a large role in these large-scale movements, because winds and currents are affected, but additional research is required to understand how environmental variability triggers or limits green sea turtle (honu) migration and reproduction.

Oceanic habitats are used by juveniles as noted in Section A.9.2, *Life History*, migrating adults, and, on some occasions, by green sea turtles (honu) that reside in the oceanic zone for foraging. Despite these uses of the oceanic zone, much remains unknown about how oceanography affects juvenile survival, adult migration, and prey availability in this species.

On shore, green sea turtles (honu) rely on safe and "healthy" beaches characterized by intact dune structure, native vegetation, lack of artificial lighting, and normal beach temperatures for nesting (Limpus 1971; Salmon et al. 1992; Ackerman 1997; Witherington 1997; Lorne and Salmon 2007). Research has shown that higher sand temperatures result in disproportionate sex ratios in sea turtles (higher temperatures result disproportionately more females produced and vice versa for males), which in turn can lead to lower fecundity rates and ultimately population declines (Blechschmidt et al. 2020). Coastal areas denuded of vegetation or where development is occurring can also affect the quality of nesting habitat by disrupting normal thermal regimes but also lead to the potential for tidal inundation associated with lack of vegetation. Nests laid in these areas are at a higher risk than those on more pristine beaches (Schroeder and Mosier 2000).

As noted above, green sea turtles (honu) have been shown to consume a wide variety of seagrass, marine algae, and invertebrates (Bjorndal 1997). Limited studies of oceanic adults have shown them to be primarily carnivorous (Arthur et al. 2008; Parker et al. 2011). Parker et al. (2011) conducted one of the few diet analyses of oceanic green sea turtles (honu). The authors studied ten animals opportunistically obtained as fisheries bycatch within the CNPDPS. Analysis indicated that green sea turtles (honu) of the CNPDPS during the oceanic life stage were "carnivorous with some omnivorous tendencies, foraging within the first 100 m of the water column." Neritic-stage juvenile and adult green turtles have been found to be generally herbivorous, foraging on seagrasses and marine algae, although some populations appear to forage heavily on invertebrates (Bjorndal 1997; Jones and Seminoff 2013). Additionally, some populations may exhibit one or more ontogenetic dietary shifts (i.e., developmental events that occur during the existence of a living organism) after recruitment to the neritic zone (Arthur et al. 2008; Howell et al. 2013). The CNPDPS of the green sea turtle (honu) is distinct in that this population segment has integrated invasive plant species into its diet (Russell and Balazs 2009). Seminoff et al. (2015) noted a scarcity of detailed diet information among the various life stages for this species globally.

3A.9.4 Distribution and Population Trends

3A.9.4.1 Current and Historic Distribution

The range of the CNPDPS of the green sea turtle (honu) includes the Hawaiian Archipelago and Johnston Atoll. The Hawaiian Archipelago represents the most geographically isolated chain of islands globally and the CNPDPS distribution reflects that isolation. The Hawaiian Archipelago consists of the MHI: Ni‘ihau, Kaua‘i, O‘ahu, Moloka‘i, Maui, Lāna‘i, Kaho‘olawe, and Hawai‘i, and the Northwestern Hawaiian Islands which extend to Kure Atoll and are within Papahānaumokuākea Marine National Monument (Papahānaumokuākea). From 1965 to 2013, 17,536 individuals of the CNPDPS of the green sea turtle (honu) have been tagged, an effort that has involved all post-pelagic size classes from juveniles to adults. With only three exceptions, the 7,360 recaptures of these tagged turtles have been made within the Hawaiian Archipelago. The outliers involved one recovery each in Japan, the Marshall Islands, and the Philippines (Seminoff et al. 2015).

The principal nesting site for the CNPDPS of the green sea turtle (honu) where approximately 95 percent of all nesting occurs is French Frigate Shoals (Lalo), an atoll in Papahānaumokuākea (islands that make up the northwestern portion of the Hawaiian Archipelago) (Figure 9). Based on data collected from 1973 to 2005, East Island is where approximately 50 percent of the nesting occurs within French Frigate Shoals (Lalo) (Balazs and Chaloupka 2004, 2006). Since nesting surveys of the CNPDPS of the green sea turtle (honu) were initiated in 1973, there has been a marked increase in numbers nesting at East Island. The other islands within French Frigate Shoals (Lalo) include Tern, Trig, Gin, and Little Gin, all of which combined, account for the remainder of CNPDPS green sea turtle (honu) nesting at the atoll.

At East Island, the mean annual nesting abundance was 83 females during the first 4 years of monitoring (1973–1977) which increased to 464 females during the monitoring period of 2009–2012 (Seminoff et al. 2015). This trend represents an annual increase of 4.8 percent for the CNPDPS of the green sea turtle (honu) since monitoring began (Seminoff et al. 2015). Information on at-sea abundance trends is consistent with the increase in nesting (Balazs et al. 1996, 2005; Balazs 2000; Seminoff et al. 2015).

In 2018, East Island was dramatically altered by a Category 3 Hurricane, Walaka. The storm shrank the roughly 11-acre island by 94 percent. As sand re-accreted over time, the island moved offshore from its pre-Walaka position. In 2019, the island grew by nearly 600 percent and as of 2020, East Island had returned to nearly 60 percent of its pre-Walaka size (Kane et al. 2020) and appears to have shifted slightly from its pre-Walaka position.

Surveys were conducted in 2019 (National Oceanic and Atmospheric Administration 2019) at both East and Tern Islands. In 2019, 106 females were identified on at East Island (National Oceanic and Atmospheric Administration 2020a) and 251 females were identified at Tern Island (National Oceanic and Atmospheric Administration 2019). Relative to recent years, abundances of nesting females had increased at Tern Island and decreased at East Island in 2019. It is unclear if this increase is due solely to habitat loss and displacement from East and Trig islets or if there were additional factors facilitating increased abundance of nesting females at Tern Island (National Oceanic and Atmospheric Administration 2019). At both islands, additional ecological changes were observed. At Tern Island, the loss of vegetation due to Walaka and increased entrapment of nesters nesting over a larger area within overall suboptimal habitat has been observed. At East Island, surveys found that nests were frequently washed out., including the loss of an important index site that had been used to monitor trends in abundance for CNPDPS of the green sea turtle (honu) over the last 30 years (National Oceanic and Atmospheric Administration 2020a). In 2020, normal survey efforts were interrupted by COVID-19 but opportunistic surveys were able to be completed by Papahānaumokuākea Marine National Monument Co Trustee Agency partner staff already deployed prior to COVID-19 restrictions; these data were not publicly available (National Oceanic and Atmospheric Administration 2020b).

3A.9.4.2 Within the Plan Area

Seminoff et al. (2015) calculated and summarized abundance of nesting individuals across all locations within the CNPDPS of the green sea turtle (honu). Estimated total nester abundance was calculated as [(total counted females / year of monitoring) x remigration interval]. For Kauaʻi, green sea turtle (honu) monitoring data collected from 2010 to 2012 were used to calculate an estimated nester abundance of 16 females. This represents only 0.39 percent of the total estimate of 3,864 breeding females calculated for the CNPDPS of the green sea turtle (honu).

In addition, Parker and Balazs (2015) documented 20 nesting sites[1] from 1976 to 2012 around Kauaʻi. All but two were described as having intermittent or indeterminate use (Figure 9). The two locations regularly used by nesting females are Lāwaʻi Kai and Kīpū Kai on the south side of the island. Average annual nesting density of green sea turtles (honu) at all Kauaʻi sites is very low, ranging from less than one (i.e., one nest every several years) to one to two nests per year between 2015 and 2020 (State of Hawaiʻi Division of Aquatic Resources 2020). Lāwaʻi Kai and Kīpū Kai averaged one to two nests per year during the same time period (State of Hawaiʻi Division of Aquatic Resources 2020). Although nesting density is low, observations of nesting have increased over the past 5 years (State of Hawaiʻi Division of Aquatic Resources 2020).

[1] Nesting data reported from Kauaʻi are speculative due to the lack of systematic surveys. Estimates may also be skewed toward high-use beaches and beaches that regularly have resting seals (as this is how green sea turtle [honu] nests have been opportunistically found).

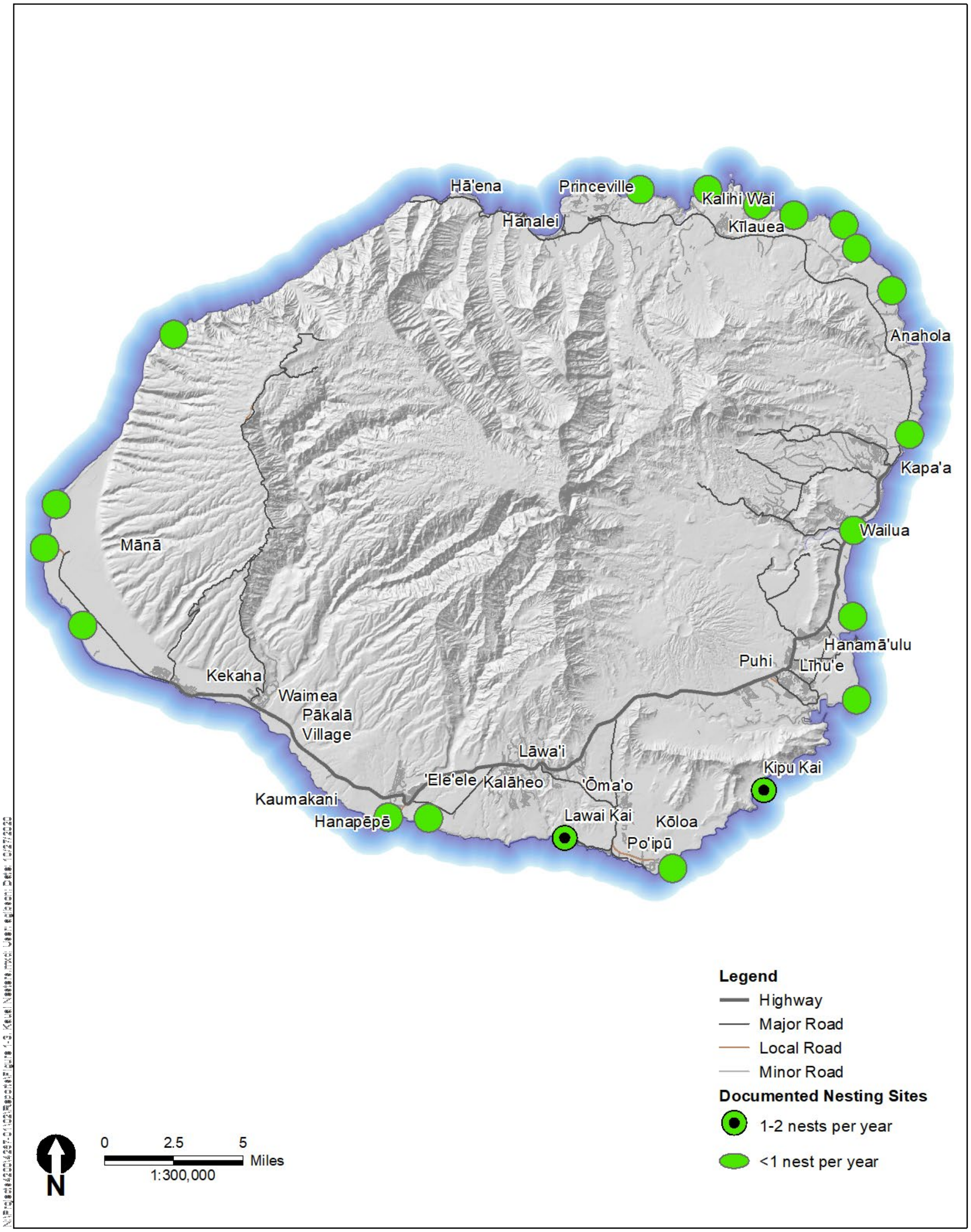

Figure 9. Location and Estimated Abundance of Central North Pacific Distinct Population Segment of the Green Sea Turtle (honu) Nests on Kauaʻi

3A.9.5 Threats

Seminoff et al. (2015) present the status review of the green sea turtle (honu) across the global range and document threats as part of the overall evaluation of each DPS. Consistent with the overall global threats, the primary causes of the decline of the CNPDPS of the green sea turtle (honu) are attributed to a variety of anthropogenic threats. Threats, such as bycatch in fishing gear (the incidental capture of non-target species), pollution, interactions with recreational and commercial vessels, development and public use of beaches, climate change, artificial lighting, predation, disease, beach driving, and major storm events all negatively affect green sea turtles (honu) in this DPS. Three of the most common reasons for sea turtle strandings in Hawai'i are entanglement in fishing lines, interactions with fishing hooks, and interaction with marine debris (usually entanglement in nets) (Francke et al. 2013).

Coastal development and construction, artificial lighting, vehicular and pedestrian traffic, beach pollution, tourism, and other human-related activities are increasing threats to the basking and nesting population in the MHI (currently very limited) and negatively affect hatchling and nesting turtles on beaches where these threats are present. Climate change effects, especially sea level rise, is a threat to the terrestrial and neritic-oceanic zones in both the MHI and Papahānaumokuākea ; potential effects on green sea turtle (honu) life stages that rely on other zones are less certain.

3A.9.5.1 Development

Human populations are growing rapidly in many areas of the insular Pacific and this expansion is exerting increased pressure on limited island resources. The most valuable land on most Pacific islands is often located along the coastline, particularly when it is associated with a sandy beach. Construction is occurring at a rapid rate in some areas and is resulting in loss or degradation of green sea turtle nesting habitat (honu). Construction-related threats to the region's nesting beaches include construction of buildings (e.g., hotels, houses, restaurants) and recreational facilities (e.g., golf courses) on or directly adjacent to the beach; clearing of stabilizing beach vegetation, which accelerates erosion; and use of heavy construction equipment on the beach, which can cause sand compaction or beach erosion. Lighting associated with coastal development also degrades nesting habitat (Section A.9.5.4, *Artificial Light Attraction*).

3A.9.5.2 Public Use of Beaches

Increased public use of nesting beaches is a threat to green sea turtle (honu) nesting habitat in Kaua'i. Public use of beaches includes a variety of recreational activities, such as picnicking (which can include beach camping and fires), swimming, surfing, playing sports, scuba diving, use of watercraft in the nearshore environment, and snorkeling access (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998). Public use of beaches can also increase litter and other refuse on the beach, which can attract destructive non-native animals such as pigs. Although driving on Kaua'i's beaches is illegal, there is extensive vehicle traffic in suitable green sea turtle (honu) nesting habitat (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998).

3A.9.5.3 Vessel Strikes

Various types of watercraft can strike green sea turtles (honu) when they are at or near the surface. Vessel strikes are a major threat to large juveniles at sea and adults in nearshore areas. High boat traffic areas such as marinas present a high risk to this species, and nesting females are vulnerable to vessel strikes when making reproductive migrations or while they are near shore during the nesting season (National Marine Fisheries Service 2021). Sea turtles can also be struck and seriously injured by boat propellers, hydrofoils and jet skis. From 2005 to 2009, 18.2 percent of all stranded green turtles (695 of 3818) in the U.S. Atlantic (Northeast, Southeast, and Gulf of Mexico) were documented as having sustained some type of propeller or collision injuries (Seminoff et al. 2015).

Green sea turtles (honu) have been documented as occasionally being hit by boats in Kauaʻi. In December 2020, a green sea turtle (honu) was struck by a boat and stranded on the shoreline. The individual had to be euthanized due the extent of its injuries. The turtle is just one of 22 that were injured in the NMFS Pacific Islands Region since March 2020 (Wu 2020).

3A.9.5.4 Climate Change

Global climate change will lead to alterations of green sea turtle (honu) nesting habitat. For example, sea level rise will result in increased erosion of nesting beaches and significant loss of habitat (Baker et al. 2006; Intergovernmental Panel on Climate Change 2007). The extent to which green sea turtles (honu) can adapt to these changes in nesting beach location and quality is unknown. Climate change will likely also cause higher sand temperatures leading to increased feminization of surviving hatchings (i.e., changes in sex ratio); and some beaches will also experience lethal incubation temperatures that will result in complete losses of hatchling cohorts (Glen and Mrosovsky 2004; Fuentes et al. 2010, 2011; Booth et al. 2020). Increased sea surface temperatures may alter the timing of nesting for some stocks (Weishampel et al. 2004), although the implications of changes in nesting timing are unclear. Changes in sea temperatures will also likely alter seagrass, macroalgae, and invertebrate populations in coastal habitats in many regions (Scavia et al. 2002). Climate forecasts are needed in population models to understand the impacts of rising temperatures (e.g., sand temperatures) on hatchling sex ratios and hatching success.

East and Tern islands of French Frigate Shoals (Lalo), the center of the CNPDPS range, are vulnerable to sea level rise (Baker et al. 2006). High-resolution digital elevation data and models are necessary to describe observed sea level rise and its future modeled potential at French Frigate Shoals (Lalo) and other nesting sites to assess green sea turtle (honu) vulnerability.

Changing storm dynamics and intensity because of climate change are emerging concerns for habitat in both the MHI and the Papahānaumokuākea (Baker et al. 2006; Keller et al. 2009). Storms and seasonal changes in current patterns can reduce or eliminate sandy beaches, degrade turtle nesting habitat, and cause barriers to adult and hatchling turtle movements on affected beaches.

One such notable event occurred in early October 2018 when Hurricane Walaka, a category 3 storm, directly affected French Frigate Shoals (Lalo). Satellite imagery documented dramatically altered shoreline habitat on East and Tern islands. East Island was almost completely claimed by the ocean. Unhatched turtle nests were severely affected by the storm at French Frigate Shoals (Lalo) as reported to USFWS by personal observations. One observation reported the runway at Tern Island was littered with turtle eggs destroyed from the storm. Consequently, the impacts of the hurricane affected nesting rates for 2018 and subsequent years following the event (U.S. Fish and Wildlife Service pers. comm.).

Some islands in French Frigate Shoals (Lalo) had already become submerged and were lost prior to Hurricane Walaka. As is common in sand-dominated ecosystems, Whale and Skate Islands were lost to erosion during the 1990s and Trig Island eroded earlier in 2018. Observations have led scientists to believe that, when these events occur, animals adapt by changing breeding locations (Papahānaumokuākea Marine National Monument 2018).

3A.9.5.5 Artificial Light Attraction

The presence of artificial lights on or adjacent to sea turtle nesting beaches alters the behavior of nesting adults (Witherington 1992); it is often fatal to emerging hatchlings, as they are attracted to light sources and drawn away from the water (Witherington and Bjorndal 1991; Nelson Sella et al. 2006). Light pollution has also been shown to affect females by deterring them from coming ashore to nest or drawing them away from the ocean after they are done nesting. These impacts have been well documented along coastal stretches of Florida and MHI. Based on hatchling orientation index surveys at nests located on 23 representative beaches in six Florida counties in 1993 and 1994, Witherington and Martin (1996) found approximately 10–30 percent of all sea turtle nests in each county showed evidence of hatchlings disoriented by artificial lighting.

Despite Seminoff et al. (2015) attempts to provide detailed analysis of all known threats to the species and relevant DPSs, light pollution is absent from the analysis for the CNPDPS. Although there is scant documentation for negative impacts from artificial lighting related to nesting on Kauaʻi, it is well known that artificial lighting affects sea turtles in the MHI. On Kauaʻi, there is recent documentation (2020) of one incident of more than one hatchling from a single nest being run over by vehicles near Kekaha Beach, resulting from disorientation due to artificial lighting emitted by a nearby streetlight adjacent to the main highway (Kauaʻi Hawaiian Monk Seal Conservation Hui pers. comm.). In addition, at least two known disorientation incidents also have occurred at a hotel in Poʻipū and one at Salt Pond County Park (Reiss pers. comm.). There are also numerous examples of hawksbill sea turtle (honuʻea) (*Eretmochelys imbricata*) disorientation of both hatchlings and nesting females from artificial lighting on Maui and the Island of Hawaiʻi. For example, on Maui in 1993 and 1996, two female hawksbills (honuʻea) with eggs and numerous hatchlings were killed by cars while trying to cross North Kīhei Road from the adjacent nesting beach (Hawaiʻi Wildlife Fund 2021).

3A.9.5.6 Disease

Fibropapilloma disease affects green sea turtles (honu) found in the MHI (Francke et al. 2013). This disease results in internal and external tumors (fibropapillomas) that may grow large enough to hamper swimming, vision, feeding, and potential escape from predators. In 2012 alone, 36 green turtle strandings in the MHI involved fibropapilloma tumors (Francke 2013). The exact numbers of animals affected by fibropapilloma is unknown because reported stranding data availability is limited and only represent a fraction of all CNPDPS of the green sea turtle (honu) mortalities. Depending on the area of Hawaiʻi, fibropapilloma disease appears to have peaked, remained the same, or increased (Van Houtan et al. 2010). Environmental factors may be significant in promoting fibropapilloma incidence; eutrophication (increase in nutrients) of coastal marine ecosystems also may promote this disease (Van Houtan et al. 2010). Fibropapilloma remains an important concern, particularly given the continued (and possibly future increasing) human impacts, including eutrophication of coastal marine ecosystems. Spirorchid (blood fluke) infections are reported for the CNPDPS of the green sea turtle (honu) (Greenblatt et al. 2005; Work et al. 2005); however, the extent to which this is a threat to the population is unknown.

3A.9.5.7 Predation

Predation of green sea turtle (honu) hatchlings by native species is normal and is something to which green sea turtles (honu) have adapted. Ghost crabs (*Ocypode* spp.) prey on hatchlings at French Frigate Shoals (Lalo) (Niethammer et al. 1997). The exact number of hatchlings lost is unknown but is estimated at approximately 5 percent (Balazs 1980). Hatchlings may also be eaten by fish when they enter the ocean. Large grouper (*Epinephelus tauvina*) are documented predators of post-hatchling green turtles in Hawaiʻi; however, the extent of grouper depredation is unknown (Balazs 1995). Seabirds, primarily the great frigatebird (ʻiwa) (*Fregatta minor*), an opportunistic predator of other seabird nestlings and known to prey on sea turtle hatchlings elsewhere, may also prey on sea turtle hatchlings at French Frigate Shoals (Lalo) (Balazs and Kubis 2007). Stranding records from Papahānaumokuākea and MHI (e.g., Francke 2013) show shark predation of CNPDPS of the green sea turtle (honu), predominantly adult turtles. The exact numbers of animals taken by sharks is unknown because reported strandings only represent a fraction of all CNPDPS of the green sea turtle (honu) mortalities.

Depredation of green sea turtle (honu) hatchlings by introduced species can exert additional pressure on the population in the cumulative context of additional anthropogenic sources. Mongoose, rats, dogs, feral pigs, and cats—all introduced species—exist on the MHI and are known to prey on eggs and hatchlings, although the exact impact on the current low level of nesting is unclear. If nesting in the MHI increases, it is likely the threat from these predators would increase.

3A.9.5.8 Illegal Harvest

While the harvesting of eggs and turtles was likely the major contributing factor to the historical decline of the population globally, current illegal harvest of green sea turtles (honu) for human consumption is limited. Harvest of CNPDPS of the green sea turtle (honu) has been illegal since it was listed under the federal ESA in 1978; furthermore, federal and state cooperative efforts and existing legislation appear to be minimizing the threat from illegal harvest. It is possible that human take today is underreported: anecdotal information suggests that some degree of illegal take continues to occur throughout the MHI.

3A.9.5.9 Marine Pollution, Fisheries Direct and Fisheries Indirect Interactions

Marine pollution includes the ingestion of, and entanglement in, marine debris, is another anthropogenic threat to CNPDPS of the green sea turtle (honu) throughout their range. Turtles ingest plastic, monofilament fishing line, and other marine debris (Bjorndal et al. 1994). Although direct effects may or may not be lethal, they result in varying side effects that could increase the probability of death (Balazs 1985a; Carr 1987; McCauley and Bjorndal 1999). CNPDPS of the green sea turtle (honu) can also be affected by contamination from herbicides, pesticides, oil spills, and other chemicals; as well as impacts on water quality (e.g., increases in water column sediments) resulting from structural degradation associated with excessive boat anchoring, dredging, and other sources (Francour et al. 1999; Lee Long et al. 2000; Waycott et al. 2005).

Historic military-related activities within the area covered by CNPDPS of green sea turtle (honu) have been a legacy of modification of offshore and onshore habitat at French Frigate Shoals (Lalo), including contamination (e.g., point sources of polychlorinated biphenyls because of former Long Range Navigation stations). Elevated levels of contamination remain in soils and nearshore sediment and biota; and sea and land pollution related to past and present human activities continues to stress the Papahānaumokuākea ecosystem (Wedding et al. 2008). During the 20th century, Johnston Atoll was the location of significant human and military activities such as guano mining, missile launching, airplane operations, nuclear testing, and chemical weapons incineration. The lingering effects of these activities include soil contamination, such as petroleum contamination of turtle foraging habitat (Balazs 1985b). However, the current effects of these activities on the marine environment and sea turtles are unclear.

Marine debris is a known threat for the CNPDPS of the green sea turtle (honu) in both terrestrial and marine environments. In 1996, it was estimated that between 750 and 1,000 tons of marine debris were on reefs and beaches in the Papahānaumokuākea, with fishing nets discarded or lost in the northeastern Pacific Ocean contributing the most (Keller et al. 2009). Keller et al. (2009) explain that even if no new debris were to enter the ocean, existing debris in the ocean will continue to accumulate in the Papahānaumokuākea for years. Such debris poses a major entanglement threat to sea turtles in the Papahānaumokuākea and can result in serious injury or mortality; it also can cause damage to habitat (Wedding et al. 2008). Balazs and Kubis (2007) describe entanglement and ingestion of marine debris as a potential threat to CNPDPS of the green sea turtle (honu), specifying discarded or abandoned fishing gear (nets and lines), as well as plastics (bags, six-pack rings, tar balls, polystyrene or other items that could ensnare or be eaten). Stranding information shows that fishing line and gill net gear entanglement is one of the causes of CNPDPS of the green sea turtle (honu) strandings and mortality in the MHI (Francke 2013, 2014). For example, 36 strandings in 2012 (Francke 2013) and 42 strandings in 2013 were related to entanglement in or ingestion of fishing line (Francke 2014). This number is a subset of the total number of animals possibly affected by this threat.

Interactions between the CNPDPS of green sea turtles (honu) and commercial and recreational fisheries in the Exclusive Economic Zone of the MHI can result in entanglement, injury, and mortality.

In addition, hook-and-line fishing from shore or boats hook and entangle individuals from the CNPDPS of the green sea turtle (honu) (National Marine Fisheries Service 2012; Francke et al. 2013). Interactions with nearshore recreational fisheries are identified in the NMFS stranding database as those turtles that strand as a result of interactions with fishhooks and fishing line. These include turtles that were hooked externally, ingested hooks, became entangled in fishing line, or exhibited intestinal prolapses due to line ingestion. Hook-and-line interactions have increased over time, with more than 60 turtles in 2011 and 46 turtles in 2012 stranded (Francke 2013; Francke et al. 2013; Ikonomopoulou et al. 2013). While current public outreach efforts by NMFS and its partners are attempting to reduce the magnitude of impact on CNPDPS of the green sea turtle (honu) from hook-and-line fishing, injury or mortality from the hooking or from the effects of line remaining on turtles that are cut free or break the line remains an issue (National Oceanic and Atmospheric Administration 2013).

Net and gill net entanglement cases include unidentified nearshore and pelagic nets, including cargo nets, trawl nets, lobster nets, and monofilament gill nets. Each year, individuals from the CNPDPS of the green sea turtle (honu) are incidentally entangled in net gear and some of these result in mortality (e.g., Francke 2013); however, the reported stranding is believed to be a smaller subset of the actual level of interaction with this gear. Henderson et al. (1987) documented sea turtle mortality resulting from entanglement in fishing gear in Hawaiʻi. Chaloupka et al. (2008) reported that between 1982 and 2002 approximately 7 percent of stranding related to gear-induced trauma were attributed to hook-and-line fishing; 5 percent for gill-net fishing. While gill nets are regulated by the State of Hawaiʻi, fishers are only required to inspect them completely every 2 hours, so entanglement and drowning do occur (National Marine Fisheries Service 2012).

Hawaiʻi-based pelagic longline fisheries use baited lines up to several miles long that have thousands of hooks and lures that inadvertently catch turtles, resulting in death by drowning (as they are unable to rise to the surface for air) or digestive debilitation (line and hook gets lodged in the stomach) (Sea Turtle Conservancy 2020). These fisheries are expected to take up to seven individuals from the CNPDPS of the green sea turtle (honu) annually (National Marine Fisheries Service 2005, 2012). Sea turtle bycatch rates in foreign fisheries are estimated to be at least 10 times and perhaps 20 times greater than Hawaiʻi-based fisheries (Bartram and Kaneko 2004; Kaneko and Bartram 2008), given the much greater fishing effort among foreign vessels (National Marine Fisheries Service 2012). While exact numbers are not available, at a minimum, an estimated 100 individuals of the CNPDPS of the green sea turtle (honu) are captured and killed annually as longline bycatch (National Marine Fisheries Service 2012).

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Appendix 4A

Conservation Site Selection

4A.1 Introduction

4A.1.1 Purpose

The purpose of this appendix is to describe the conservation site selection process for the Kauaʻi Island Utility Cooperative (KIUC) Habitat Conservation Plan (HCP). The conservation sites are the locations where Conservation Measure 4, *Manage and Enhance Seabird Breeding Habitat and Colonies at Conservation Sites* (hereafter Conservation Measure 4), will be implemented. Management actions under Conservation Measure 4 include predator control, predator exclusion fencing, social attraction, and invasive plant species control. This appendix describes the conservation site selection background, conservation site selection process, and the conservation sites for the KIUC HCP.

4A.1.2 Conservation Site Selection Background

The HCP conservation strategy includes conservation measures to offset the injury and mortality of Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu) from collisions with KIUC powerlines and fallout from KIUC lights. Collisions by band-rumped storm-petrel (ʻakēʻakē) have not been quantified but are thought to be infrequent due to the species' flight behavior (Ainley pers. comm.) and lack of any documented powerline collisions to date (Travers et al. 2020) and, as such, any impacts on this species would be mitigated by the conservation measures for the other two covered seabirds. A critical aspect of the conservation strategy is that the conservation requirements are commensurate with the amount of unavoidable take estimated to be caused by KIUC powerlines to meet the state and federal requirements for an HCP.

The goal of the KIUC HCP conservation strategy for the covered seabird species is to result in a population size, age structure, population growth rate, demography, and distribution that is representative of a viable metapopulation on the Island of Kauaʻi that will provide for the survival of the Kauaʻi metapopulation and contribute to species' recovery. This goal will be achieved, in part, by implementing Conservation Measure 4 at the conservation sites.

4A.2 Conservation Site Selection

4A.2.1 Site Selection Methods

4A.2.1.1 Identification of Potential Conservation Sites

The U.S. Fish and Wildlife Service (USFWS), the State of Hawaiʻi Division of Forestry and Wildlife (DOFAW), KIUC, and other stakeholders and species experts have been working collaboratively since 2002 to identify and evaluate potential conservation sites to contribute to viable metapopulations of the covered seabird species on Kauaʻi (Kauaʻi Island Utility Cooperative 2011). Initially, potential sites were identified through a desktop assessment using selection criteria that were developed in consultation with DOFAW, USFWS, and species experts.

During the evaluation process, DOFAW and USFWS worked with KIUC to narrow the list of potential sites and review new sites as they were proposed. Raine et al. (2020) provided key information on the current status of the covered seabird populations, practicability of implementing the conservation measures, and site constraints, to inform the site selection process. KIUC coordinated with USFWS and DOFAW staff and Dr. Andre Raine along with Lindsay Young of Pacific Rim Conservation for suggestions on appropriate sites and the practicability of implementing conservation measures at those sites. In 2020, Lindsey Young of Pacific Rim Conservation was contracted to conduct a feasibility analysis on potential conservation sites to further inform conservation site selection (Young 2020).

4A.2.1.2 Habitat Suitability Models and Population Estimation

An important determinant of conservation sites is the presence of suitable breeding habitat for the two primary covered seabirds, Newell's shearwater ('a'o) and Hawaiian petrel ('ua'u). Habitat distribution models were used to determine the location of suitable breeding habitat as a starting point to identify possible suitable conservation sites. Troy et al. (2014, 2016, 2017) developed habitat suitability models for both Newell's shearwater ('a'o) and Hawaiian petrel ('ua'u) using abiotic and biotic environmental parameters (e.g., elevation, wind speed, slope, vegetation cover) that are key nesting habitat characteristic of these species. These parameters were presented in a digital raster layer representing independent variables to produce the model in a GIS framework at a 164-foot (ft) by 164-ft (50-meter [m] by 50-m) pixel resolution representing categorical values of habitat suitability from 1 to 10. The output of the model is the predicted probability that each pixel supports (or could support) the nesting activities of Newell's shearwater ('a'o) and Hawaiian petrel ('ua'u) based on the environmental conditions of the pixel.

In 2018, Raine et al. used the Troy et al. (2014, 2016, 2017) habitat suitability models to estimate population sizes of endangered seabird colonies on Kaua'i. Pixels valued 8 or higher were extracted from the habitat suitability models and used to identify areas of suitable habitat for each species within each conservation site. Areas of suitable breeding habitat were refined using current seabird activity for each species, as determined from the result of the Kaua'i Endangered Seabird Recovery Project's auditory surveys. The average minimum area between burrows was then used to calculate an average density (burrow per m). Then, the minimum burrow densities for each species were multiplied by the total area of regions identified as occupied suitable breeding habitat (i.e., area with suitable breeding habitat in an area within constant intensive activity, as determined by auditory surveys) allowing the calculation of a total population estimate for each site (Raine et al. 2018).

4A.2.1.3 Evaluation of Conservation Site Selection Criteria

The conservation site selection criteria listed in the following sections were developed by Raine et al. (2020) as a way of prioritizing known endangered seabird colonies that would be most suitable for long-term conservation under the KIUC HCP. Each conservation site is assessed against 14 criteria, with each criterion given a score from 0 or 1 to 5. Conservation sites are ranked independently for each covered seabird species. However, a criterion for the presence of multiple species is also included to increase the value of a conservation site with more than one covered seabird species.[1]

A description of the relative scores is outlined at the beginning of each criterion for ease of reference. Once each criterion was summed to a total score, the conservation sites with the highest scores were those that were selected as conservation sites for the HCP. A perfect score would total 96 points[2] (Raine et al. 2020).

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[1] The multiple species criterion score only goes from 1 to 3 because there are only 3 covered seabird species.

[2] The perfect score is over 70 because a few criteria are doubled or tripled to increase their significance for conservation site selection.

Covered Species Occupancy

Criterion 1. Presence of a covered seabird breeding colony

Criterion 1 is defined as nesting within a conservation site by the covered seabird species. This criterion requires occurrence data (i.e., auditory surveys and/or burrow monitoring) to determine whether the site is occupied.

The criterion scores for presence of a covered species breeding colony are as follows:

- 0—No colony present
- 1—Species recorded at least once during auditory surveys
- 2—Auditory surveys confirm areas of activity identified as hotspot light (i.e., '*localized aerial activity, sporadic calling*')
- 3—Auditory surveys confirm areas of activity identified as hotspot heavy (i.e., '*localized aerial activity, continuous calling*')
- 4—Auditory surveys confirmed ground calling (highest level of evidence that a breeding colony exists at the site below the discovery of an actual burrow)
- 5—Confirmed breeding colony (through the discovery of active burrows)

The covered species occupancy criterion score is multiplied by a factor of two if a breeding colony is present to increase its weight. Conservation sites that contain a covered species breeding colony should be weighted more heavily than sites where social attraction is required to initiate a breeding colony. The criterion score is multiplied by a factor of three if the density of breeding birds at the site is high (i.e., for Newell's shearwater [ʻaʻo], the density at the Upper Limahuli Preserve [average nearest neighbor distance 62.7 ft {19.1 m}] and for and Hawaiian petrel [ʻuaʻu] the density at North Bog [average nearest neighbor distance 45.6 ft {13.9 m}]).

Sites with a criterion score of 0 for covered species occupancy were only included as a conservation site in the KIUC HCP if they met Criterion 2 or Criterion 3. If one or both of these criteria are met, then these sites could be considered if social attraction was planned to be used as a management tool to create a new breeding colony within the conservation site.

Criterion 2. Presence of a covered species breeding colony adjacent to the conservation site

Criterion 2 is defined as nesting by one or more of the covered species adjacent to the conservation site (within 0.62 mile [1 kilometer {km}]). This criterion requires occurrence data (i.e., auditory surveys and/or burrow monitoring) to determine whether the adjacent habitat is occupied.

The criterion scores for presence of a breeding colony adjacent to the conservation site are as follows:

- 0—No colony present
- 1—Species recorded at least once during auditory surveys
- 2—Auditory surveys confirm areas of activity identified as hotspot light (i.e., '*localized aerial activity, sporadic calling*')
- 3—Auditory surveys confirm areas of activity identified as hotspot heavy ('*localized aerial activity, continuous calling*')

- 4—Auditory surveys confirmed ground calling
- 5—Confirmed nest site

Conservation sites with adjacent breeding colonies would be ranked higher than conservation sites with little to no adjacent covered species activity.

Criterion 3. Presence of covered species transiting over the site

Criterion 3 is defined as presence of one or more of the covered species transiting over the conservation site. Conservation sites that are on a known flyway would be ranked higher than conservation sites that are not. This criterion requires auditory surveys and song meters to determine if the covered species pass over the conservation site.

The criterion scores for covered species occupancy are as follows:

- 0—No seabirds transiting over the site
- 1—Occasional covered seabirds transiting over the site, but not nightly
- 2— Occasional covered seabirds transiting over the site, on a nightly basis
- 3—Small numbers (<30) of covered seabirds transiting over the site during peak movement hours on a nightly basis
- 4—Moderate (31–75) numbers of covered seabirds transiting over the site during peak movement hours on a nightly basis
- 5—High numbers (76+) of covered seabirds transiting over the site during peak movement hours on a nightly basis

Social attraction in the conservation sites that are located within the nocturnal flyway is more likely to successfully attract breeding adults than in conservation sites with little or no covered seabird activity.

Criterion 4. Presence of multiple covered species at the conservation site

Criterion 4 is defined as occupancy of a conservation site by multiple covered species. This criterion requires occurrence data (i.e., auditory surveys and/or burrow monitoring) to determine whether the site is occupied.

The criterion scores for covered species occupancy are as follows (because there are three covered seabird species the maximum score is 3).

- 1—One species present
- 2—Two species present
- 3—Three species present

Conservation sites with multiple covered species increase the cost-benefit of the conservation measures because the same conservation actions can affect multiple covered species. The criterion score is multiplied by a factor of two if multiple species are present to increase its weight. Conservation sites with multiple covered species are of higher value than conservation sites with only one covered species colony.

Habitat Quality

Criterion 5. Presence of Invasive Plant Species

Criterion 5 requires an assessment of the quality of the habitat for breeding seabirds within the conservation site. On Kaua'i, Newell's shearwater ('a'o) and Hawaiian petrel ('ua'u) nest in wet montane forests with a high proportion of native trees (particularly 'ōhi'a lehua [*Metrosideros polymorpha*] in the canopy and native plants in the understory (particularly false staghorn [uluhe; *Dicranopteris linearis*]) (Raine et al. 2021). Newell's shearwater ('a'o) are also found in the sheer cliffs of the Nā Pali Coast (where band-rumped storm-petrel ['akē'akē]) are also found).

This criterion should, however, be considered with the following proviso in mind: the requirement that plants are native species is less important than the structural composition of the vegetation and the topography of the conservation site. That can be seen in the presence of Newell's shearwater ('a'o) in the coastal habitat present at Kīlauea Point National Wildlife Refuge, which is vastly different from other breeding colonies on the island. Habitat quality should primarily be considered in terms of the presence of invasive plant species that alter habitat structure to impede burrowing and nesting behavior (e.g., strawberry guava [*Psidium littoralei*], Australian tree fern [*Sphaeropteris cooperi*], Himalayan ginger [kāhili ginger] [*Hedychium gardnerianum*]) and the level of ongoing habitat management within the conservation site. Conservation sites with high levels of invasive plants are assigned a low score. If positive habitat modification can occur in the conservation site after the fence enclosure is created (i.e., the terrain is easy to work in), then this was reflected in the scoring system. Good-quality native habitat was assigned the highest possible score.

- 1—Predominantly nonnative invasive plant species with no invasive plant species management
- 2—Native plant species mixed with a higher proportion of nonnative invasive plant species and no invasive plant management
- 3—Native plant species mixed equally with nonnative invasive plant species and sporadic invasive plant species control
- 4—High-quality native habitat with a lower proportion of nonnative invasive species and moderate invasive plant species management
- 5—Predominantly native plant species with intensive invasive plant species management

Predators

Criterion 6. Terrestrial predators

Criterion 6 is defined as the abundance of terrestrial predators in the conservation site and the level of ongoing predator control. Various factors can be used to infer whether or not the conservation site is likely to have high or low densities of terrestrial predators, such as proximity to urban areas, presence of roads or trails leading to the breeding site, degree of human traffic in the area (i.e., more humans leads to more trash and direct feeding), and topography and natural barriers that prevent predator movement.

- 1—High density of terrestrial predators, no ongoing predator control
- 2—High density of terrestrial predators, sporadic predator control
- 3—Moderate density of terrestrial predators, ongoing predator control

- 4—Low density of terrestrial predators, ongoing intensive predator control
- 5—No terrestrial predators (only applicable to areas where eradication has already occurred [e.g., Lehua Islet, fenced social attraction sites])

The greater the abundance of terrestrial predators present within a conservation site, the more difficult it will be to reduce or eradicate them and limit future incursion. While terrestrial predators are found throughout Kauaʻi, they are particularly prevalent in lowland areas near urban centers. Conservation sites with a high abundance of terrestrial predators would be ranked lower than conservation sites where predators are present in lower densities.

Criterion 7. Aerial introduced predators (barn owls [*Tyto alba*])

Criterion 7 is defined as the abundance of barn owls within the conservation site and the level of ongoing barn owl control. Various factors can be used to infer whether or not the conservation site is likely to have high or low densities of barn owls present, including proximity to rural areas and open fields (barn owls occur at higher densities in open areas), topography, and type of habitat in the conservation site.

- 1—High levels of barn owl activity or data deficient, no active barn owl control
- 2—Moderate levels of barn owl activity, no active barn owl control
- 3—Moderate levels of barn owl activity, sporadic barn owl control
- 4—Moderate levels of barn owl activity, regular barn owl control
- 5—Low levels of barn owl activity, intensive barn owl control

Conservation sites where barn owls are present in large numbers (particularly in the lowlands and near agricultural areas) will present significant management challenges. Barn owl control requires year-round targeted control efforts by well-trained professionals. As such, conservation sites with a lower density of barn owls would score higher than conservation sites with a high density of barn owls. For conservation sites where barn owl density is unknown, this criterion will score 3, which assumes that there are likely to be some barn owls within the conservation site given that this species is distributed across Kauaʻi.

Existing Management

Criterion 8. Existing management activities

Criterion 8 is defined as the status of management activities within the conservation site, including infrastructure to support management activities. Scores for this criterion are multiplied by a factor of two because the presence of existing management actions and infrastructure greatly reduce startup costs and reduce the time to realize covered species benefits.

- 0—No existing management
- 1—Very little existing management and infrastructure
- 2—Existing management but limited infrastructure
- 3—Existing management and infrastructure but they are not seabird-directed
- 4—Existing seabird-directed management and infrastructure ongoing for short-time (1–2 years)

- 5—Existing seabird-directed management has been ongoing for many years (3+ years) and infrastructure is present and in good condition

Scores for this criterion consider land ownership (i.e., federal, state, private), which may have relevance for whether or not the conservation site is already managed (e.g., within the Department of Land and Natural Resources System or has a private landowner who is supportive seabird management on their land), the conservation status of the parcel (i.e., if the land is already within a Conservation District or within a protected area such as a Hono O Nā Pali Natural Area Reserve [NAR], State Wilderness Park, or National Park), infrastructure present (e.g., fences, helicopter landing sites, weatherports), and the scope of any existing management activities. This criterion must also evaluate whether the current management regime on the conservation site is compatible with the biological goals and objectives of the KIUC HCP and is sustainable for the life of the permit term (i.e., due to land ownership/status/zoning). Conservation sites with existing covered seabird-directed management activities that are compatible with the biological goals and objectives of the KIUC HCP would score higher than locations without existing management.

Site Practicability

Criterion 9. Predator control operations

Criterion 9 is defined as the factors that limit predator control operations, such as steepness and slope, geographic scale, habitat structure, and substrate that directly affect the practicability of implementing the conservation measures within a conservation site. Sites with steep valleys, dense vegetation, or sites that are very large will all require significantly more effort in terms of predator control and would thus be less practicable than smaller areas or areas with gently undulating terrain and sparser vegetation. In addition, conservation sites where the topography results in fences with open ends (e.g., waterfalls, sheer cliffs) would be ranked lower than sites where fencing can be constructed without open ends (Young 2020).

- 0—Physical site conditions prevent predator control operations
- 1—Low practicability of predator control operations
- 2—Low to moderate practicability of predator control operations
- 3—Moderate practicability of predator control operations
- 4—High practicability of predator control operations
- 5—High practicability of predator control operations and predator eradication practicable if coupled with a predator exclusion fence or if an islet

The predator control operations criterion is multiplied by a factor of two to increase its weight in the total score, given that the physical site conditions can severely affect the feasibility of implementing the conservation measures within a conservation site. If no conservation measures were practicable, this criterion received a score of 0.

Criterion 10. Practicability of terrestrial predator exclusion fence construction

Criterion 10 is defined as the practicability of constructing a terrestrial predator exclusion fence within the conservation site. The factors that determine the practicability of constructing terrestrial predator exclusion fencing is the same as described for predator control operations above (Criterion 9). Installation of terrestrial predator exclusion fencing is challenging because it requires infrastructure (e.g., horizontal mesh skirt) to exclude both small mammals and ungulates. While a site may be practicable to fence, the landowners may not agree to have a predator exclusion fence on their land.

- 0—Terrestrial predator exclusion fence construction is impracticable
- 1—Terrestrial predator exclusion fencing is very difficult to construct in any portion of the site
- 2—Terrestrial predator exclusion fencing construction is practicable over a small portion of the site
- 3—Terrestrial predator exclusion fencing construction is practicable over between a quarter and half of the site
- 4—Terrestrial predator exclusion fencing construction is practicable over majority of site
- 5—Entire site can easily be fenced

The practicability of terrestrial predator exclusion fence construction criterion is multiplied by a factor of two to increase its weight in the total score. Terrestrial predator exclusion fencing will further increase the effectiveness of open management predator control.

Criterion 11. Practicability of ungulate fence construction

Criterion 11 is defined as the practicability of constructing an ungulate exclusion fence within the conservation site.

- 0—Ungulate fencing construction is impracticable
- 1—Ungulate fencing is very difficult to construct in any portion of the site
- 2—Ungulate fencing construction is practicable over a small portion of the site
- 3—Ungulate fencing construction is practicable over between a quarter and half of the site
- 4—Ungulate fencing construction is practicable over majority of site
- 5—Entire site can easily be fenced

The factors that determine the practicability of constructing ungulate fencing include habitat structure, geographic scale, substrate, and topography. Large conservation sites with steep valleys, dense vegetation, drainages, or crumbly substrate would be ranked lower than smaller conservation sites with gently undulating terrain, sparser vegetation, no drainages, and a sturdy substrate. While a site may be practicable to fence, the landowners may not agree to have an ungulate exclusion fence on their land.

Criterion 12. Accessibility

Criterion 12 is defined as the existing site infrastructure (e.g., roads, trails, helicopter landing sites) that determine site accessibility and safety. Transportation to and from the site is a critical consideration, both in terms of the initial setup as well as follow-up monitoring and control efforts once the conservation measure is in place. For example, site infrastructure was reviewed to determine whether a site could be accessed by trails and/or roads not blocked with fencing or gates, or by helicopter.

- 1—Limited accessibility

- 2—Accessible by helicopter or boat, but weather may limit helicopter or boat access at certain times of the year
- 3—Accessible year-round by helicopter
- 4—Accessible by road vehicles, but weather may limit road access at certain time of the year
- 5—Accessible year-round by road vehicles

Conservation sites that are difficult to access, or are not practicable for road vehicles and require special transportation (i.e., helicopters or boats), will result in higher operational costs and may present logistical difficulties (e.g., if access is weather dependent this may result in fewer visits due to flight cancellations). Consequently, remote sites that require helicopters or boats would rank lower than those which can be easily accessed by roads or dirt tracks. Sites that could not be accessed by trails or roads, or by specialized transportation (e.g., no nearby landing site is practicable), were eliminated from further consideration.

Landowner Approval

Criterion 13. Landowner approval

Criterion 13 is defined as the degree of landowner willingness to allow implementation of the conservation measures on their land. For a site to be selected, landowner approval is necessary to implement the conservation measures as planned. The factors to consider under this criterion include: (1) who is the landowner, (2) are there multiple landowners, (3) are there socio-political factors that increase or decrease landowner willingness, and (4) is there political or social opposition to implementation of the conservation measures on the conservation site and if so, is appropriate outreach being conducted?

- 0—Currently no access from landowner
- 1—Low likelihood of landowner approval
- 2—Moderate likelihood of landowner approval
- 3—Initial conversations with landowner have occurred but interest is not known
- 4—Landowner has expressed interest
- 5—Agreement with landowner in place or high likelihood of receiving landowner approval

It is necessary to secure agreements with landowners, whether state or private, for access to a conservation site for at least 30 years so that conservation measures could be implemented for at least the duration of the HCP permit term. Generally, landowner approval is accomplished through coordination and negotiation directly with the landowner. If the landowner is not willing, the conservation site would receive a score of 0 under this criterion.

Anthropogenic Threats

Criterion 14. Anthropogenic threats

Criterion 14 is defined as the presence of powerlines and lights on or adjacent to the site, or on the flyway for which birds would access the site. This criteria also considers if there are: (1) foreseeable development projects in the area (e.g., new housing developments) or (2) impending minimization actions (e.g., the removal of powerlines, use of diverters to reduce strikes, removal or dimming of known problem lights). The site selection process evaluates whether existing and future KIUC infrastructure and surrounding urbanization pose a threat to the covered seabird colony based on the location of the infrastructure and urban development in relation to the colony. This criterion was necessary to avoid compromising the conservation benefits generated by the HCP, especially as the seabird colonies increase in size with implementation of the conservation measures.

- 1—High levels of anthropogenic threats that are unlikely to be minimized
- 2—High level of anthropogenic threats, some of which can be minimized if sufficient funding is available
- 3—Moderate level of anthropogenic threats, some of which can be minimized if sufficient funding is available
- 4—Low level of anthropogenic threats or moderate/high level of anthropogenic threats, most of which can be minimized
- 5—Minimal anthropogenic threats

4A.2.2 Site Selection Scores

A total of 28 sites were evaluated against the 14 criteria listed above. Each criterion was scored separately for Newell’s shearwater (‘a‘o) and Hawaiian petrel (‘ua‘u), as shown in Tables 4A-1 and 4A-2, respectively. Site selection scores are not included in this appendix for band-rumped storm-petrel (‘akē‘akē) because, as stated in Section 1.2, *Conservation Site Selection Background*, at present the known impacts on this species are so low they are assumed to be mitigated by the conservation measures for the other two covered seabirds.

Table 4A-1. Conservation Site Selection Scores for Newell's Shearwater (ʻaʻo), Listed by Total Score (Highest to Lowest)

Site Selection Criterion	Criterion 1. Presence of a covered seabird breeding colony	Criterion 2. Presence of a covered seabird breeding colony adjacent to the conservation site	Criterion 3. Presence of a covered species transiting over the site	Criterion 4. Presence of multiple covered species at the conservation site	Criterion 5. Presence of invasive plant species	Criterion 6. Terrestrial predators	Criterion 7. Barn owls	Criterion 8. Existing management activities	Criterion 9. Predator control operations	Criterion 10. Practicability of terrestrial predator exclusion fence construction	Criterion 11. Practicability of ungulate fence construction	Criterion 12. Accessibility	Criterion 13. Landowner approval	Criterion 14. Anthropogenic threats	Total
Max Score	10	5	5	6	5	5	5	10	10	10	10	5	5	5	96
Pōhākea	10	5	5	4	4	4	4	10	8	10	10	3	5	5	87
Upper Limahuli Valley	10	5	5	4	5	4	3	10	8	10	10	3	5	5	87
Honopū—upper valley	10	5	5	4	3	3	3	8	8	10	10	4	3	5	81
Hanakoa	10	5	5	4	3	4	4	10	8	6	10	2	5	5	81
Hanakāpiʻai	10	5	5	4	3	4	4	10	8	6	10	2	5	5	81
North Bog	10	5	4	4	4	4	4	10	8	6	10	2	5	5	81
Upper Mānoa Valley	10	5	5	4	3	3	4	10	8	10	10	3	1	5	81
Pihea	4	5	4	4	4	4	4	10	8	2	10	5	5	5	74
Nuʻalolo Kai	8	5	5	4	3	3	2	8	8	6	8	3	4	5	72
Honopū—lower valley	8	5	5	4	2	3	2	8	8	8	8	3	3	5	72
Nuʻalolo Aina	8	5	5	4	2	3	3	8	8	6	8	3	3	5	71
Lumahaʻi Valley	8	5	5	4	3	1	1	6	8	8	10	3	4	4	70
Hanalei Valley	8	5	5	4	3	1	1	3	8	6	10	4	4	3	65
Waimea Canyon	8	4	5	4	3	1	1	2	8	8	8	5	3	3	63
Awaʻawapuhi	8	5	5	4	2	2	2	6	8	2	8	3	3	5	63

Site Selection Criterion	Criterion 1. Presence of a covered seabird breeding colony	Criterion 2. Presence of a covered seabird breeding colony adjacent to the conservation site	Criterion 3. Presence of a covered species transiting over the site	Criterion 4. Presence of multiple covered species at the conservation site	Criterion 5. Presence of invasive plant species	Criterion 6. Terrestrial predators	Criterion 7. Barn owls	Criterion 8. Existing management activities	Criterion 9. Predator control operations	Criterion 10. Practicability of terrestrial predator exclusion fence construction	Criterion 11. Practicability of ungulate fence construction	Criterion 12. Accessibility	Criterion 13. Landowner approval	Criterion 14. Anthropogenic threats	Total
Waiʻoli	8	5	5	2	2	1	1	10	8	4	8	3	2	3	62
HNP New	6	3	3	4	4	2	2	2	8	6	10	2	4	5	61
Nāmolokama	8	5	5	2	3	2	2	4	8	2	10	1	4	4	60
Lāʻau	8	4	5	4	3	1	2	4	8	2	10	1	3	4	59
Kalalau Valley	8	5	5	4	4	2	1	4	6	4	8	2	1	5	59
Lehua Islet	0	0	2	2	2	5	3	4	10	10	10	2	4	5	59
Miloliʻi	4	2	3	4	2	2	1	2	8	2	6	3	2	5	46
Kāhili	10	3	4	4	2	1	1	4	8	2	4	5	1	1	50
Waipā	0	5	5	2	2	1	1	2	8	4	8	3	2	3	46
Hāʻupu	4	2	3	4	3	1	1	2	8	4	4	3	1	1	41
Koluahonu	2	3	3	2	1	1	1	2	6	6	6	4	1	1	39
Sleeping Giant	4	2	3	2	1	1	1	2	6	2	6	5	1	1	37

Table 4A-2. Conservation Site Selection Scores for Hawaiian Petrel (ʻuaʻu), Listed by Total Score (Highest to Lowest)

Site Selection Criterion	Criterion 1. Presence of a covered seabird breeding colony	Criterion 2. Presence of a covered seabird breeding colony adjacent to the conservation site	Criterion 3. Presence of a covered species transiting over the site	Criterion 4. Presence of multiple covered species at the conservation site	Criterion 5. Presence of invasive plant species	Criterion 6. Terrestrial predators	Criterion 7. Barn owls	Criterion 8. Existing management activities	Criterion 9. Predator control operations	Criterion 10. Practicability of terrestrial predator exclusion fence construction	Criterion 11. Practicability of ungulate fence construction	Criterion 12. Accessibility	Criterion 13. Landowner approval	Criterion 14. Anthropo-genic threats	Total
Max Score	10	5	5	6	5	5	5	10	10	10	10	5	5	5	96
Pōhākea	10	5	5	4	4	4	4	10	8	10	10	3	5	5	87
Upper Limahuli Preserve	10	5	5	4	5	4	3	10	8	10	10	3	5	5	87
North Bog	10	5	5	4	4	4	4	10	8	6	10	2	5	5	82
Pihea	10	5	5	4	4	4	4	10	8	2	10	5	5	5	81
Hanakoa	10	5	5	4	3	4	4	10	8	6	10	2	5	5	81
Hanakāpiʻai	10	5	5	4	3	4	4	10	8	6	10	2	5	5	81
Upper Mānoa Valley	0	5	5	4	3	3	4	10	8	10	10	3	1	5	71
Lumahaʻi Valley	8	4	5	4	3	1	1	6	8	8	10	3	4	4	69
Hanalei Valley	8	4	5	4	3	1	1	4	8	6	10	4	4	3	65
Lehua Islet	0	0	1	2	1	5	3	10	10	10	10	2	5	5	64
HNP New	6	3	3	4	4	2	2	4	8	6	10	2	4	5	63
Honopū—upper valley	0	0	1	4	3	3	3	8	8	10	8	4	3	5	60
Lāʻau	8	4	5	4	3	1	2	2	8	2	10	1	3	4	57
Nuʻalolo Kai	0	0	1	4	4	3	1	8	8	6	8	3	4	5	55
Honopū—lower valley	0	0	1	4	2	3	2	8	8	8	8	3	3	5	55

Site Selection Criterion	Criterion 1. Presence of a covered seabird breeding colony	Criterion 2. Presence of a covered seabird breeding colony adjacent to the conservation site	Criterion 3. Presence of a covered species transiting over the site	Criterion 4. Presence of multiple covered species at the conservation site	Criterion 5. Presence of invasive plant species	Criterion 6. Terrestrial predators	Criterion 7. Barn owls	Criterion 8. Existing management activities	Criterion 9. Predator control operations	Criterion 10. Practicability of terrestrial predator exclusion fence construction	Criterion 11. Practicability of ungulate fence construction	Criterion 12. Accessibility	Criterion 13. Landowner approval	Criterion 14. Anthropo-genic threats	Total
Waipā	8	5	5	2	2	1	1	2	8	4	8	3	2	3	54
Nuʻalolo Aina	0	0	1	4	2	3	3	6	8	6	8	3	3	3	50
Nāmolokama	0	4	5	2	3	2	2	2	8	2	10	1	4	4	49
Kalalau Valley	0	5	5	4	4	2	1	2	6	4	8	2	1	5	49
Waimea Canyon	0	0	2	4	3	1	1	4	8	8	8	5	2	3	49
Waiʻoli	0	4	5	2	2	1	1	2	8	4	8	3	2	3	45
Awaʻawapuhi	0	0	1	4	2	2	2	4	8	2	8	3	3	5	44
Miloliʻi	0	0	1	4	2	2	1	4	8	2	6	3	2	5	40
Kāhili	4	2	3	4	2	1	1	2	8	2	4	5	1	1	40
Hāʻupu	0	0	2	4	3	1	1	2	8	4	4	3	1	1	34
Koluahonu	0	1	2	2	1	1	1	2	6	6	6	4	1	1	34
Sleeping Giant	0	0	2	2	1	1	1	2	6	2	6	5	1	1	30

4A.2.3 KIUC HCP Conservation Sites

A total of nine conservation sites with the highest site selection scores have been selected for the KIUC HCP. A tenth site is still being evaluated, as described below. All of the selected conservation sites are located within the “no light conservation area” identified by the USFWS on the north shore of Kauaʻi. The majority of the conservation sites that were selected for the KIUC HCP are the same sites where KIUC has been funding predator control and seabird monitoring (and invasive plant species control at two sites) annually since 2011 for the Short-Term HCP and in the interim period between the Short-Term HCP and commencement of this KIUC HCP. This provided KIUC, USFWS, and DOFAW with a large amount of data that was used to determine if management at these sites would continue to benefit the covered seabird species during HCP implementation. Because management had been occurring at these sites for such a long time, it also led to the decision to include these sites as conservation sites for the KIUC HCP rather than replace them with new sites. Other significant factors for selection of the conservation sites in the KIUC HCP included site adjacency and presence of existing fences. The location of all selected conservation sites is shown in Figure 4A-1. Table 4-4 in Chapter 4, *Conservation Strategy*, identifies the total size of each selected conservation site and the estimated number of Newell’s shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu) breeding pairs, and Table 4-5 in Chapter 4, identifies the management action that will be implemented in each conservation site.

KIUC will select a tenth conservation site but the final location of this site is still under evaluation. The final site is identified temporarily as “Conservation Site 10” and will be located at one of four potential sites in the area shown as a dashed purple line on Figure 4A-1 in the northwest corner of Kauaʻi. KIUC is currently evaluating four candidate locations for Conservation Site 10 against the selection criteria listed above. Specifically, Conservation Site 10 will be selected based on the presence of Newell’s shearwater (ʻaʻo) colonies and the feasibility of establishing a predator exclusion fence and initiating social attraction. KIUC will select and commit to a specific location and configuration for Conservation Site 10 no later than the end of 2023 and before permit issuance.

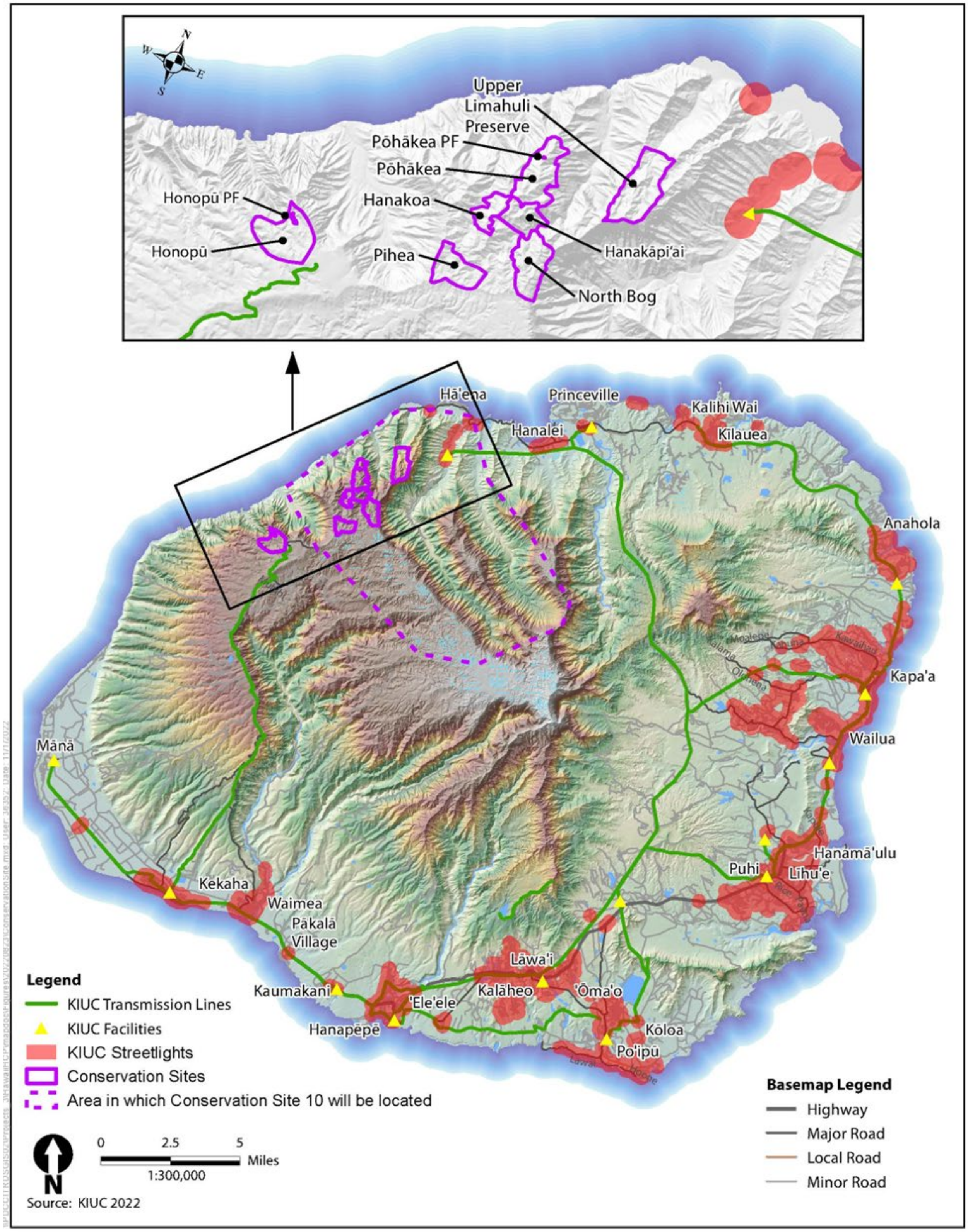

Figure 4A-1. KIUC HCP Conservation Sites

4A.2.3.1 Upper Limahuli Preserve

The Upper Limahuli Preserve (Preserve) is a 378-acre (ac) (153-hectare [ht]) conservation site ranging in elevation between 1,600 and 3,200 ft (488 and 975 m). The Preserve is owned and managed in perpetuity as a conservation area by the National Tropical Botanical Garden, who have agreed to include the Preserve as a conservation site in the HCP. The Preserve contains numerous steep ridgelines and cliffs that can only be accessed by helicopter.

Based on currently available data, 167 Newell's shearwater (ʻaʻo), 49 Hawaiian petrel (ʻuaʻu), and 38 unidentified burrows have been located at the Preserve (Raine et al. 2022) and the population estimate for the species within the site is between 498 and 617 Newell's shearwater (ʻaʻo) breeding pairs and between 112 and 135 Hawaiian petrel (ʻuaʻu) breeding pairs (Raine 2022). Tracking of nesting adults indicates that most birds arrive and depart from the colony over the closely adjacent ocean, with only a few tracks showing birds flying high over existing powerlines (Raine et al. 2017). In 2009, work was completed on an ungulate exclusion fence that now protects the entire Preserve from ungulates. Other infrastructure includes several helicopter landing zones, two weatherports to support personnel and operations, and an extensive network of trails.

KIUC has funded predator control and monitoring efforts at this location since 2011, with predator control operations increasing in scope and personnel in recent years. Ongoing management activities at this site include invasive plant removal, maintenance of ungulate fencing, monitoring to keep the site ungulate-free, predator control (rats, cats, pigs, and barn owl), acoustic assessment of seabird activity, auditory surveys, and estimation of annual seabird reproductive success through nest monitoring.

The Preserve was included as a conservation site because it had a willing landowner and significant populations of both covered seabirds (particularly Newell's shearwater [ʻaʻo]). The large size of the site also suggests that the populations of both species can be expanded into new portions of the Preserve using social attraction techniques. The conservation site was also selected because of the substantial existing infrastructure, including the extensive ungulate exclusion fence that has been maintained successfully since 2009.

4A.2.3.2 North Bog

North Bog is part of the Hono O Nā Pali NAR, managed by DOFAW. DOFAW has approved inclusion of North Bog as a conservation site in the HCP. The North Bog conservation site, encompassing 348 ac (141 ht), is a site where seabird management has been ongoing. Site access for fence construction, predator control, and monitoring activities is by helicopter only, although in emergencies there is a trail to hike out. Given the site's remote location on the edge of Wainiha Valley, powerline collisions and light attraction are a lower risk to breeding birds. Site infrastructure consists of a helicopter landing zone, a weatherport to support personnel and operations, and an approximately 2-ac (0.8-ht) ungulate exclusion fence installed to protect rare native plants. A new ungulate exclusion fence was constructed by DOFAW in 2014 to protect the Hono O Nā Pali NAR. This fence extends from the Pihea lookout to the Kilohana lookout, preventing ingress by pigs from the Alakaʻi Swamp. A second ungulate exclusion fence was constructed in 2017 extending northward from the Pihea lookout, preventing ingress by pigs from the Kalalau Valley and further wing fences have been built on the Nā Pali Coast for the same reason.

Based on currently available data, a total of 2 Newell's shearwater (ʻaʻo), 235 Hawaiian petrel (ʻuaʻu), and 39 unidentified burrows have been located (Raine et al. 2022). The population estimate for the two species within the site is between 66 and 80 Newell's shearwater (ʻaʻo) breeding pairs and between 880 and 1,261 Hawaiian petrel (ʻuaʻu) breeding pairs (Raine 2022).

Current seabird management actions include nest site monitoring, predator control (rats, cats, pigs, and barn owl), acoustic assessment of seabird activity, and estimation of annual seabird reproductive success. KIUC has funded predator control and monitoring efforts at this location since 2015.

4A.2.3.3 Pōhākea

Pōhākea is part of the Hono O Nā Pali NAR, managed by DOFAW. DOFAW has approved inclusion of Pōhākea as a conservation site in the HCP. Located in the northeastern corner of the Hono O Nā Pali NAR, Pōhākea is a 363-ac (147-ht) site bordered to the east by the Hanakāpiʻai drainage and to the south by the Hanakāpiʻai conservation site (Figure 4A-1). The Pōhākea site is on the Nā Pali Coast and as such is at low risk from existing powerlines and coastal lights. Site access for predator control and monitoring activities is by helicopter only.

Pōhākea is considered an important conservation site for seabirds. Based on currently available data, a total of 58 Newell's shearwater (ʻaʻo), 67 Hawaiian petrel (ʻuaʻu), and 33 unidentified burrows have been located (Raine et al. 2022). The population estimate for the two species within the site is between 290 and 464 Newell's shearwater (ʻaʻo) breeding pairs and between 161 and 611 Hawaiian petrel (ʻuaʻu) breeding pairs (Raine 2022). Current seabird conservation activities include nest monitoring, predator control (rats, cats, pigs, and barn owls), acoustic assessment of seabird activity, and estimation of annual seabird reproductive success. All the Pōhākea conservation site (i.e., all 363 ac [146.9 ht]) supports potential habitat for one or both of the covered seabirds (Troy et al. 2014, 2017). Construction of ungulate fencing associated with this conservation area has already been completed by the Hono O Nā Pali NAR program. KIUC has funded predator control and monitoring efforts at this location in recent years.

4A.2.3.4 Pōhākea PF

Pōhākea PF (which stands for predator exclusion fence) is a small 0.34-ac (0.14-ht) area located within the northern portion of the larger Pōhākea conservation site, described above in Section 2.3.4, *Pōhākea*. A 0.34-ac (0.14-ht) in length predator exclusion fence was created by DOFAW and DOFAW partners around the site in 2021, and 50 artificial burrows and a sound system will be deployed inside the fence area in early 2022 (prior to the start of the breeding season) to attract Newell's shearwater (ʻaʻo) to the fully protected area. The site was chosen for several reasons—(i) close proximity to a large breeding cluster of Newell's shearwater (ʻaʻo), (ii) located on a flyway for Newell's shearwater (ʻaʻo) transiting overhead to colonies in the back of Wainiha Valley, (iii) a steep bowl topography to allow nesting shearwaters to take off from without colliding with the fence and (iv) a high proportion of invasive vegetation (especially Himalayan ginger [kāhili ginger]), meaning that burrows could be dug into the site without disturbing significant amounts of native vegetation and no rare plant species. KIUC will take control of the predator exclusion fenced area in 2022 and maintain and manage it as a conservation site in accordance with this HCP.

4A.2.3.5 Honopū (and Honopū PF)

The Honopū conservation site is part of the Nā Pali Coast State Wilderness Park managed by the Division of State Parks. Approval from State Parks and DOFAW is pending for inclusion of this conservation site in the HCP. Development of this site involves a large ungulate fence and a smaller predator exclusion fence located within the ungulate fence, the establishment of predator control in both fenced areas and the establishment of social attraction in the predator exclusion fence. It can be accessed via several trails from the main Kokeʻe Road and has a scattered trail system and two helicopter landing zones. No weatherports or other infrastructure are currently present. Site access for fence maintenance, predator control, and covered species monitoring is predominantly on foot. The conservation site is located along the edge of the Kalalau Valley and the risk from powerlines and coastal lights is minimal.[3]

A 2.7-mile (4.4-km) ungulate fence was constructed by the State of Hawaiʻi and partners which tied off at the steep, impassable cliffs of Honopū Valley, resulting in a conservation site of 239 ac (97 ht). Within the Honopū conservation site a total of four Newell's shearwater (ʻaʻo) burrows have been located (Raine pers. comm.), two of which were active in 2020. While the conservation site contains suitable breeding habitat for Newell's shearwater (ʻaʻo), decades of predation from cats, rats, pigs, and barn owl have restricted the breeding population predominantly to the inaccessible Nā Pali cliffs. Therefore, while the current breeding population of Newell's shearwater (ʻaʻo) within the ungulate fenced area is 90 to 92 breeding pairs, the potential population estimate for the site is 396 to 487 pairs. Hawaiian petrels (ʻuaʻu) are not known to breed in this area, although small numbers transit over. Band-rumped storm-petrels (ʻakēʻakē) breed in good numbers on the cliffs adjacent to the conservation site, and this species is also often seen flying over the area. KIUC began funding and implementing predator control and seabird monitoring at Honopū in 2022.

In addition, a 3.3-ac (1.3-ht) predator exclusion fence and social attraction site (i.e., Honopū PF) is currently being developed by the State and partners inside the ungulate fence area, covering the northern edge of the conservation site overlooking the cliffs of Honopū Valley. In April 2021, 35 artificial burrows were installed in one section of the site for band-rumped storm-petrel (ʻakēʻakē) and 29 artificial burrows for both Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu) in another section. The proximity of this conservation site to large breeding colonies of both Newell's shearwater (ʻaʻo) and band-rumped storm-petrel (ʻakēʻakē) in the cliffs of Honopū Valley make this an ideal social attraction site for these two species.

4A.2.3.6 Pihea

Pihea is a 515-ac (208-ht) site that is part of the Nā Pali Coast State Wilderness Park managed by the Division of State Parks. State Parks has approved inclusion of this conservation site in the HCP. The Pihea conservation site can be accessed from the Pihea trail from Puʻu O Kila lookout, a scattered trail system, and there are two helicopter landing zones. No weatherports or other infrastructure are currently present. Several sections of strategic ungulate fence spanning 1.2 miles (1.9 km) have been installed by the Hono O Nā Pali NAR since 2014, resulting in regional conservation benefits that extend to the Pihea conservation site. The site is located along the edge of the Kalalau Valley and the risk from powerlines and coastal lights is minimal.[4] Site access for fence construction, maintenance, and predator control and monitoring is predominantly by helicopter.

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[3] The site sits below the Kokeʻe Air Force Station, where a large fallout event of Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu) occurred in 2015. The Air Force Station has since changed its lights and—as long as this lighting protocol is maintained—presents minimal fallout risk to birds breeding in this area.

[4] The site does point towards the Kōkeʻe Air Force Station, where a large fallout event of Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu) occurred in 2015. The Air Force Station has since changed its lights and—as long as this lighting protocol is maintained—now presents minimal fallout risk to birds breeding in this area.

Based on currently available data, a total of 144 Hawaiian petrel (ʻuaʻu) burrows and 27 unidentified burrows have been located (Raine et al. 2022) and the population estimate for this species within the site is between 645 and 815 Hawaiian petrel (ʻuaʻu) breeding pairs (Raine 2022). The lack of a robust Newell's shearwater (ʻaʻo) population at Pihea is likely because most Newell's shearwaters (ʻaʻo) nest along the edge of Kalalau Valley, which cannot be accessed safely for monitoring because of the steepness of the terrain.

4A.2.3.7 Hanakoa

Hanakoa is part of the Hono O Nā Pali NAR managed by DOFAW. DOFAW has approved inclusion of Hanakoa as a conservation site in the HCP. The Hanakoa conservation site encompasses 186 ac (75 ht) within the Hono O Nā Pali NAR and is situated immediately adjacent and to the west of the Pōhākea and Hanakāpiʻai conservation areas (Figure 4A-1). The Hanakoa conservation site is in the interior mountainous region and thus at limited risk from existing powerlines and coastal lights. Site access for predator control and monitoring activities is by helicopter only.

Hanakoa is considered an important conservation site for seabirds. To date a total of 2 Newell's shearwater (ʻaʻo), 176 Hawaiian petrel (ʻuaʻu), and 36 unidentified burrows have been located (Raine et al. 2022). The population estimate for the two species within this site is between 45 and 74 Newell's shearwater (ʻaʻo) breeding pairs and between 171 and 455 Hawaiian petrel (ʻuaʻu) breeding pairs (Raine 2022).

Construction of ungulate fence associated with this conservation area was completed by the Hono O Nā Pali NAR program. Funding for predator control efforts, between 2016 and 2019 was secured through the National Fish and Wildlife Foundation (via American Bird Conservancy) by D. E. Shaw Renewable Investments, LLC in partial fulfillment of Hawaiian petrel (ʻuaʻu) mitigation obligations under the HCP for Kawailoa Wind. KIUC began funding predator control and seabird monitoring at Hanakoa in 2021.

4A.2.3.8 Hanakāpiʻai

Hanakāpiʻai is part of the Hono O Nā Pali NAR managed by DOFAW. DOFAW approved inclusion of Hanakāpiʻai as a conservation site in the HCP. Bordered by North Bog to the east, Pōhākea to the west, and Hanakoa to the south (Figure 4A-1), Hanakāpiʻai is considered an important conservation site for seabirds, especially Hawaiian petrel (ʻuaʻu). The conservation site contains numerous steep ridgelines and cliffs that can only be accessed by helicopter. The Hanakāpiʻai site has three landing zones for helicopters and a scattered trail system. The conservation site is in the interior of the Hono O Nā Pali NAR and thus at limited risk from artificial lights and powerlines.

The Hanakāpiʻai conservation site encompasses 187 ac (76 ht) of potential habitat. To date a total of 19 Newell's shearwater (ʻaʻo), 316 Hawaiian petrel (ʻuaʻu), and 65 unidentified burrows have been located (Raine et al. 2022). The population estimate for the two species within this site is between 76 and 85 Newell's shearwater (ʻaʻo) breeding pairs and between 289 and 398 Hawaiian petrel (ʻuaʻu) breeding pairs (Raine 2022).

Construction of ungulate fencing associated with this conservation area was completed by the Hono O Nā Pali NAR program and funding for predator control efforts was initially undertaken through funding from the National Fish and Wildlife Foundation (via American Bird Conservancy) between 2016 and 2019 and via D. E. Shaw Renewable Investments, LLC in partial fulfillment of Hawaiian petrel (ʻuaʻu) mitigation obligations under the HCP for Kawailoa Wind, in 2020. KIUC began funding and implementing predator control and seabird monitoring at Hanakāpiʻai in 2021.

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4A.3.2 Personal Communication

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Appendix 4B
KIUC Minimization Projects

Span Number	Span Name	Distance (miles)	Minimization Type	Year
1	Mana Substation to WKEP	0.0526	69kV removal	2022
1	Mana Substation to WKEP	0.0526	Static wire removal	2022
2	Mana Substation to WKEP	0.0734	69kV removal	2022
2	Mana Substation to WKEP	0.0734	Static wire removal	2022
3	Mana Substation to WKEP	0.0757	69kV removal	2022
3	Mana Substation to WKEP	0.0757	Static wire removal	2022
4	Mana Substation to WKEP	0.0834	69kV removal	2022
4	Mana Substation to WKEP	0.0834	Static wire removal	2022
5	Mana Substation to WKEP	0.0807	69kV removal	2022
5	Mana Substation to WKEP	0.0807	Static wire removal	2022
6	Mana Substation to WKEP	0.0771	69kV removal	2022
6	Mana Substation to WKEP	0.0771	Static wire removal	2022
7	Mana Substation to WKEP	0.0754	69kV removal	2022
7	Mana Substation to WKEP	0.0754	Static wire removal	2022
8	Mana Substation to WKEP	0.0477	69kV removal	2022
8	Mana Substation to WKEP	0.0477	Static wire removal	2022
9	Mana Substation to WKEP	0.0459	69kV removal	2022
9	Mana Substation to WKEP	0.0459	Static wire removal	2022
10	Mana Substation to WKEP	0.0462	69kV removal	2022
10	Mana Substation to WKEP	0.0462	Static wire removal	2022
11	Mana Substation to WKEP	0.0477	69kV removal	2022
11	Mana Substation to WKEP	0.0477	Static wire removal	2022
12	Mana Substation to WKEP	0.0468	69kV removal	2022
12	Mana Substation to WKEP	0.0468	Static wire removal	2022
13	Mana Substation to WKEP	0.0375	69kV removal	2022
13	Mana Substation to WKEP	0.0375	Static wire removal	2022
14	Mana Substation to WKEP	0.0505	69kV removal	2022
14	Mana Substation to WKEP	0.0505	Static wire removal	2022
15	Mana Substation to WKEP	0.0513	69kV removal	2022
15	Mana Substation to WKEP	0.0513	Static wire removal	2022
16	Mana Substation to WKEP	0.0505	69kV removal	2022
16	Mana Substation to WKEP	0.0505	Static wire removal	2022
17	Mana Substation to WKEP	0.0666	69kV removal	2022
17	Mana Substation to WKEP	0.0666	Static wire removal	2022

18	Mana Substation to WKEP	0.0522	69kV removal	2022
18	Mana Substation to WKEP	0.0522	Static wire removal	2022
19	Mana Substation to WKEP	0.0339	69kV removal	2022
19	Mana Substation to WKEP	0.0339	Static wire removal	2022
20	Mana Substation to WKEP	0.0680	69kV removal	2022
20	Mana Substation to WKEP	0.0680	Static wire removal	2022
21	Mana Substation to WKEP	0.0725	69kV removal	2022
21	Mana Substation to WKEP	0.0725	Static wire removal	2022
22	Mana Substation to WKEP	0.0394	69kV removal	2022
22	Mana Substation to WKEP	0.0394	Static wire removal	2022
23	Mana Substation to WKEP	0.0718	69kV removal	2022
23	Mana Substation to WKEP	0.0718	Static wire removal	2022
24	Mana Substation to WKEP	0.0724	69kV removal	2022
24	Mana Substation to WKEP	0.0724	Static wire removal	2022
25	Mana Substation to WKEP	0.0738	69kV removal	2022
25	Mana Substation to WKEP	0.0738	Static wire removal	2022
26	Mana Substation to WKEP	0.0730	69kV removal	2022
26	Mana Substation to WKEP	0.0730	Static wire removal	2022
27	Mana Substation to WKEP	0.0691	69kV removal	2022
27	Mana Substation to WKEP	0.0691	Static wire removal	2022
28	Mana Substation to WKEP	0.0799	69kV removal	2022
28	Mana Substation to WKEP	0.0799	Static wire removal	2022
29	Mana Substation to WKEP	0.0759	69kV removal	2022
29	Mana Substation to WKEP	0.0759	Static wire removal	2022
30	WKEP to Kekaha Substation	0.0450	Diverter installation (Reflective)	2021
31	WKEP to Kekaha Substation	0.0482	Diverter installation (Reflective)	2021
32	WKEP to Kekaha Substation	0.0741	Diverter installation (Reflective)	2021
33	WKEP to Kekaha Substation	0.0397	Diverter installation (Reflective)	2021
34	WKEP to Kekaha Substation	0.0551	Diverter installation (Reflective)	2021
35	WKEP to Kekaha Substation	0.0545	Diverter installation (Reflective)	2021
36	WKEP to Kekaha Substation	0.0545	Diverter installation (Reflective)	2021
37	WKEP to Kekaha Substation	0.0572	Diverter installation (Reflective)	2021
38	WKEP to Kekaha Substation	0.0748	Diverter installation (Reflective)	2021
39	WKEP to Kekaha Substation	0.0732	Diverter installation (Reflective)	2021
40	WKEP to Kekaha Substation	0.0733	Diverter installation (Reflective)	2021

41	WKEP to Kekaha Substation	0.0731	Diverter installation (Reflective)	2021
42	WKEP to Kekaha Substation	0.0738	Diverter installation (Reflective)	2021
43	WKEP to Kekaha Substation	0.0744	Diverter installation (Reflective)	2021
44	WKEP to Kekaha Substation	0.0361	Diverter installation (Reflective)	2021
45	WKEP to Kekaha Substation	0.0682	Diverter installation (Reflective)	2021
46	WKEP to Kekaha Substation	0.0775	Diverter installation (Reflective)	2021
47	WKEP to Kekaha Substation	0.0793	Diverter installation (Reflective)	2021
48	WKEP to Kekaha Substation	0.0795	Diverter installation (Reflective)	2021
49	WKEP to Kekaha Substation	0.0792	Diverter installation (Reflective)	2021
50	WKEP to Kekaha Substation	0.0811	Diverter installation (Reflective)	2021
51	WKEP to Kekaha Substation	0.0366	Diverter installation (Reflective)	2021
52	WKEP to Kekaha Substation	0.0750	Diverter installation (Reflective)	2021
53	WKEP to Kekaha Substation	0.0742	Diverter installation (Reflective)	2021
54	WKEP to Kekaha Substation	0.0728	Diverter installation (Reflective)	2021
55	WKEP to Kekaha Substation	0.0744	Diverter installation (Reflective)	2021
56	WKEP to Kekaha Substation	0.0723	Diverter installation (Reflective)	2021
57	WKEP to Kekaha Substation	0.0750	Diverter installation (Reflective)	2021
58	WKEP to Kekaha Substation	0.0383	Diverter installation (Reflective)	2021
59	WKEP to Kekaha Substation	0.0758	Diverter installation (Reflective)	2021
60	WKEP to Kekaha Substation	0.0759	Diverter installation (Reflective)	2021
61	WKEP to Kekaha Substation	0.0577	Diverter installation (Reflective)	2021
62	WKEP to Kekaha Substation	0.0545	Diverter installation (Reflective)	2021
63	WKEP to Kekaha Substation	0.0660	Diverter installation (Reflective)	2021
64	WKEP to Kekaha Substation	0.0652	Diverter installation (Reflective)	2021
65	WKEP to Kekaha Substation	0.0655	Diverter installation (Reflective)	2021
66	WKEP to Kekaha Substation	0.0647	Diverter installation (Reflective)	2021
67	WKEP to Kekaha Substation	0.0371	Diverter installation (Reflective)	2021
68	WKEP to Kekaha Substation	0.0769	Diverter installation (Reflective)	2021
69	WKEP to Kekaha Substation	0.0751	Diverter installation (Reflective)	2021
70	WKEP to Kekaha Substation	0.0744	Diverter installation (Reflective)	2021
71	WKEP to Kekaha Substation	0.0734	Diverter installation (Reflective)	2021
72	WKEP to Kekaha Substation	0.0758	Diverter installation (Reflective)	2021
73	WKEP to Kekaha Substation	0.0368	Diverter installation (Reflective)	2021
74	WKEP to Kekaha Substation	0.0764	Diverter installation (Reflective)	2021
75	WKEP to Kekaha Substation	0.0732	Diverter installation (Reflective)	2021

76	WKEP to Kekaha Substation	0.0731	Diverter installation (Reflective)	2021
77	WKEP to Kekaha Substation	0.0753	Diverter installation (Reflective)	2021
78	WKEP to Kekaha Substation	0.1202	Diverter installation (Reflective)	2021
79	WKEP to Kekaha Substation	0.0625	Diverter installation (Reflective)	2021
80	WKEP to Kekaha Substation	0.0755	Diverter installation (Reflective)	2021
81	WKEP to Kekaha Substation	0.0656	Diverter installation (Reflective)	2021
82	WKEP to Kekaha Substation	0.0421	Diverter installation (Reflective)	2021
83	WKEP to Kekaha Substation	0.0539	Diverter installation (Reflective)	2021
84	WKEP to Kekaha Substation	0.0423	Diverter installation (Reflective)	2021
85	WKEP to Kekaha Substation	0.0413	Diverter installation (Reflective)	2021
86	WKEP to Kekaha Substation	0.0801	Diverter installation (Reflective)	2021
87	WKEP to Kekaha Substation	0.0589	Diverter installation (Reflective)	2021
88	WKEP to Kekaha Substation	0.0685	Diverter installation (Reflective)	2021
89	WKEP to Kekaha Substation	0.0659	Diverter installation (Reflective)	2021
90	WKEP to Kekaha Substation	0.0630	Diverter installation (Reflective)	2021
91	WKEP to Kekaha Substation	0.0665	Diverter installation (Reflective)	2021
92	WKEP to Kekaha Substation	0.0654	Diverter installation (Reflective)	2021
93	WKEP to Kekaha Substation	0.0388	Diverter installation (Reflective)	2021
94	WKEP to Kekaha Substation	0.0393	Diverter installation (Reflective)	2021
95	WKEP to Kekaha Substation	0.0264	Diverter installation (Reflective)	2021
96	WKEP to Kekaha Substation	0.0616	Diverter installation (Reflective)	2021
97	WKEP to Kekaha Substation	0.0547	Diverter installation (Reflective)	2021
98	WKEP to Kekaha Substation	0.0636	Diverter installation (Reflective)	2021
99	WKEP to Kekaha Substation	0.0310	Diverter installation (Reflective)	2021
100	WKEP to Kekaha Substation	0.0539	Diverter installation (Reflective)	2021
101	WKEP to Kekaha Substation	0.0769	Diverter installation (Reflective)	2021
102	WKEP to Kekaha Substation	0.0655	Diverter installation (Reflective)	2021
103	WKEP to Kekaha Substation	0.0750	Diverter installation (Reflective)	2021
104	WKEP to Kekaha Substation	0.0727	Diverter installation (Reflective)	2022
105	WKEP to Kekaha Substation	0.0432	Diverter installation (Reflective)	2021
106	WKEP to Kekaha Substation	0.0367	Diverter installation (Reflective)	2021
107	WKEP to Kekaha Substation	0.0542	Diverter installation (Reflective)	2021
108	WKEP to Kekaha Substation	0.0596	Diverter installation (Reflective)	2021
109	WKEP to Kekaha Substation	0.0553	Diverter installation (Reflective)	2021
110	WKEP to Kekaha Substation	0.0592	Diverter installation (Reflective)	2021

111	WKEP to Kekaha Substation	0.0567	Diverter installation (Reflective)	2021
112	WKEP to Kekaha Substation	0.0505	Diverter installation (Reflective)	2021
113	WKEP to Kekaha Substation	0.0259	Diverter installation (Reflective)	2021
116	Kekaha Substation to Waimea Bridge	0.0788	Diverter installation (Reflective)	2022
116	Kekaha Substation to Waimea Bridge	0.0788	Static wire removal	2022
117	Kekaha Substation to Waimea Bridge	0.0670	Diverter installation (Reflective)	2021
117	Kekaha Substation to Waimea Bridge	0.0670	Static wire removal	2021
118	Kekaha Substation to Waimea Bridge	0.0543	Diverter installation (Reflective)	2021
118	Kekaha Substation to Waimea Bridge	0.0543	Static wire removal	2021
119	Kekaha Substation to Waimea Bridge	0.0533	Diverter installation (Reflective)	2022
119	Kekaha Substation to Waimea Bridge	0.0533	Static wire removal	2021
120	Kekaha Substation to Waimea Bridge	0.0584	Diverter installation (Reflective)	2022
120	Kekaha Substation to Waimea Bridge	0.0584	Static wire removal	2021
121	Kekaha Substation to Waimea Bridge	0.0335	Diverter installation (Reflective)	2022
121	Kekaha Substation to Waimea Bridge	0.0335	Static wire removal	2021
122	Kekaha Substation to Waimea Bridge	0.0387	Diverter installation (Reflective)	2022
122	Kekaha Substation to Waimea Bridge	0.0387	Static wire removal	2021
123	Kekaha Substation to Waimea Bridge	0.0388	Diverter installation (Reflective)	2022
123	Kekaha Substation to Waimea Bridge	0.0388	Static wire removal	2021
124	Kekaha Substation to Waimea Bridge	0.0439	Diverter installation (Reflective)	2022
124	Kekaha Substation to Waimea Bridge	0.0439	Static wire removal	2021
125	Kekaha Substation to Waimea Bridge	0.0331	Diverter installation (Reflective)	2022
125	Kekaha Substation to Waimea Bridge	0.0331	Static wire removal	2021
126	Kekaha Substation to Waimea Bridge	0.0490	Diverter installation (Reflective)	2022
126	Kekaha Substation to Waimea Bridge	0.0490	Static wire removal	2021
127	Kekaha Substation to Waimea Bridge	0.0531	Diverter installation (Reflective)	2022
127	Kekaha Substation to Waimea Bridge	0.0531	Static wire removal	2021
128	Kekaha Substation to Waimea Bridge	0.0237	Diverter installation (Reflective)	2022
128	Kekaha Substation to Waimea Bridge	0.0237	Static wire removal	2021
129	Kekaha Substation to Waimea Bridge	0.0236	Diverter installation (Reflective)	2022
129	Kekaha Substation to Waimea Bridge	0.0236	Static wire removal	2021
130	Kekaha Substation to Waimea Bridge	0.0281	Diverter installation (Reflective)	2022
130	Kekaha Substation to Waimea Bridge	0.0281	Static wire removal	2021
131	Kekaha Substation to Waimea Bridge	0.0312	Diverter installation (Reflective)	2022
131	Kekaha Substation to Waimea Bridge	0.0312	Static wire removal	2021

132	Kekaha Substation to Waimea Bridge	0.0546	Diverter installation (Reflective)	2022
132	Kekaha Substation to Waimea Bridge	0.0546	Static wire removal	2021
133	Kekaha Substation to Waimea Bridge	0.0609	Diverter installation (Reflective)	2022
133	Kekaha Substation to Waimea Bridge	0.0609	Static wire removal	2021
134	Kekaha Substation to Waimea Bridge	0.0729	Diverter installation (Reflective)	2022
134	Kekaha Substation to Waimea Bridge	0.0729	Static wire removal	2021
135	Kekaha Substation to Waimea Bridge	0.0788	Diverter installation (Reflective)	2022
135	Kekaha Substation to Waimea Bridge	0.0788	Static wire removal	2021
136	Kekaha Substation to Waimea Bridge	0.0741	Diverter installation (Reflective)	2022
136	Kekaha Substation to Waimea Bridge	0.0741	Static wire removal	2021
137	Kekaha Substation to Waimea Bridge	0.0757	Diverter installation (Reflective)	2022
137	Kekaha Substation to Waimea Bridge	0.0757	Static wire removal	2021
138	Kekaha Substation to Waimea Bridge	0.0760	Diverter installation (Reflective)	2022
138	Kekaha Substation to Waimea Bridge	0.0760	Static wire removal	2021
139	Kekaha Substation to Waimea Bridge	0.0738	Diverter installation (Reflective)	2022
139	Kekaha Substation to Waimea Bridge	0.0738	Static wire removal	2021
140	Kekaha Substation to Waimea Bridge	0.0775	Diverter installation (Reflective)	2022
140	Kekaha Substation to Waimea Bridge	0.0775	Static wire removal	2021
141	Kekaha Substation to Waimea Bridge	0.0748	Diverter installation (Reflective)	2022
141	Kekaha Substation to Waimea Bridge	0.0748	Static wire removal	2021
142	Kekaha Substation to Waimea Bridge	0.0766	Diverter installation (Reflective)	2022
142	Kekaha Substation to Waimea Bridge	0.0766	Static wire removal	2021
143	Kekaha Substation to Waimea Bridge	0.0817	Diverter installation (Reflective)	2022
143	Kekaha Substation to Waimea Bridge	0.0817	Static wire removal	2021
144	Kekaha Substation to Waimea Bridge	0.0692	Diverter installation (Reflective)	2022
144	Kekaha Substation to Waimea Bridge	0.0692	Static wire removal	2021
145	Kekaha Substation to Waimea Bridge	0.0760	Diverter installation (Reflective)	2022
145	Kekaha Substation to Waimea Bridge	0.0760	Static wire removal	2021
146	Kekaha Substation to Waimea Bridge	0.0766	Diverter installation (Reflective)	2022
146	Kekaha Substation to Waimea Bridge	0.0766	Static wire removal	2021
147	Kekaha Substation to Waimea Bridge	0.0731	Diverter installation (Reflective)	2022
147	Kekaha Substation to Waimea Bridge	0.0731	Static wire removal	2021
148	Kekaha Substation to Waimea Bridge	0.0725	Diverter installation (Reflective)	2022
148	Kekaha Substation to Waimea Bridge	0.0725	Static wire removal	2021
149	Kekaha Substation to Waimea Bridge	0.0817	Diverter installation (Reflective)	2022

149	Kekaha Substation to Waimea Bridge	0.0817	Static wire removal	2021
150	Kekaha Substation to Waimea Bridge	0.0846	Diverter installation (Reflective)	2022
150	Kekaha Substation to Waimea Bridge	0.0846	Static wire removal	2021
151	Kekaha Substation to Waimea Bridge	0.0703	Diverter installation (Reflective)	2022
151	Kekaha Substation to Waimea Bridge	0.0703	Static wire removal	2021
152	Kekaha Substation to Waimea Bridge	0.0762	Diverter installation (Reflective)	2022
152	Kekaha Substation to Waimea Bridge	0.0762	Static wire removal	2021
153	Kekaha Substation to Waimea Bridge	0.0757	Diverter installation (Reflective)	2022
153	Kekaha Substation to Waimea Bridge	0.0757	Static wire removal	2021
154	Kekaha Substation to Waimea Bridge	0.0735	Diverter installation (Reflective)	2022
154	Kekaha Substation to Waimea Bridge	0.0735	Static wire removal	2021
155	Kekaha Substation to Waimea Bridge	0.0585	Diverter installation (Reflective)	2022
155	Kekaha Substation to Waimea Bridge	0.0585	Static wire removal	2021
156	Kekaha Substation to Waimea Bridge	0.0587	Diverter installation (Reflective)	2022
156	Kekaha Substation to Waimea Bridge	0.0587	Static wire removal	2021
157	Kekaha Substation to Waimea Bridge	0.0423	Diverter installation (Reflective)	2022
157	Kekaha Substation to Waimea Bridge	0.0423	Static wire removal	2021
158	Kekaha Substation to Waimea Bridge	0.0565	Diverter installation (Reflective)	2022
158	Kekaha Substation to Waimea Bridge	0.0565	Static wire removal	2021
159	Kekaha Substation to Waimea Bridge	0.0579	Diverter installation (Reflective)	2022
159	Kekaha Substation to Waimea Bridge	0.0579	Static wire removal	2021
160	Kekaha Substation to Waimea Bridge	0.0528	Diverter installation (Reflective)	2022
160	Kekaha Substation to Waimea Bridge	0.0528	Static wire removal	2021
161	Kekaha Substation to Waimea Bridge	0.0557	Static wire removal	2021
162	Kekaha Substation to Waimea Bridge	0.0245	Diverter installation (Reflective)	2022
162	Kekaha Substation to Waimea Bridge	0.0245	Static wire removal	2021
163	Kekaha Substation to Waimea Bridge	0.0285	Diverter installation (Reflective)	2022
163	Kekaha Substation to Waimea Bridge	0.0285	Static wire removal	2021
164	Kekaha Substation to Waimea Bridge	0.0558	Diverter installation (Reflective)	2022
164	Kekaha Substation to Waimea Bridge	0.0558	Static wire removal	2021
165	Kekaha Substation to Waimea Bridge	0.0608	Diverter installation (Reflective)	2022
165	Kekaha Substation to Waimea Bridge	0.0608	Static wire removal	2021
166	Kekaha Substation to Waimea Bridge	0.0383	Diverter installation (Reflective)	2022
166	Kekaha Substation to Waimea Bridge	0.0383	Static wire removal	2021
167	Kekaha Substation to Waimea Bridge	0.0329	Diverter installation (Reflective)	2022

167	Kekaha Substation to Waimea Bridge	0.0329	Static wire removal	2021
168	Kekaha Substation to Waimea Bridge	0.0342	Diverter installation (Reflective)	2022
168	Kekaha Substation to Waimea Bridge	0.0342	Static wire removal	2021
169	Kekaha Substation to Waimea Bridge	0.0292	Diverter installation (Reflective)	2022
169	Kekaha Substation to Waimea Bridge	0.0292	Static wire removal	2021
170	Kekaha Substation to Waimea Bridge	0.0333	Diverter installation (Reflective)	2022
170	Kekaha Substation to Waimea Bridge	0.0333	Static wire removal	2021
171	Kekaha Substation to Waimea Bridge	0.0582	Diverter installation (Reflective)	2022
171	Kekaha Substation to Waimea Bridge	0.0582	Static wire removal	2021
172	Kekaha Substation to Waimea Bridge	0.0461	Diverter installation (Reflective)	2022
172	Kekaha Substation to Waimea Bridge	0.0461	Static wire removal	2021
173	Kekaha Substation to Waimea Bridge	0.0919	Diverter installation (Reflective)	2022
173	Kekaha Substation to Waimea Bridge	0.0919	Static wire removal	2021
174	Waimea Bridge to Kaumakani	0.0781	Diverter installation (Reflective)	2022
174	Waimea Bridge to Kaumakani	0.0781	Static wire removal	2021
175	Waimea Bridge to Kaumakani	0.0728	Diverter installation (Reflective)	2022
175	Waimea Bridge to Kaumakani	0.0728	Static wire removal	2021
176	Waimea Bridge to Kaumakani	0.0753	Diverter installation (Reflective)	2022
176	Waimea Bridge to Kaumakani	0.0753	Static wire removal	2021
177	Waimea Bridge to Kaumakani	0.0778	Diverter installation (Reflective)	2022
177	Waimea Bridge to Kaumakani	0.0778	Static wire removal	2021
178	Waimea Bridge to Kaumakani	0.0753	Diverter installation (Reflective)	2022
178	Waimea Bridge to Kaumakani	0.0753	Static wire removal	2021
179	Waimea Bridge to Kaumakani	0.0524	Diverter installation (Reflective)	2022
179	Waimea Bridge to Kaumakani	0.0524	Static wire removal	2021
180	Waimea Bridge to Kaumakani	0.0694	Diverter installation (Reflective)	2022
180	Waimea Bridge to Kaumakani	0.0694	Static wire removal	2021
181	Waimea Bridge to Kaumakani	0.0756	Diverter installation (Reflective)	2022
181	Waimea Bridge to Kaumakani	0.0756	Static wire removal	2021
182	Waimea Bridge to Kaumakani	0.0747	Diverter installation (Reflective)	2022
182	Waimea Bridge to Kaumakani	0.0747	Static wire removal	2021
183	Waimea Bridge to Kaumakani	0.0751	Diverter installation (Reflective)	2022
183	Waimea Bridge to Kaumakani	0.0751	Static wire removal	2021
184	Waimea Bridge to Kaumakani	0.0829	Diverter installation (Reflective)	2022
184	Waimea Bridge to Kaumakani	0.0829	Static wire removal	2021

185	Waimea Bridge to Kaumakani	0.0749	Diverter installation (Reflective)	2022
185	Waimea Bridge to Kaumakani	0.0749	Static wire removal	2021
186	Waimea Bridge to Kaumakani	0.0391	Diverter installation (Reflective)	2022
186	Waimea Bridge to Kaumakani	0.0391	Static wire removal	2021
187	Waimea Bridge to Kaumakani	0.0363	Diverter installation (Reflective)	2022
187	Waimea Bridge to Kaumakani	0.0363	Static wire removal	2021
188	Waimea Bridge to Kaumakani	0.0387	Diverter installation (Reflective)	2022
188	Waimea Bridge to Kaumakani	0.0387	Static wire removal	2021
189	Waimea Bridge to Kaumakani	0.0369	Diverter installation (Reflective)	2022
189	Waimea Bridge to Kaumakani	0.0369	Static wire removal	2021
190	Waimea Bridge to Kaumakani	0.0390	Diverter installation (Reflective)	2022
190	Waimea Bridge to Kaumakani	0.0390	Static wire removal	2021
191	Waimea Bridge to Kaumakani	0.0390	Diverter installation (Reflective)	2022
191	Waimea Bridge to Kaumakani	0.0390	Static wire removal	2021
192	Waimea Bridge to Kaumakani	0.0335	Diverter installation (Reflective)	2022
192	Waimea Bridge to Kaumakani	0.0335	Static wire removal	2021
193	Waimea Bridge to Kaumakani	0.0402	Diverter installation (Reflective)	2022
193	Waimea Bridge to Kaumakani	0.0402	Static wire removal	2021
194	Waimea Bridge to Kaumakani	0.0336	Diverter installation (Reflective)	2022
194	Waimea Bridge to Kaumakani	0.0336	Static wire removal	2021
195	Waimea Bridge to Kaumakani	0.0810	Diverter installation (Reflective)	2022
195	Waimea Bridge to Kaumakani	0.0810	Static wire removal	2021
196	Waimea Bridge to Kaumakani	0.0731	Diverter installation (Reflective)	2022
196	Waimea Bridge to Kaumakani	0.0731	Static wire removal	2021
197	Waimea Bridge to Kaumakani	0.0767	Diverter installation (Reflective)	2022
197	Waimea Bridge to Kaumakani	0.0767	Static wire removal	2021
198	Waimea Bridge to Kaumakani	0.0768	Diverter installation (Reflective)	2022
198	Waimea Bridge to Kaumakani	0.0768	Static wire removal	2021
199	Waimea Bridge to Kaumakani	0.0745	Diverter installation (Reflective)	2022
199	Waimea Bridge to Kaumakani	0.0745	Static wire removal	2021
200	Waimea Bridge to Kaumakani	0.0780	Diverter installation (Reflective)	2022
200	Waimea Bridge to Kaumakani	0.0780	Static wire removal	2021
201	Waimea Bridge to Kaumakani	0.0749	Diverter installation (Reflective)	2022
201	Waimea Bridge to Kaumakani	0.0749	Static wire removal	2021
202	Waimea Bridge to Kaumakani	0.0759	Diverter installation (Reflective)	2022

202	Waimea Bridge to Kaumakani	0.0759	Static wire removal	2021
203	Waimea Bridge to Kaumakani	0.0542	Diverter installation (Reflective)	2022
203	Waimea Bridge to Kaumakani	0.0542	Static wire removal	2021
204	Waimea Bridge to Kaumakani	0.0501	Diverter installation (Reflective)	2022
204	Waimea Bridge to Kaumakani	0.0501	Static wire removal	2021
205	Waimea Bridge to Kaumakani	0.0624	Diverter installation (Reflective)	2022
205	Waimea Bridge to Kaumakani	0.0624	Static wire removal	2021
206	Waimea Bridge to Kaumakani	0.0629	Diverter installation (Reflective)	2022
206	Waimea Bridge to Kaumakani	0.0629	Static wire removal	2021
207	Waimea Bridge to Kaumakani	0.0688	Diverter installation (Reflective)	2022
207	Waimea Bridge to Kaumakani	0.0688	Static wire removal	2021
208	Waimea Bridge to Kaumakani	0.0430	Diverter installation (Reflective)	2022
208	Waimea Bridge to Kaumakani	0.0430	Static wire removal	2021
209	Waimea Bridge to Kaumakani	0.0587	Diverter installation (Reflective)	2022
209	Waimea Bridge to Kaumakani	0.0587	Static wire removal	2021
210	Waimea Bridge to Kaumakani	0.0740	Diverter installation (Reflective)	2022
210	Waimea Bridge to Kaumakani	0.0740	Static wire removal	2021
211	Waimea Bridge to Kaumakani	0.0724	Diverter installation (Reflective)	2022
211	Waimea Bridge to Kaumakani	0.0724	Static wire removal	2021
212	Waimea Bridge to Kaumakani	0.0896	Diverter installation (Reflective)	2022
212	Waimea Bridge to Kaumakani	0.0896	Static wire removal	2021
213	Waimea Bridge to Kaumakani	0.0740	Diverter installation (Reflective)	2022
213	Waimea Bridge to Kaumakani	0.0740	Static wire removal	2021
214	Waimea Bridge to Kaumakani	0.0802	Diverter installation (Reflective)	2022
214	Waimea Bridge to Kaumakani	0.0802	Static wire removal	2021
215	Waimea Bridge to Kaumakani	0.0791	Diverter installation (Reflective)	2022
215	Waimea Bridge to Kaumakani	0.0791	Static wire removal	2021
216	Waimea Bridge to Kaumakani	0.0654	Diverter installation (Reflective)	2022
216	Waimea Bridge to Kaumakani	0.0654	Static wire removal	2021
217	Waimea Bridge to Kaumakani	0.0781	Diverter installation (Reflective)	2022
217	Waimea Bridge to Kaumakani	0.0781	Static wire removal	2021
218	Waimea Bridge to Kaumakani	0.0943	Diverter installation (Reflective)	2022
218	Waimea Bridge to Kaumakani	0.0943	Static wire removal	2021
219	Waimea Bridge to Kaumakani	0.0919	Diverter installation (Reflective)	2022
219	Waimea Bridge to Kaumakani	0.0919	Static wire removal	2021

220	Waimea Bridge to Kaumakani	0.0799	Diverter installation (Reflective)	2022
220	Waimea Bridge to Kaumakani	0.0799	Static wire removal	2021
221	Waimea Bridge to Kaumakani	0.0701	Diverter installation (Reflective)	2022
221	Waimea Bridge to Kaumakani	0.0701	Static wire removal	2021
222	Waimea Bridge to Kaumakani	0.0663	Diverter installation (Reflective)	2022
222	Waimea Bridge to Kaumakani	0.0663	Static wire removal	2021
223	Waimea Bridge to Kaumakani	0.0752	Diverter installation (Reflective)	2022
223	Waimea Bridge to Kaumakani	0.0752	Static wire removal	2021
224	Waimea Bridge to Kaumakani	0.0777	Diverter installation (Reflective)	2022
224	Waimea Bridge to Kaumakani	0.0777	Static wire removal	2021
225	Waimea Bridge to Kaumakani	0.0401	Diverter installation (Reflective)	2022
225	Waimea Bridge to Kaumakani	0.0401	Static wire removal	2021
226	Waimea Bridge to Kaumakani	0.0406	Diverter installation (Reflective)	2022
226	Waimea Bridge to Kaumakani	0.0406	Static wire removal	2021
227	Waimea Bridge to Kaumakani	0.0590	Diverter installation (Reflective)	2022
227	Waimea Bridge to Kaumakani	0.0590	Static wire removal	2021
228	Waimea Bridge to Kaumakani	0.0611	Diverter installation (Reflective)	2022
228	Waimea Bridge to Kaumakani	0.0611	Static wire removal	2021
229	Waimea Bridge to Kaumakani	0.0532	Diverter installation (Reflective)	2022
229	Waimea Bridge to Kaumakani	0.0532	Static wire removal	2021
230	Waimea Bridge to Kaumakani	0.0774	Diverter installation (Reflective)	2022
230	Waimea Bridge to Kaumakani	0.0774	Static wire removal	2021
231	Waimea Bridge to Kaumakani	0.0801	Diverter installation (Reflective)	2022
231	Waimea Bridge to Kaumakani	0.0801	Static wire removal	2021
232	Waimea Bridge to Kaumakani	0.0401	Diverter installation (Reflective)	2022
232	Waimea Bridge to Kaumakani	0.0401	Static wire removal	2021
233	Waimea Bridge to Kaumakani	0.0735	Diverter installation (Reflective)	2022
233	Waimea Bridge to Kaumakani	0.0735	Static wire removal	2021
234	Waimea Bridge to Kaumakani	0.0590	Diverter installation (Reflective)	2022
234	Waimea Bridge to Kaumakani	0.0590	Static wire removal	2021
235	Waimea Bridge to Kaumakani	0.0474	Diverter installation (Reflective)	2022
235	Waimea Bridge to Kaumakani	0.0474	Static wire removal	2021
236	Waimea Bridge to Kaumakani	0.1019	Diverter installation (Reflective)	2022
236	Waimea Bridge to Kaumakani	0.1019	Static wire removal	2021
237	Waimea Bridge to Kaumakani	0.1036	Diverter installation (Reflective)	2022

237	Waimea Bridge to Kaumakani	0.1036	Static wire removal	2021
238	Waimea Bridge to Kaumakani	0.0469	Diverter installation (Reflective)	2022
238	Waimea Bridge to Kaumakani	0.0469	Static wire removal	2021
239	Waimea Bridge to Kaumakani	0.0473	Diverter installation (Reflective)	2022
239	Waimea Bridge to Kaumakani	0.0473	Static wire removal	2021
240	Waimea Bridge to Kaumakani	0.0386	Diverter installation (Reflective)	2022
240	Waimea Bridge to Kaumakani	0.0386	Static wire removal	2021
241	Waimea Bridge to Kaumakani	0.0391	Diverter installation (Reflective)	2022
241	Waimea Bridge to Kaumakani	0.0391	Static wire removal	2021
242	Waimea Bridge to Kaumakani	0.0376	Diverter installation (Reflective)	2022
242	Waimea Bridge to Kaumakani	0.0376	Static wire removal	2021
243	Waimea Bridge to Kaumakani	0.0376	Diverter installation (Reflective)	2022
243	Waimea Bridge to Kaumakani	0.0376	Static wire removal	2021
244	Waimea Bridge to Kaumakani	0.0769	Diverter installation (Reflective)	2015
244	Waimea Bridge to Kaumakani	0.0769	Static wire removal	2021
245	Waimea Bridge to Kaumakani	0.0716	Diverter installation (Reflective)	2015
245	Waimea Bridge to Kaumakani	0.0716	Static wire removal	2021
246	Waimea Bridge to Kaumakani	0.0766	Diverter installation (Reflective)	2015
246	Waimea Bridge to Kaumakani	0.0766	Static wire removal	2021
247	Waimea Bridge to Kaumakani	0.0741	Diverter installation (Reflective)	2015
247	Waimea Bridge to Kaumakani	0.0741	Static wire removal	2021
248	Waimea Bridge to Kaumakani	0.0361	Diverter installation (Reflective)	2022
248	Waimea Bridge to Kaumakani	0.0361	Static wire removal	2021
249	Waimea Bridge to Kaumakani	0.0391	Diverter installation (Reflective)	2022
249	Waimea Bridge to Kaumakani	0.0391	Static wire removal	2021
250	Waimea Bridge to Kaumakani	0.0412	Diverter installation (Reflective)	2022
250	Waimea Bridge to Kaumakani	0.0412	Static wire removal	2021
251	Waimea Bridge to Kaumakani	0.0333	Diverter installation (Reflective)	2022
251	Waimea Bridge to Kaumakani	0.0333	Static wire removal	2021
252	Waimea Bridge to Kaumakani	0.0365	Diverter installation (Reflective)	2022
252	Waimea Bridge to Kaumakani	0.0365	Static wire removal	2021
253	Waimea Bridge to Kaumakani	0.0385	Diverter installation (Reflective)	2015
253	Waimea Bridge to Kaumakani	0.0385	Static wire removal	2021
254	Waimea Bridge to Kaumakani	0.0720	Diverter installation (Reflective)	2015
254	Waimea Bridge to Kaumakani	0.0720	Static wire removal	2021

255	Waimea Bridge to Kaumakani	0.0778	Diverter installation (Reflective)	2022
255	Waimea Bridge to Kaumakani	0.0778	Static wire removal	2021
256	Waimea Bridge to Kaumakani	0.0757	Diverter installation (Reflective)	2022
256	Waimea Bridge to Kaumakani	0.0757	Static wire removal	2021
257	Waimea Bridge to Kaumakani	0.0790	Diverter installation (Reflective)	2022
257	Waimea Bridge to Kaumakani	0.0790	Static wire removal	2021
258	Waimea Bridge to Kaumakani	0.0452	Diverter installation (Reflective)	2022
258	Waimea Bridge to Kaumakani	0.0452	Static wire removal	2021
259	Waimea Bridge to Kaumakani	0.0499	Diverter installation (Reflective)	2022
259	Waimea Bridge to Kaumakani	0.0499	Static wire removal	2021
260	Kaumakani to Port Allen	0.0263	Diverter installation (Reflective)	2022
260	Kaumakani to Port Allen	0.0263	Static wire removal	2021
261	Kaumakani to Port Allen	0.0476	Diverter installation (Reflective)	2022
261	Kaumakani to Port Allen	0.0476	Static wire removal	2021
262	Kaumakani to Port Allen	0.0754	Diverter installation (Reflective)	2022
262	Kaumakani to Port Allen	0.0754	Static wire removal	2021
263	Kaumakani to Port Allen	0.0719	Diverter installation (Reflective)	2022
263	Kaumakani to Port Allen	0.0719	Static wire removal	2021
264	Kaumakani to Port Allen	0.0773	Diverter installation (Reflective)	2022
264	Kaumakani to Port Allen	0.0773	Static wire removal	2021
265	Kaumakani to Port Allen	0.0364	Diverter installation (Reflective)	2022
265	Kaumakani to Port Allen	0.0364	Static wire removal	2021
266	Kaumakani to Port Allen	0.0486	Diverter installation (Reflective)	2022
266	Kaumakani to Port Allen	0.0486	Static wire removal	2021
267	Kaumakani to Port Allen	0.0513	Diverter installation (Reflective)	2021
267	Kaumakani to Port Allen	0.0513	Static wire removal	2021
268	Kaumakani to Port Allen	0.0832	Diverter installation (Reflective)	2022
268	Kaumakani to Port Allen	0.0832	Static wire removal	2021
269	Kaumakani to Port Allen	0.0496	Diverter installation (Reflective)	2021
269	Kaumakani to Port Allen	0.0496	Static wire removal	2021
270	Kaumakani to Port Allen	0.0567	Diverter installation (Reflective)	2021
270	Kaumakani to Port Allen	0.0567	Static wire removal	2021
271	Kaumakani to Port Allen	0.0792	Diverter installation (Reflective)	2021
271	Kaumakani to Port Allen	0.0792	Static wire removal	2021
272	Kaumakani to Port Allen	0.0153	Diverter installation (Reflective)	2021

272	Kaumakani to Port Allen	0.0153	Static wire removal	2021
273	Kaumakani to Port Allen	0.0208	Diverter installation (Reflective)	2021
273	Kaumakani to Port Allen	0.0208	Static wire removal	2021
274	Kaumakani to Port Allen	0.0120	Diverter installation (Reflective)	2021
274	Kaumakani to Port Allen	0.0120	Static wire removal	2021
275	Kaumakani to Port Allen	0.0500	Diverter installation (Reflective)	2021
275	Kaumakani to Port Allen	0.0500	Static wire removal	2021
276	Kaumakani to Port Allen	0.0831	Diverter installation (Reflective)	2021
276	Kaumakani to Port Allen	0.0831	Static wire removal	2021
277	Kaumakani to Port Allen	0.0693	Diverter installation (Reflective)	2021
277	Kaumakani to Port Allen	0.0693	Static wire removal	2021
277	Kaumakani to Port Allen	0.0693	Static wire removal	2021
278	Kaumakani to Port Allen	0.0581	Diverter installation (Reflective)	2021
278	Kaumakani to Port Allen	0.0581	Static wire removal	2021
279	Kaumakani to Port Allen	0.0229	Diverter installation (Reflective)	2021
279	Kaumakani to Port Allen	0.0229	Static wire removal	2021
280	Kaumakani to Port Allen	0.0642	Diverter installation (Reflective)	2021
280	Kaumakani to Port Allen	0.0642	Static wire removal	2021
281	Kaumakani to Port Allen	0.0660	Diverter installation (Reflective)	2021
281	Kaumakani to Port Allen	0.0660	Static wire removal	2021
282	Kaumakani to Port Allen	0.0211	Diverter installation (Reflective)	2021
282	Kaumakani to Port Allen	0.0211	Static wire removal	2021
283	Kaumakani to Port Allen	0.0341	Diverter installation (Reflective)	2021
283	Kaumakani to Port Allen	0.0341	Static wire removal	2021
284	Kaumakani to Port Allen	0.0386	Diverter installation (Reflective)	2021
284	Kaumakani to Port Allen	0.0386	Static wire removal	2021
285	Kaumakani to Port Allen	0.0260	Diverter installation (Reflective)	2021
285	Kaumakani to Port Allen	0.0260	Static wire removal	2021
286	Kaumakani to Port Allen	0.0498	Diverter installation (Reflective)	2021
286	Kaumakani to Port Allen	0.0498	Static wire removal	2021
287	Kaumakani to Port Allen	0.0461	Diverter installation (Reflective)	2021
287	Kaumakani to Port Allen	0.0461	Static wire removal	2022
289	Kaumakani to Port Allen	0.0364	Diverter installation (Reflective)	2022
289	Kaumakani to Port Allen	0.0364	Static wire removal	2022
290	PAGS to Waialo Rd/Hwy intersection	0.0337	Diverter installation (Reflective)	2021

290	PAGS to Waialo Rd/Hwy intersection	0.0337	Static wire removal	2021
291	PAGS to Waialo Rd/Hwy intersection	0.0379	Diverter installation (Reflective)	2021
291	PAGS to Waialo Rd/Hwy intersection	0.0379	Static wire removal	2021
292	PAGS to Waialo Rd/Hwy intersection	0.0374	Diverter installation (Reflective)	2021
292	PAGS to Waialo Rd/Hwy intersection	0.0374	Static wire removal	2021
293	PAGS to Waialo Rd/Hwy intersection	0.0411	Diverter installation (Reflective)	2021
293	PAGS to Waialo Rd/Hwy intersection	0.0411	Static wire removal	2021
294	PAGS to Waialo Rd/Hwy intersection	0.0367	Diverter installation (Reflective)	2021
294	PAGS to Waialo Rd/Hwy intersection	0.0367	Static wire removal	2021
295	PAGS to Waialo Rd/Hwy intersection	0.0406	Diverter installation (Reflective)	2021
295	PAGS to Waialo Rd/Hwy intersection	0.0406	Static wire removal	2021
296	PAGS to Waialo Rd/Hwy intersection	0.0437	Diverter installation (Reflective)	2021
296	PAGS to Waialo Rd/Hwy intersection	0.0437	Static wire removal	2021
297	PAGS to Waialo Rd/Hwy intersection	0.0210	Diverter installation (Reflective)	2021
297	PAGS to Waialo Rd/Hwy intersection	0.0210	Static wire removal	2021
298	Waialo Rd/Hwy intersection to Brydsewood	0.0278	Diverter installation (Reflective)	2021
298	Waialo Rd/Hwy intersection to Brydsewood	0.0278	Static wire removal	2019
299	Waialo Rd/Hwy intersection to Brydsewood	0.0254	Diverter installation (Reflective)	2021
299	Waialo Rd/Hwy intersection to Brydsewood	0.0254	Static wire removal	2019
300	Waialo Rd/Hwy intersection to Brydsewood	0.0282	Diverter installation (Reflective)	2021
300	Waialo Rd/Hwy intersection to Brydsewood	0.0282	Static wire removal	2019
301	Waialo Rd/Hwy intersection to Brydsewood	0.0282	Diverter installation (Reflective)	2021
301	Waialo Rd/Hwy intersection to Brydsewood	0.0282	Static wire removal	2019
302	Waialo Rd/Hwy intersection to Brydsewood	0.0282	Diverter installation (Reflective)	2021
302	Waialo Rd/Hwy intersection to Brydsewood	0.0282	Static wire removal	2019
303	Waialo Rd/Hwy intersection to Brydsewood	0.0377	Diverter installation (Reflective)	2022
303	Waialo Rd/Hwy intersection to Brydsewood	0.0377	Static wire removal	2019
304	Waialo Rd/Hwy intersection to Brydsewood	0.0336	Diverter installation (Reflective)	2022
304	Waialo Rd/Hwy intersection to Brydsewood	0.0336	Static wire removal	2019
305	Waialo Rd/Hwy intersection to Brydsewood	0.0663	Diverter installation (Reflective)	2022
305	Waialo Rd/Hwy intersection to Brydsewood	0.0663	Static wire removal	2019
306	Waialo Rd/Hwy intersection to Brydsewood	0.0653	Diverter installation (Reflective)	2022
306	Waialo Rd/Hwy intersection to Brydsewood	0.0653	Static wire removal	2019
307	Waialo Rd/Hwy intersection to Brydsewood	0.0625	Diverter installation (Reflective)	2022
307	Waialo Rd/Hwy intersection to Brydsewood	0.0625	Static wire removal	2019

308	Waialo Rd/Hwy intersection to Brydsewood	0.0423	Diverter installation (Reflective)	2021
308	Waialo Rd/Hwy intersection to Brydsewood	0.0423	Static wire removal	2019
309	Waialo Rd/Hwy intersection to Brydsewood	0.0312	Diverter installation (Reflective)	2021
309	Waialo Rd/Hwy intersection to Brydsewood	0.0312	Static wire removal	2019
310	Waialo Rd/Hwy intersection to Brydsewood	0.0721	Diverter installation (Reflective)	2021
310	Waialo Rd/Hwy intersection to Brydsewood	0.0721	Static wire removal	2019
311	Waialo Rd/Hwy intersection to Brydsewood	0.0626	Diverter installation (Reflective)	2021
311	Waialo Rd/Hwy intersection to Brydsewood	0.0626	Static wire removal	2019
312	Waialo Rd/Hwy intersection to Brydsewood	0.0371	Diverter installation (Reflective)	2021
312	Waialo Rd/Hwy intersection to Brydsewood	0.0371	Static wire removal	2019
313	Waialo Rd/Hwy intersection to Brydsewood	0.0310	Diverter installation (Reflective)	2022
313	Waialo Rd/Hwy intersection to Brydsewood	0.0310	Static wire removal	2019
314	Waialo Rd/Hwy intersection to Brydsewood	0.0709	Diverter installation (Reflective)	2022
314	Waialo Rd/Hwy intersection to Brydsewood	0.0709	Static wire removal	2019
315	Waialo Rd/Hwy intersection to Brydsewood	0.0741	Diverter installation (LED)	2022
315	Waialo Rd/Hwy intersection to Brydsewood	0.0741	Static wire removal	2019
316	Waialo Rd/Hwy intersection to Brydsewood	0.0750	Diverter installation (Reflective)	2022
316	Waialo Rd/Hwy intersection to Brydsewood	0.0750	Static wire removal	2019
317	Waialo Rd/Hwy intersection to Brydsewood	0.0781	Diverter installation (Reflective)	2021
317	Waialo Rd/Hwy intersection to Brydsewood	0.0781	Static wire removal	2019
318	Waialo Rd/Hwy intersection to Brydsewood	0.0299	Diverter installation (Reflective)	2021
318	Waialo Rd/Hwy intersection to Brydsewood	0.0299	Static wire removal	2019
319	Waialo Rd/Hwy intersection to Brydsewood	0.0537	Diverter installation (Reflective)	2021
319	Waialo Rd/Hwy intersection to Brydsewood	0.0537	Static wire removal	2019
320	Waialo Rd/Hwy intersection to Brydsewood	0.0590	Diverter installation (Reflective)	2021
320	Waialo Rd/Hwy intersection to Brydsewood	0.0590	Static wire removal	2019
321	Waialo Rd/Hwy intersection to Brydsewood	0.0554	Diverter installation (Reflective)	2021
321	Waialo Rd/Hwy intersection to Brydsewood	0.0554	Static wire removal	2019
322	Waialo Rd/Hwy intersection to Brydsewood	0.0436	Diverter installation (Reflective)	2021
322	Waialo Rd/Hwy intersection to Brydsewood	0.0436	Static wire removal	2019
323	Waialo Rd/Hwy intersection to Brydsewood	0.0723	Diverter installation (Reflective)	2021
323	Waialo Rd/Hwy intersection to Brydsewood	0.0723	Static wire removal	2019
324	Waialo Rd/Hwy intersection to Brydsewood	0.0751	Diverter installation (Reflective)	2021
324	Waialo Rd/Hwy intersection to Brydsewood	0.0751	Static wire removal	2019
325	Waialo Rd/Hwy intersection to Brydsewood	0.0466	Diverter installation (Reflective)	2021

325	Waialo Rd/Hwy intersection to Brydsewood	0.0466	Static wire removal	2019
326	Waialo Rd/Hwy intersection to Brydsewood	0.0468	Diverter installation (Reflective)	2021
326	Waialo Rd/Hwy intersection to Brydsewood	0.0468	Static wire removal	2019
327	Waialo Rd/Hwy intersection to Brydsewood	0.0074	Static wire removal	2022
328	Waialo Rd/Hwy intersection to Brydsewood	0.1601	Static wire removal	2016
329	Waialo Rd/Hwy intersection to Brydsewood	0.1170	Static wire removal	2016
330	Waialo Rd/Hwy intersection to Brydsewood	0.1922	Diverter installation (Reflective)	2021
330	Waialo Rd/Hwy intersection to Brydsewood	0.1922	Static wire removal	2016
331	Waialo Rd/Hwy intersection to Brydsewood	0.1533	Diverter installation (Reflective)	2021
331	Waialo Rd/Hwy intersection to Brydsewood	0.1533	Static wire removal	2016
332	Waialo Rd/Hwy intersection to Brydsewood	0.1064	Diverter installation (Reflective)	2021
332	Waialo Rd/Hwy intersection to Brydsewood	0.1064	Static wire removal	2016
333	Waialo Rd/Hwy intersection to Brydsewood	0.1330	Diverter installation (Reflective)	2021
333	Waialo Rd/Hwy intersection to Brydsewood	0.1330	Static wire removal	2016
334	Waialo Rd/Hwy intersection to Brydsewood	0.3177	Static wire removal	2016
335	Waialo Rd/Hwy intersection to Brydsewood	0.1156	Diverter installation (Reflective)	2021
335	Waialo Rd/Hwy intersection to Brydsewood	0.1156	Static wire removal	2016
336	Waialo Rd/Hwy intersection to Brydsewood	0.1161	Diverter installation (Reflective)	2021
336	Waialo Rd/Hwy intersection to Brydsewood	0.1161	Static wire removal	2016
337	Waialo Rd/Hwy intersection to Brydsewood	0.1174	Static wire removal	2016
338	Waialo Rd/Hwy intersection to Brydsewood	0.1456	Static wire removal	2016
339	Waialo Rd/Hwy intersection to Brydsewood	0.1353	Diverter installation (Reflective)	2021
339	Waialo Rd/Hwy intersection to Brydsewood	0.1353	Static wire removal	2016
340	Waialo Rd/Hwy intersection to Brydsewood	0.1378	Diverter installation (Reflective)	2021
340	Waialo Rd/Hwy intersection to Brydsewood	0.1378	Static wire removal	2016
341	Waialo Rd/Hwy intersection to Brydsewood	0.0961	Diverter installation (Reflective)	2021
341	Waialo Rd/Hwy intersection to Brydsewood	0.0961	Static wire removal	2016
342	Waialo Rd/Hwy intersection to Brydsewood	0.1582	Static wire removal	2016
343	Fujita Tap	0.2674	Diverter installation (Reflective)	2022
343	Fujita Tap	0.2674	Static wire removal	2022
344	Fujita Tap	0.1144	Diverter installation (Reflective)	2022
344	Fujita Tap	0.1144	Static wire removal	2022
346	Fujita Tap	0.1209	Diverter installation (Reflective)	2022
346	Fujita Tap	0.1209	Static wire removal	2022
347	Fujita Tap	0.1405	Diverter installation (Reflective)	2022

347	Fujita Tap	0.1405	Static wire removal	2022
348	Fujita Tap	0.1188	Diverter installation (Reflective)	2022
348	Fujita Tap	0.1188	Static wire removal	2022
349	Fujita Tap	0.2632	Diverter installation (Reflective)	2022
349	Fujita Tap	0.2632	Static wire removal	2022
350	Fujita Tap	0.1798	Diverter installation (Reflective)	2022
351	Fujita Tap	0.1673	Diverter installation (Reflective)	2022
352	Fujita Tap	0.4467	Diverter installation (Reflective)	2022
352	Fujita Tap	0.4467	Static wire removal	2016
353	Fujita Tap	0.0274	Diverter installation (Reflective)	2022
354	Fujita Tap	0.1845	Diverter installation (Reflective)	2022
354	Fujita Tap	0.1845	Static wire removal	2022
355	Fujita Tap	0.1461	Diverter installation (Reflective)	2022
355	Fujita Tap	0.1461	Static wire removal	2022
356	Fujita Tap	0.1156	Diverter installation (Reflective)	2022
356	Fujita Tap	0.1156	Static wire removal	2022
357	Fujita Tap	0.1226	Diverter installation (Reflective)	2022
357	Fujita Tap	0.1226	Static wire removal	2022
358	Fujita Tap	0.1965	Diverter installation (Reflective)	2022
358	Fujita Tap	0.1965	Static wire removal	2022
359	Fujita Tap	0.5587	Diverter installation (Reflective)	2022
359	Fujita Tap	0.5587	Static wire removal	2022
361	Fujita Tap	0.2174	Diverter installation (Reflective)	2021
361	Fujita Tap	0.2174	Static wire removal	2022
362	Fujita Tap	0.1666	Diverter installation (Reflective)	2021
362	Fujita Tap	0.1666	Static wire removal	2022
363	Fujita Tap	0.1442	Diverter installation (Reflective)	2021
363	Fujita Tap	0.1442	Static wire removal	2022
364	Fujita Tap	0.1487	Diverter installation (Reflective)	2021
364	Fujita Tap	0.1487	Static wire removal	2022
365	Fujita Tap	0.1400	Diverter installation (Reflective)	2021
365	Fujita Tap	0.1400	Static wire removal	2021
365	Fujita Tap	0.1400	Static wire removal	2021
366	Fujita Tap	0.1312	Diverter installation (Reflective)	2021
366	Fujita Tap	0.1312	Static wire removal	2021

366	Fujita Tap	0.1312	Static wire removal	2021
367	Fujita Tap	0.1278	Diverter installation (Reflective)	2021
367	Fujita Tap	0.1278	Static wire removal	2021
367	Fujita Tap	0.1278	Static wire removal	2021
368	Fujita Tap	0.1461	Diverter installation (Reflective)	2022
368	Fujita Tap	0.1461	Static wire removal	2022
369	Fujita Tap	0.1861	Diverter installation (Reflective)	2022
369	Fujita Tap	0.1861	Static wire removal	2022
370	Fujita Tap	0.1610	Diverter installation (Reflective)	2022
370	Fujita Tap	0.1610	Static wire removal	2022
371	Fujita Tap	0.1603	Diverter installation (Reflective)	2021
371	Fujita Tap	0.1603	Static wire removal	2021
372	Fujita Tap	0.1322	Diverter installation (Reflective)	2021
372	Fujita Tap	0.1322	Static wire removal	2021
373	Fujita Tap	0.1376	Diverter installation (Reflective)	2021
373	Fujita Tap	0.1376	Static wire removal	2021
374	Fujita Tap	0.1526	Diverter installation (Reflective)	2021
374	Fujita Tap	0.1526	Static wire removal	2021
375	Fujita Tap	0.1377	Diverter installation (Reflective)	2021
375	Fujita Tap	0.1377	Static wire removal	2021
376	Fujita Tap	0.1498	Diverter installation (Reflective)	2021
376	Fujita Tap	0.1498	Static wire removal	2021
377	Fujita Tap	0.1467	Diverter installation (Reflective)	2021
377	Fujita Tap	0.1467	Static wire removal	2022
378	Fujita Tap to Kilohana Tap	0.1582	Diverter installation (Reflective)	2022
378	Fujita Tap to Kilohana Tap	0.1582	Static wire removal	2022
379	Fujita Tap to Kilohana Tap	0.1840	Diverter installation (Reflective)	2022
379	Fujita Tap to Kilohana Tap	0.1840	Static wire removal	2022
380	Fujita Tap to Kilohana Tap	0.1811	Diverter installation (Reflective)	2021
380	Fujita Tap to Kilohana Tap	0.1811	Static wire removal	2022
381	Fujita Tap to Kilohana Tap	0.1987	Diverter installation (Reflective)	2021
381	Fujita Tap to Kilohana Tap	0.1987	Static wire removal	2022
382	Fujita Tap to Kilohana Tap	0.1025	Diverter installation (Reflective)	2022
382	Fujita Tap to Kilohana Tap	0.1025	Static wire removal	2022
383	Fujita Tap to Kilohana Tap	0.2119	Diverter installation (Reflective)	2022

383	Fujita Tap to Kilohana Tap	0.2119	Static wire removal	2022
384	Fujita Tap to Kilohana Tap	0.1521	Diverter installation (Reflective)	2022
384	Fujita Tap to Kilohana Tap	0.1521	Static wire removal	2022
385	Fujita Tap to Kilohana Tap	0.1747	Diverter installation (Reflective)	2022
385	Fujita Tap to Kilohana Tap	0.1747	Static wire removal	2022
386	Fujita Tap to Kilohana Tap	0.1371	Diverter installation (Reflective)	2021
386	Fujita Tap to Kilohana Tap	0.1371	Static wire removal	2022
387	Fujita Tap to Kilohana Tap	0.1789	Diverter installation (Reflective)	2021
387	Fujita Tap to Kilohana Tap	0.1789	Static wire removal	2022
388	Fujita Tap to Kilohana Tap	0.1902	Diverter installation (Reflective)	2021
388	Fujita Tap to Kilohana Tap	0.1902	Static wire removal	2022
389	Kilohana to Hanahanapuni (CP1 and CP2)	0.1543	Diverter installation (Reflective)	2021
389	Kilohana to Hanahanapuni (CP1 and CP2)	0.1543	Reconfiguration	2020
389	Kilohana to Hanahanapuni (CP1 and CP2)	0.1543	Static wire removal	2020
390	Kilohana to Hanahanapuni (CP1 and CP2)	0.2215	Diverter installation (Reflective)	2021
390	Kilohana to Hanahanapuni (CP1 and CP2)	0.2215	Reconfiguration	2020
390	Kilohana to Hanahanapuni (CP1 and CP2)	0.2215	Static wire removal	2020
391	Kilohana to Hanahanapuni (CP1 and CP2)	0.1737	Diverter installation (Reflective)	2021
391	Kilohana to Hanahanapuni (CP1 and CP2)	0.1737	Reconfiguration	2020
391	Kilohana to Hanahanapuni (CP1 and CP2)	0.1737	Static wire removal	2020
392	Kilohana to Hanahanapuni (CP1 and CP2)	0.1475	Diverter installation (Reflective)	2021
392	Kilohana to Hanahanapuni (CP1 and CP2)	0.1475	Reconfiguration	2020
392	Kilohana to Hanahanapuni (CP1 and CP2)	0.1475	Static wire removal	2020
393	Kilohana to Hanahanapuni (CP1 and CP2)	0.1522	Diverter installation (Reflective)	2021
393	Kilohana to Hanahanapuni (CP1 and CP2)	0.1522	Reconfiguration	2020
393	Kilohana to Hanahanapuni (CP1 and CP2)	0.1522	Static wire removal	2020
394	Kilohana to Hanahanapuni (CP1 and CP2)	0.3866	Diverter installation (Reflective)	2021
394	Kilohana to Hanahanapuni (CP1 and CP2)	0.3866	Reconfiguration	2020
394	Kilohana to Hanahanapuni (CP1 and CP2)	0.3866	Static wire removal	2020
395	Kilohana to Hanahanapuni (CP1 and CP2)	0.3567	Diverter installation (Reflective)	2021
395	Kilohana to Hanahanapuni (CP1 and CP2)	0.3567	Reconfiguration	2020
395	Kilohana to Hanahanapuni (CP1 and CP2)	0.3567	Static wire removal	2020
396	Kilohana to Hanahanapuni (CP1 and CP2)	0.2601	Diverter installation (Reflective)	2021
396	Kilohana to Hanahanapuni (CP1 and CP2)	0.2601	Reconfiguration	2020
396	Kilohana to Hanahanapuni (CP1 and CP2)	0.2601	Static wire removal	2020

397	Kilohana to Hanahanapuni (CP1 and CP2)	0.1472	Diverter installation (Reflective)	2021
397	Kilohana to Hanahanapuni (CP1 and CP2)	0.1472	Reconfiguration	2020
397	Kilohana to Hanahanapuni (CP1 and CP2)	0.1472	Static wire removal	2020
398	Kilohana to Hanahanapuni (CP1 and CP2)	0.1618	Diverter installation (Reflective)	2021
398	Kilohana to Hanahanapuni (CP1 and CP2)	0.1618	Reconfiguration	2020
398	Kilohana to Hanahanapuni (CP1 and CP2)	0.1618	Static wire removal	2020
399	Kilohana to Hanahanapuni (CP1 and CP2)	0.2034	Diverter installation (Reflective)	2021
399	Kilohana to Hanahanapuni (CP1 and CP2)	0.2034	Reconfiguration	2020
399	Kilohana to Hanahanapuni (CP1 and CP2)	0.2034	Static wire removal	2020
400	Kilohana to Hanahanapuni (CP1 and CP2)	0.2107	Diverter installation (Reflective)	2021
400	Kilohana to Hanahanapuni (CP1 and CP2)	0.2107	Reconfiguration	2020
400	Kilohana to Hanahanapuni (CP1 and CP2)	0.2107	Static wire removal	2020
401	Kilohana to Hanahanapuni (CP1 and CP2)	0.2422	Diverter installation (Reflective)	2021
401	Kilohana to Hanahanapuni (CP1 and CP2)	0.2422	Reconfiguration	2020
401	Kilohana to Hanahanapuni (CP1 and CP2)	0.2422	Static wire removal	2020
402	Kilohana to Hanahanapuni (CP1 and CP2)	0.2233	Diverter installation (Reflective)	2021
402	Kilohana to Hanahanapuni (CP1 and CP2)	0.2233	Reconfiguration	2020
402	Kilohana to Hanahanapuni (CP1 and CP2)	0.2233	Static wire removal	2020
403	Kilohana to Hanahanapuni (CP1 and CP2)	0.1316	Diverter installation (Reflective)	2021
403	Kilohana to Hanahanapuni (CP1 and CP2)	0.1316	Reconfiguration	2020
403	Kilohana to Hanahanapuni (CP1 and CP2)	0.1316	Static wire removal	2020
404	Kilohana to Hanahanapuni (CP1 and CP2)	0.2498	Diverter installation (Reflective)	2021
404	Kilohana to Hanahanapuni (CP1 and CP2)	0.2498	Reconfiguration	2020
404	Kilohana to Hanahanapuni (CP1 and CP2)	0.2498	Static wire removal	2020
405	Kilohana to Hanahanapuni (CP1 and CP2)	0.1358	Diverter installation (Reflective)	2021
405	Kilohana to Hanahanapuni (CP1 and CP2)	0.1358	Reconfiguration	2020
405	Kilohana to Hanahanapuni (CP1 and CP2)	0.1358	Static wire removal	2020
406	Kilohana to Hanahanapuni (CP1 and CP2)	0.1803	Diverter installation (Reflective)	2021
406	Kilohana to Hanahanapuni (CP1 and CP2)	0.1803	Reconfiguration	2020
406	Kilohana to Hanahanapuni (CP1 and CP2)	0.1803	Static wire removal	2020
407	Kilohana to Hanahanapuni (CP1 and CP2)	0.1440	Diverter installation (Reflective)	2021
407	Kilohana to Hanahanapuni (CP1 and CP2)	0.1440	Reconfiguration	2020
407	Kilohana to Hanahanapuni (CP1 and CP2)	0.1440	Static wire removal	2020
408	Kilohana to Hanahanapuni (CP1 and CP2)	0.1251	Diverter installation (Reflective)	2021
408	Kilohana to Hanahanapuni (CP1 and CP2)	0.1251	Reconfiguration	2020

408	Kilohana to Hanahanapuni (CP1 and CP2)	0.1251	Static wire removal	2020
409	Kilohana to Hanahanapuni (CP1 and CP2)	0.0943	Diverter installation (Reflective)	2021
409	Kilohana to Hanahanapuni (CP1 and CP2)	0.0943	Reconfiguration	2020
409	Kilohana to Hanahanapuni (CP1 and CP2)	0.0943	Static wire removal	2020
410	Kilohana to Hanahanapuni (CP1 and CP2)	0.1997	Diverter installation (Reflective)	2021
410	Kilohana to Hanahanapuni (CP1 and CP2)	0.1997	Reconfiguration	2020
410	Kilohana to Hanahanapuni (CP1 and CP2)	0.1997	Static wire removal	2020
411	Kilohana to Hanahanapuni (CP1 and CP2)	0.1941	Diverter installation (Reflective)	2021
411	Kilohana to Hanahanapuni (CP1 and CP2)	0.1941	Reconfiguration	2020
411	Kilohana to Hanahanapuni (CP1 and CP2)	0.1941	Static wire removal	2020
412	Kilohana to Hanahanapuni (CP1 and CP2)	0.1766	Diverter installation (Reflective)	2021
412	Kilohana to Hanahanapuni (CP1 and CP2)	0.1766	Reconfiguration	2020
412	Kilohana to Hanahanapuni (CP1 and CP2)	0.1766	Static wire removal	2020
413	Kilohana to Hanahanapuni (CP1 and CP2)	0.2763	Diverter installation (Reflective)	2021
413	Kilohana to Hanahanapuni (CP1 and CP2)	0.2763	Reconfiguration	2020
413	Kilohana to Hanahanapuni (CP1 and CP2)	0.2763	Static wire removal	2020
414	Kilohana to Hanahanapuni (CP1 and CP2)	0.1573	Diverter installation (Reflective)	2021
414	Kilohana to Hanahanapuni (CP1 and CP2)	0.1573	Reconfiguration	2020
414	Kilohana to Hanahanapuni (CP1 and CP2)	0.1573	Static wire removal	2020
415	Kilohana to Hanahanapuni (CP1 and CP2)	0.1627	Diverter installation (Reflective)	2021
415	Kilohana to Hanahanapuni (CP1 and CP2)	0.1627	Reconfiguration	2020
415	Kilohana to Hanahanapuni (CP1 and CP2)	0.1627	Static wire removal	2020
416	Kilohana to Hanahanapuni (CP1 and CP2)	0.1751	Diverter installation (Reflective)	2021
416	Kilohana to Hanahanapuni (CP1 and CP2)	0.1751	Reconfiguration	2020
416	Kilohana to Hanahanapuni (CP1 and CP2)	0.1751	Static wire removal	2020
417	Kilohana to Hanahanapuni (CP1 and CP2)	0.1372	Diverter installation (Reflective)	2021
417	Kilohana to Hanahanapuni (CP1 and CP2)	0.1372	Reconfiguration	2020
417	Kilohana to Hanahanapuni (CP1 and CP2)	0.1372	Static wire removal	2020
418	Hanahanapuni towards PLT	0.3180	Diverter installation (LED)	2021
419	Hanahanapuni towards PLT	0.4932	Diverter installation (LED)	2021
420	PLT entrance Wailua	0.1481	Diverter installation (LED)	2022
421	PLT entrance Wailua	0.2231	Diverter installation (LED)	2022
422	PLT entrance Wailua	0.2233	Diverter installation (LED)	2022
423	PLT entrance Wailua	0.3024	Diverter installation (LED)	2022
424	Powerline Trail S2	0.3072	Diverter installation (LED)	2022

425	Powerline Trail S2	0.3509	Diverter installation (LED)	2022
426	Powerline Trail S2	0.5663	Diverter installation (LED)	2022
427	Powerline Trail S2	0.2916	Diverter installation (LED)	2022
428	Powerline Trail S2	0.2752	Diverter installation (LED)	2022
429	Powerline Trail S2	0.2018	Diverter installation (LED)	2022
430	Powerline Trail S2	0.1391	Diverter installation (LED)	2021
431	Powerline Trail S2	0.0939	Diverter installation (LED)	2021
432	Powerline Trail S2	0.1595	Diverter installation (LED)	2022
433	Powerline Trail S2	0.1666	Diverter installation (LED)	2022
434	Powerline Trail N1	0.2799	Diverter installation (LED)	2022
435	Powerline Trail N1	0.1477	Diverter installation (LED)	2022
436	Powerline Trail N1	0.3084	Diverter installation (LED)	2022
437	Powerline Trail N1	0.1244	Diverter installation (LED)	2022
438	Powerline Trail N1	0.2152	Diverter installation (LED)	2021
439	Powerline Trail N1	0.1341	Diverter installation (LED)	2021
440	Powerline Trail N1	0.1106	Diverter installation (LED)	2022
441	Powerline Trail N1	0.2110	Diverter installation (LED)	2022
442	Powerline Trail N1	0.2128	Diverter installation (LED)	2021
443	Powerline Trail N1	0.1448	Diverter installation (LED)	2021
444	Powerline Trail N1	0.1405	Diverter installation (LED)	2022
445	Powerline Trail N1	0.1717	Diverter installation (LED)	2022
446	Powerline Trail N1	0.1995	Diverter installation (LED)	2021
447	Powerline Trail N1	0.1454	Diverter installation (LED)	2021
448	Powerline Trail N1	0.1167	Diverter installation (LED)	2022
449	Powerline Trail N1	0.1213	Diverter installation (LED)	2022
450	Powerline Trail N1	0.1961	Diverter installation (LED)	2021
451	Powerline Trail N1	0.2230	Diverter installation (LED)	2021
452	Powerline Trail N1	0.1729	Diverter installation (LED)	2022
453	Powerline Trail N1	0.1309	Diverter installation (LED)	2022
454	Powerline Trail N1	0.2701	Diverter installation (LED)	2022
455	Powerline Trail unminimized	0.1656	Diverter installation (LED)	2022
456	Powerline Trail unminimized	0.1799	Diverter installation (LED)	2022
457	Powerline Trail unminimized	0.1864	Diverter installation (LED)	2022
458	Powerline Trail unminimized	0.2883	Diverter installation (LED)	2022
459	Powerline Trail unminimized	0.2129	Diverter installation (LED)	2022

460	Powerline Trail unminimized	0.1549	Diverter installation (LED)	2022
461	Powerline Trail unminimized	0.1769	Diverter installation (LED)	2022
462	PLT to Hanalei Tap double circuit Transmission	0.3974	Diverter installation (LED)	2022
463	PLT to Hanalei Tap double circuit Transmission	0.2953	Diverter installation (LED)	2022
464	PLT to Hanalei Tap double circuit Transmission	0.3573	Diverter installation (Reflective)	2022
466	PLT to Hanalei Tap double circuit Transmission	0.3200	Diverter installation (Reflective)	2022
467	PLT to Hanalei Tap double circuit Transmission	0.5252	Diverter installation (Reflective)	2022
468	Hanalei Tap to Hanalei Taro Fields	0.1790	Diverter installation (Reflective)	2022
469	Hanalei Tap to Hanalei Taro Fields	0.1778	Diverter installation (Reflective)	2022
470	Hanalei Tap to Hanalei Taro Fields	0.1133	Diverter installation (Reflective)	2022
471	Hanalei Tap to Hanalei Taro Fields	0.0689	Diverter installation (Reflective)	2022
472	Hanalei Tap to Hanalei Taro Fields	0.0887	Diverter installation (Reflective)	2022
473	Hanalei Tap to Hanalei Taro Fields	0.0431	Diverter installation (Reflective)	2022
474	Hanalei Tap to Hanalei Taro Fields	0.0396	Diverter installation (Reflective)	2022
475	Hanalei Tap to Hanalei Taro Fields	0.0920	Diverter installation (Reflective)	2022
476	Hanalei Tap to Hanalei Taro Fields	0.1718	Diverter installation (Reflective)	2022
477	Hanalei Tap to Hanalei Taro Fields	0.0981	Diverter installation (Reflective)	2022
478	Hanalei Taro Fields to Wainiha Substation	0.5152	Diverter installation (Reflective)	2022
479	Hanalei Taro Fields to Wainiha Substation	0.4034	Diverter installation (Reflective)	2022
480	Hanalei Taro Fields to Wainiha Substation	0.4278	Diverter installation (Reflective)	2022
481	Hanalei Taro Fields to Wainiha Substation	0.4559	Diverter installation (Reflective)	2022
482	Hanalei Taro Fields to Wainiha Substation	0.7410	Diverter installation (Reflective)	2022
483	Hanalei Taro Fields to Wainiha Substation	0.4473	Diverter installation (Reflective)	2022
485	Hanalei Taro Fields to Wainiha Substation	0.2582	Diverter installation (Reflective)	2022
486	Port Allen to Halewili Positron	0.0780	Diverter installation (Reflective)	2022
486	Port Allen to Halewili Positron	0.0780	Static wire removal	2021
487	Port Allen to Halewili Positron	0.0810	Diverter installation (Reflective)	2021
487	Port Allen to Halewili Positron	0.0810	Static wire removal	2021
487	Port Allen to Halewili Positron	0.0810	Static wire removal	2021
488	Port Allen to Halewili Positron	0.0684	Diverter installation (Reflective)	2021
488	Port Allen to Halewili Positron	0.0684	Static wire removal	2021
488	Port Allen to Halewili Positron	0.0684	Static wire removal	2021
489	Port Allen to Halewili Positron	0.0663	Diverter installation (Reflective)	2021
489	Port Allen to Halewili Positron	0.0663	Static wire removal	2021
489	Port Allen to Halewili Positron	0.0663	Static wire removal	2021

490	Port Allen to Halewili Positron	0.0715	Diverter installation (Reflective)	2021
490	Port Allen to Halewili Positron	0.0715	Static wire removal	2021
490	Port Allen to Halewili Positron	0.0715	Static wire removal	2021
491	Port Allen to Halewili Positron	0.0687	Diverter installation (Reflective)	2021
491	Port Allen to Halewili Positron	0.0687	Static wire removal	2021
491	Port Allen to Halewili Positron	0.0687	Static wire removal	2021
492	Port Allen to Halewili Positron	0.0688	Diverter installation (Reflective)	2021
492	Port Allen to Halewili Positron	0.0688	Static wire removal	2021
492	Port Allen to Halewili Positron	0.0688	Static wire removal	2021
493	Port Allen to Halewili Positron	0.0697	Diverter installation (Reflective)	2021
493	Port Allen to Halewili Positron	0.0697	Static wire removal	2021
493	Port Allen to Halewili Positron	0.0697	Static wire removal	2021
494	Port Allen to Halewili Positron	0.0687	Diverter installation (Reflective)	2021
494	Port Allen to Halewili Positron	0.0687	Static wire removal	2021
494	Port Allen to Halewili Positron	0.0687	Static wire removal	2021
495	Port Allen to Halewili Positron	0.0755	Diverter installation (Reflective)	2021
495	Port Allen to Halewili Positron	0.0755	Static wire removal	2021
495	Port Allen to Halewili Positron	0.0755	Static wire removal	2021
496	Port Allen to Halewili Positron	0.0312	Diverter installation (Reflective)	2021
496	Port Allen to Halewili Positron	0.0312	Static wire removal	2021
496	Port Allen to Halewili Positron	0.0312	Static wire removal	2021
497	Port Allen to Halewili Positron	0.0574	Diverter installation (Reflective)	2021
497	Port Allen to Halewili Positron	0.0574	Static wire removal	2021
497	Port Allen to Halewili Positron	0.0574	Static wire removal	2021
498	Port Allen to Halewili Positron	0.0642	Diverter installation (Reflective)	2021
498	Port Allen to Halewili Positron	0.0642	Static wire removal	2021
498	Port Allen to Halewili Positron	0.0642	Static wire removal	2021
499	Port Allen to Halewili Positron	0.0607	Diverter installation (Reflective)	2021
499	Port Allen to Halewili Positron	0.0607	Static wire removal	2021
499	Port Allen to Halewili Positron	0.0607	Static wire removal	2021
500	Halewili Positron to Aepo Substation	0.0658	Diverter installation (Reflective)	2021
500	Halewili Positron to Aepo Substation	0.0658	Static wire removal	2022
501	Halewili Positron to Aepo Substation	0.0644	Diverter installation (Reflective)	2021
501	Halewili Positron to Aepo Substation	0.0644	Static wire removal	2022
502	Halewili Positron to Aepo Substation	0.0654	Diverter installation (Reflective)	2021

502	Halewili Positron to Aepo Substation	0.0654	Static wire removal	2022
503	Halewili Positron to Aepo Substation	0.0647	Diverter installation (Reflective)	2021
503	Halewili Positron to Aepo Substation	0.0647	Static wire removal	2022
504	Halewili Positron to Aepo Substation	0.0646	Diverter installation (Reflective)	2021
504	Halewili Positron to Aepo Substation	0.0646	Static wire removal	2022
505	Halewili Positron to Aepo Substation	0.0847	Diverter installation (Reflective)	2021
505	Halewili Positron to Aepo Substation	0.0847	Static wire removal	2022
506	Halewili Positron to Aepo Substation	0.0612	Diverter installation (Reflective)	2021
506	Halewili Positron to Aepo Substation	0.0612	Static wire removal	2022
507	Halewili Positron to Aepo Substation	0.0337	Diverter installation (Reflective)	2021
507	Halewili Positron to Aepo Substation	0.0337	Static wire removal	2022
508	Halewili Positron to Aepo Substation	0.0645	Diverter installation (Reflective)	2021
508	Halewili Positron to Aepo Substation	0.0645	Static wire removal	2022
509	Halewili Positron to Aepo Substation	0.0680	Diverter installation (Reflective)	2021
509	Halewili Positron to Aepo Substation	0.0680	Static wire removal	2022
510	Halewili Positron to Aepo Substation	0.0646	Diverter installation (Reflective)	2021
510	Halewili Positron to Aepo Substation	0.0646	Static wire removal	2022
511	Halewili Positron to Aepo Substation	0.0689	Diverter installation (Reflective)	2021
511	Halewili Positron to Aepo Substation	0.0689	Static wire removal	2022
512	Halewili Positron to Aepo Substation	0.0623	Diverter installation (Reflective)	2021
512	Halewili Positron to Aepo Substation	0.0623	Static wire removal	2022
513	Halewili Positron to Aepo Substation	0.0681	Diverter installation (Reflective)	2021
513	Halewili Positron to Aepo Substation	0.0681	Static wire removal	2022
514	Halewili Positron to Aepo Substation	0.0658	Diverter installation (Reflective)	2021
514	Halewili Positron to Aepo Substation	0.0658	Static wire removal	2022
515	Halewili Positron to Aepo Substation	0.0335	Diverter installation (Reflective)	2021
515	Halewili Positron to Aepo Substation	0.0335	Static wire removal	2022
516	Halewili Positron to Aepo Substation	0.0250	Diverter installation (Reflective)	2021
516	Halewili Positron to Aepo Substation	0.0250	Static wire removal	2022
517	Halewili Positron to Aepo Substation	0.0618	Diverter installation (Reflective)	2021
517	Halewili Positron to Aepo Substation	0.0618	Static wire removal	2022
518	Halewili Positron to Aepo Substation	0.0649	Diverter installation (Reflective)	2021
518	Halewili Positron to Aepo Substation	0.0649	Static wire removal	2022
519	Halewili Positron to Aepo Substation	0.0565	Diverter installation (Reflective)	2021
519	Halewili Positron to Aepo Substation	0.0565	Static wire removal	2022

520	Halewili Positron to Aepo Substation	0.0585	Diverter installation (Reflective)	2021
520	Halewili Positron to Aepo Substation	0.0585	Static wire removal	2022
521	Halewili Positron to Aepo Substation	0.0697	Diverter installation (Reflective)	2021
521	Halewili Positron to Aepo Substation	0.0697	Static wire removal	2022
522	Halewili Positron to Aepo Substation	0.0408	Diverter installation (Reflective)	2021
522	Halewili Positron to Aepo Substation	0.0408	Static wire removal	2022
523	Halewili Positron to Aepo Substation	0.0760	Diverter installation (Reflective)	2021
523	Halewili Positron to Aepo Substation	0.0760	Static wire removal	2022
524	Halewili Positron to Aepo Substation	0.0607	Diverter installation (Reflective)	2021
524	Halewili Positron to Aepo Substation	0.0607	Static wire removal	2022
525	Halewili Positron to Aepo Substation	0.0653	Diverter installation (Reflective)	2021
525	Halewili Positron to Aepo Substation	0.0653	Static wire removal	2022
526	Halewili Positron to Aepo Substation	0.0599	Diverter installation (Reflective)	2021
526	Halewili Positron to Aepo Substation	0.0599	Static wire removal	2022
527	Halewili Positron to Aepo Substation	0.0627	Diverter installation (Reflective)	2021
527	Halewili Positron to Aepo Substation	0.0627	Static wire removal	2022
528	Halewili Positron to Aepo Substation	0.0616	Diverter installation (Reflective)	2021
528	Halewili Positron to Aepo Substation	0.0616	Static wire removal	2022
529	Halewili Positron to Aepo Substation	0.0686	Diverter installation (Reflective)	2021
529	Halewili Positron to Aepo Substation	0.0686	Static wire removal	2022
530	Halewili Positron to Aepo Substation	0.0567	Diverter installation (Reflective)	2021
530	Halewili Positron to Aepo Substation	0.0567	Static wire removal	2022
531	Halewili Positron to Aepo Substation	0.0567	Diverter installation (Reflective)	2021
531	Halewili Positron to Aepo Substation	0.0567	Static wire removal	2022
532	Halewili Positron to Aepo Substation	0.0731	Diverter installation (Reflective)	2021
532	Halewili Positron to Aepo Substation	0.0731	Static wire removal	2022
533	Halewili Positron to Aepo Substation	0.0737	Diverter installation (Reflective)	2021
533	Halewili Positron to Aepo Substation	0.0737	Static wire removal	2022
534	Halewili Positron to Aepo Substation	0.0726	Diverter installation (Reflective)	2021
534	Halewili Positron to Aepo Substation	0.0726	Static wire removal	2022
535	Halewili Positron to Aepo Substation	0.0779	Diverter installation (Reflective)	2021
535	Halewili Positron to Aepo Substation	0.0779	Static wire removal	2022
536	Halewili Positron to Aepo Substation	0.0635	Diverter installation (Reflective)	2021
536	Halewili Positron to Aepo Substation	0.0635	Static wire removal	2022
537	Halewili Positron to Aepo Substation	0.0615	Diverter installation (Reflective)	2021

537	Halewili Positron to Aepo Substation	0.0615	Static wire removal	2022
538	Halewili Positron to Aepo Substation	0.0642	Diverter installation (Reflective)	2021
538	Halewili Positron to Aepo Substation	0.0642	Static wire removal	2022
539	Halewili Positron to Aepo Substation	0.0675	Diverter installation (Reflective)	2021
539	Halewili Positron to Aepo Substation	0.0675	Static wire removal	2022
540	Halewili Positron to Aepo Substation	0.0705	Diverter installation (Reflective)	2021
540	Halewili Positron to Aepo Substation	0.0705	Static wire removal	2022
541	Halewili Positron to Aepo Substation	0.0659	Diverter installation (Reflective)	2021
541	Halewili Positron to Aepo Substation	0.0659	Static wire removal	2022
542	Halewili Positron to Aepo Substation	0.0714	Diverter installation (Reflective)	2021
542	Halewili Positron to Aepo Substation	0.0714	Static wire removal	2022
543	Halewili Positron to Aepo Substation	0.0641	Diverter installation (Reflective)	2021
543	Halewili Positron to Aepo Substation	0.0641	Static wire removal	2022
544	Halewili Positron to Aepo Substation	0.0694	Diverter installation (Reflective)	2021
544	Halewili Positron to Aepo Substation	0.0694	Static wire removal	2022
545	Halewili Positron to Aepo Substation	0.0644	Diverter installation (Reflective)	2021
545	Halewili Positron to Aepo Substation	0.0644	Static wire removal	2022
546	Halewili Positron to Aepo Substation	0.0633	Diverter installation (Reflective)	2021
546	Halewili Positron to Aepo Substation	0.0633	Static wire removal	2022
547	Halewili Positron to Aepo Substation	0.0712	Diverter installation (Reflective)	2021
547	Halewili Positron to Aepo Substation	0.0712	Static wire removal	2022
548	Halewili Positron to Aepo Substation	0.0703	Diverter installation (Reflective)	2021
548	Halewili Positron to Aepo Substation	0.0703	Static wire removal	2022
549	Halewili Positron to Aepo Substation	0.0712	Diverter installation (Reflective)	2021
549	Halewili Positron to Aepo Substation	0.0712	Static wire removal	2022
550	Halewili Positron to Aepo Substation	0.0711	Diverter installation (Reflective)	2021
550	Halewili Positron to Aepo Substation	0.0711	Static wire removal	2022
551	Halewili Positron to Aepo Substation	0.0672	Diverter installation (Reflective)	2021
551	Halewili Positron to Aepo Substation	0.0672	Static wire removal	2022
552	Halewili Positron to Aepo Substation	0.0673	Diverter installation (Reflective)	2021
552	Halewili Positron to Aepo Substation	0.0673	Static wire removal	2022
553	Halewili Positron to Aepo Substation	0.0675	Diverter installation (Reflective)	2021
553	Halewili Positron to Aepo Substation	0.0675	Static wire removal	2022
554	Halewili Positron to Aepo Substation	0.0706	Diverter installation (Reflective)	2021
554	Halewili Positron to Aepo Substation	0.0706	Static wire removal	2022

555	Halewili Positron to Aepo Substation	0.0640	Diverter installation (Reflective)	2021
555	Halewili Positron to Aepo Substation	0.0640	Static wire removal	2022
556	Halewili Positron to Aepo Substation	0.0671	Diverter installation (Reflective)	2021
556	Halewili Positron to Aepo Substation	0.0671	Static wire removal	2022
557	Halewili Positron to Aepo Substation	0.0669	Diverter installation (Reflective)	2021
557	Halewili Positron to Aepo Substation	0.0669	Static wire removal	2022
558	Halewili Positron to Aepo Substation	0.0633	Diverter installation (Reflective)	2021
558	Halewili Positron to Aepo Substation	0.0633	Static wire removal	2022
559	Halewili Positron to Aepo Substation	0.0635	Diverter installation (Reflective)	2021
559	Halewili Positron to Aepo Substation	0.0635	Static wire removal	2022
560	Halewili Positron to Aepo Substation	0.0708	Diverter installation (Reflective)	2021
560	Halewili Positron to Aepo Substation	0.0708	Static wire removal	2022
561	Halewili Positron to Aepo Substation	0.0686	Diverter installation (Reflective)	2021
561	Halewili Positron to Aepo Substation	0.0686	Static wire removal	2022
562	Halewili Positron to Aepo Substation	0.0698	Diverter installation (Reflective)	2021
562	Halewili Positron to Aepo Substation	0.0698	Static wire removal	2022
563	Halewili Positron to Aepo Substation	0.0678	Diverter installation (Reflective)	2021
563	Halewili Positron to Aepo Substation	0.0678	Static wire removal	2022
564	Halewili Positron to Aepo Substation	0.0695	Diverter installation (Reflective)	2021
564	Halewili Positron to Aepo Substation	0.0695	Static wire removal	2022
565	Halewili Positron to Aepo Substation	0.0710	Diverter installation (Reflective)	2021
565	Halewili Positron to Aepo Substation	0.0710	Static wire removal	2022
566	Halewili Positron to Aepo Substation	0.0665	Diverter installation (Reflective)	2021
566	Halewili Positron to Aepo Substation	0.0665	Static wire removal	2022
567	Halewili Positron to Aepo Substation	0.0705	Diverter installation (Reflective)	2021
567	Halewili Positron to Aepo Substation	0.0705	Static wire removal	2022
568	Halewili Positron to Aepo Substation	0.0690	Diverter installation (Reflective)	2021
568	Halewili Positron to Aepo Substation	0.0690	Static wire removal	2022
569	Halewili Positron to Aepo Substation	0.0691	Diverter installation (Reflective)	2021
569	Halewili Positron to Aepo Substation	0.0691	Static wire removal	2022
570	Halewili Positron to Aepo Substation	0.0681	Diverter installation (Reflective)	2021
570	Halewili Positron to Aepo Substation	0.0681	Static wire removal	2022
571	Halewili Positron to Aepo Substation	0.0689	Diverter installation (Reflective)	2021
571	Halewili Positron to Aepo Substation	0.0689	Static wire removal	2022
572	Halewili Positron to Aepo Substation	0.0709	Diverter installation (Reflective)	2021

572	Halewili Positron to Aepo Substation	0.0709	Static wire removal	2022
573	Halewili Positron to Aepo Substation	0.0681	Diverter installation (Reflective)	2021
573	Halewili Positron to Aepo Substation	0.0681	Static wire removal	2022
574	Halewili Positron to Aepo Substation	0.0178	Diverter installation (Reflective)	2021
574	Halewili Positron to Aepo Substation	0.0178	Static wire removal	2022
575	Halewili Positron to Aepo Substation	0.0185	Diverter installation (Reflective)	2021
575	Halewili Positron to Aepo Substation	0.0185	Static wire removal	2022
576	Halewili Positron to Aepo Substation	0.0328	Diverter installation (Reflective)	2021
576	Halewili Positron to Aepo Substation	0.0328	Static wire removal	2022
577	Halewili Positron to Aepo Substation	0.0497	Diverter installation (Reflective)	2021
577	Halewili Positron to Aepo Substation	0.0497	Static wire removal	2022
578	Halewili Positron to Aepo Substation	0.0424	Diverter installation (Reflective)	2021
578	Halewili Positron to Aepo Substation	0.0424	Static wire removal	2022
579	Halewili Positron to Aepo Substation	0.0604	Diverter installation (Reflective)	2021
579	Halewili Positron to Aepo Substation	0.0604	Static wire removal	2022
580	Halewili Positron to Aepo Substation	0.0773	Diverter installation (Reflective)	2021
580	Halewili Positron to Aepo Substation	0.0773	Static wire removal	2022
581	Halewili Positron to Aepo Substation	0.2436	Static wire removal	2016
582	Halewili Positron to Aepo Substation	0.0785	Diverter installation (Reflective)	2022
582	Halewili Positron to Aepo Substation	0.0785	Static wire removal	2022
583	Halewili Positron to Aepo Substation	0.0789	Diverter installation (Reflective)	2021
583	Halewili Positron to Aepo Substation	0.0789	Static wire removal	2022
584	Halewili Positron to Aepo Substation	0.0679	Diverter installation (LED)	2021
584	Halewili Positron to Aepo Substation	0.0679	Static wire removal	2022
585	Halewili Positron to Aepo Substation	0.0579	Diverter installation (LED)	2021
585	Halewili Positron to Aepo Substation	0.0579	Static wire removal	2022
586	Halewili Positron to Aepo Substation	0.0744	Diverter installation (LED)	2021
586	Halewili Positron to Aepo Substation	0.0744	Static wire removal	2022
587	Halewili Positron to Aepo Substation	0.0626	Diverter installation (LED)	2021
587	Halewili Positron to Aepo Substation	0.0626	Static wire removal	2022
588	Halewili Positron to Aepo Substation	0.0430	Diverter installation (LED)	2021
588	Halewili Positron to Aepo Substation	0.0430	Static wire removal	2022
589	Halewili Positron to Aepo Substation	0.0527	Diverter installation (LED)	2021
589	Halewili Positron to Aepo Substation	0.0527	Static wire removal	2022
590	Halewili Positron to Aepo Substation	0.0791	Diverter installation (LED)	2021

590	Halewili Positron to Aepo Substation	0.0791	Static wire removal	2022
591	Halewili Positron to Aepo Substation	0.0523	Diverter installation (LED)	2021
591	Halewili Positron to Aepo Substation	0.0523	Static wire removal	2022
592	Halewili Positron to Aepo Substation	0.0572	Diverter installation (LED)	2021
592	Halewili Positron to Aepo Substation	0.0572	Static wire removal	2022
593	Halewili Positron to Aepo Substation	0.0668	Diverter installation (LED)	2021
593	Halewili Positron to Aepo Substation	0.0668	Static wire removal	2022
594	Halewili Positron to Aepo Substation	0.0550	Diverter installation (LED)	2021
594	Halewili Positron to Aepo Substation	0.0550	Static wire removal	2022
595	Halewili Positron to Aepo Substation	0.0804	Diverter installation (Reflective)	2021
595	Halewili Positron to Aepo Substation	0.0804	Static wire removal	2022
597	Aepo Substation to Kukuiula Riser	0.0686	Diverter installation (Reflective)	2021
597	Aepo Substation to Kukuiula Riser	0.0686	Static wire removal	2022
598	Aepo Substation to Kukuiula Riser	0.0979	Diverter installation (Reflective)	2021
598	Aepo Substation to Kukuiula Riser	0.0979	Static wire removal	2022
599	Aepo Substation to Kukuiula Riser	0.0643	Static wire removal	2022
600	Aepo Substation to Kukuiula Riser	0.0774	Static wire removal	2022
601	Aepo Substation to Kukuiula Riser	0.1030	Diverter installation (Reflective)	2022
601	Aepo Substation to Kukuiula Riser	0.1030	Static wire removal	2022
602.1	Aepo Substation to Kukuiula Riser	0.1324	Diverter installation (Reflective)	2021
602.1	Aepo Substation to Kukuiula Riser	0.1324	Static wire removal	2022
602.2	Aepo Substation to Kukuiula Riser	0.1324	Diverter installation (Reflective)	2021
602.2	Aepo Substation to Kukuiula Riser	0.1324	Static wire removal	2022
603	Aepo Substation to Kukuiula Riser	0.0885	Diverter installation (Reflective)	2021
603	Aepo Substation to Kukuiula Riser	0.0885	Static wire removal	2022
604	Aepo Substation to Kukuiula Riser	0.0468	Diverter installation (Reflective)	2021
604	Aepo Substation to Kukuiula Riser	0.0468	Static wire removal	2022
605	Aepo Substation to Kukuiula Riser	0.0502	Diverter installation (Reflective)	2021
605	Aepo Substation to Kukuiula Riser	0.0502	Static wire removal	2022
606	Aepo Substation to Kukuiula Riser	0.0792	Diverter installation (Reflective)	2021
606	Aepo Substation to Kukuiula Riser	0.0792	Static wire removal	2022
607	Aepo Substation to Kukuiula Riser	0.0678	Static wire removal	2022
608	Aepo Substation to Kukuiula Riser	0.0612	Static wire removal	2022
609	Aepo Substation to Kukuiula Riser	0.0691	Static wire removal	2022
610	Aepo Substation to Kukuiula Riser	0.0773	Static wire removal	2022

611	Aepo Substation to Kukuiula Riser	0.0712	Static wire removal	2022
612	Aepo Substation to Kukuiula Riser	0.0615	Diverter installation (Reflective)	2021
612	Aepo Substation to Kukuiula Riser	0.0615	Static wire removal	2022
613	Aepo Substation to Kukuiula Riser	0.0713	Diverter installation (Reflective)	2021
613	Aepo Substation to Kukuiula Riser	0.0713	Static wire removal	2022
614	Aepo Substation to Kukuiula Riser	0.0987	Diverter installation (Reflective)	2021
614	Aepo Substation to Kukuiula Riser	0.0987	Static wire removal	2022
615	Aepo Substation to Kukuiula Riser	0.0856	Static wire removal	2022
616	Aepo Substation to Kukuiula Riser	0.0637	Static wire removal	2022
617	Ko'ae Housing Project	0.0595	Underground	2022
618	Ko'ae Housing Project	0.0612	Underground	2022
619	Kiahuna Golf to Koloa Substation	0.0646	Static wire removal	2022
620	Kiahuna Golf to Koloa Substation	0.0693	Static wire removal	2022
621	Kiahuna Golf to Koloa Substation	0.0654	Static wire removal	2022
622	Kiahuna Golf to Koloa Substation	0.0745	Static wire removal	2022
623	Kiahuna Golf to Koloa Substation	0.0708	Static wire removal	2022
624	Kiahuna Golf to Koloa Substation	0.0713	Diverter installation (Reflective)	2021
624	Kiahuna Golf to Koloa Substation	0.0713	Static wire removal	2022
625	Kiahuna Golf to Koloa Substation	0.0706	Static wire removal	2022
626	Kiahuna Golf to Koloa Substation	0.0622	Static wire removal	2022
627	Kiahuna Golf to Koloa Substation	0.0710	Diverter installation (Reflective)	2021
627	Kiahuna Golf to Koloa Substation	0.0710	Static wire removal	2022
628	Kiahuna Golf to Koloa Substation	0.0638	Static wire removal	2022
629	Kiahuna Golf to Koloa Substation	0.0696	Diverter installation (Reflective)	2021
629	Kiahuna Golf to Koloa Substation	0.0696	Static wire removal	2022
630	Kiahuna Golf to Koloa Substation	0.0697	Diverter installation (Reflective)	2021
630	Kiahuna Golf to Koloa Substation	0.0697	Static wire removal	2022
631	Kiahuna Golf to Koloa Substation	0.0651	Diverter installation (Reflective)	2021
631	Kiahuna Golf to Koloa Substation	0.0651	Static wire removal	2022
632	Kiahuna Golf to Koloa Substation	0.0647	Diverter installation (Reflective)	2021
632	Kiahuna Golf to Koloa Substation	0.0647	Static wire removal	2022
633	Kiahuna Golf to Koloa Substation	0.0577	Diverter installation (Reflective)	2021
633	Kiahuna Golf to Koloa Substation	0.0577	Static wire removal	2022
634	Kiahuna Golf to Koloa Substation	0.0571	Diverter installation (Reflective)	2021
634	Kiahuna Golf to Koloa Substation	0.0571	Static wire removal	2022

635	Kiahuna Golf to Koloa Substation	0.0561	Diverter installation (Reflective)	2021
635	Kiahuna Golf to Koloa Substation	0.0561	Static wire removal	2022
636	Kiahuna Golf to Koloa Substation	0.0573	Diverter installation (Reflective)	2021
636	Kiahuna Golf to Koloa Substation	0.0573	Static wire removal	2022
637	Kiahuna Golf to Koloa Substation	0.0564	Diverter installation (Reflective)	2021
637	Kiahuna Golf to Koloa Substation	0.0564	Static wire removal	2022
638	Kiahuna Golf to Koloa Substation	0.0562	Diverter installation (Reflective)	2021
638	Kiahuna Golf to Koloa Substation	0.0562	Static wire removal	2022
639	Kiahuna Golf to Koloa Substation	0.0565	Diverter installation (Reflective)	2021
639	Kiahuna Golf to Koloa Substation	0.0565	Static wire removal	2022
640	Kiahuna Golf to Koloa Substation	0.0579	Diverter installation (Reflective)	2021
640	Kiahuna Golf to Koloa Substation	0.0579	Static wire removal	2022
641	Kiahuna Golf to Koloa Substation	0.0600	Diverter installation (Reflective)	2021
641	Kiahuna Golf to Koloa Substation	0.0600	Static wire removal	2022
642	Kiahuna Golf to Koloa Substation	0.0304	Diverter installation (Reflective)	2022
642	Kiahuna Golf to Koloa Substation	0.0304	Static wire removal	2022
643	Kiahuna Golf to Koloa Substation	0.0368	Diverter installation (Reflective)	2022
643	Kiahuna Golf to Koloa Substation	0.0368	Static wire removal	2022
644	Kiahuna Golf to Koloa Substation		Diverter installation (Reflective)	2021
645	Koloa Sub to Waita Reservoir	0.0558	Diverter installation (Reflective)	2021
645	Koloa Sub to Waita Reservoir	0.0558	Static wire removal	2021
646	Koloa Sub to Waita Reservoir	0.0649	Diverter installation (Reflective)	2021
646	Koloa Sub to Waita Reservoir	0.0649	Static wire removal	2021
647	Koloa Sub to Waita Reservoir	0.0724	Diverter installation (Reflective)	2021
647	Koloa Sub to Waita Reservoir	0.0724	Static wire removal	2021
648	Koloa Sub to Waita Reservoir	0.0708	Diverter installation (Reflective)	2021
648	Koloa Sub to Waita Reservoir	0.0708	Static wire removal	2021
649	Koloa Sub to Waita Reservoir	0.0713	Diverter installation (Reflective)	2021
649	Koloa Sub to Waita Reservoir	0.0713	Static wire removal	2021
650	Koloa Sub to Waita Reservoir	0.0700	Diverter installation (Reflective)	2021
650	Koloa Sub to Waita Reservoir	0.0700	Static wire removal	2021
651	Koloa Sub to Waita Reservoir	0.0928	Diverter installation (Reflective)	2021
651	Koloa Sub to Waita Reservoir	0.0928	Static wire removal	2021
652	Koloa Sub to Waita Reservoir	0.0980	Diverter installation (Reflective)	2021
652	Koloa Sub to Waita Reservoir	0.0980	Static wire removal	2021

653	Koloa Sub to Waita Reservoir	0.1253	Diverter installation (Reflective)	2021
653	Koloa Sub to Waita Reservoir	0.1253	Static wire removal	2021
654	Koloa Sub to Waita Reservoir	0.1114	Diverter installation (Reflective)	2021
654	Koloa Sub to Waita Reservoir	0.1114	Static wire removal	2021
655	Koloa Sub to Waita Reservoir	0.0938	Diverter installation (Reflective)	2021
655	Koloa Sub to Waita Reservoir	0.0938	Static wire removal	2021
656	Koloa Sub to Waita Reservoir	0.1049	Diverter installation (Reflective)	2021
656	Koloa Sub to Waita Reservoir	0.1049	Static wire removal	2021
657	Koloa Sub to Waita Reservoir	0.0916	Diverter installation (Reflective)	2021
657	Koloa Sub to Waita Reservoir	0.0916	Static wire removal	2021
658	Koloa Sub to Waita Reservoir	0.1013	Diverter installation (Reflective)	2021
658	Koloa Sub to Waita Reservoir	0.1013	Static wire removal	2021
659	Koloa Sub to Waita Reservoir	0.0858	Diverter installation (Reflective)	2021
659	Koloa Sub to Waita Reservoir	0.0858	Static wire removal	2021
660	Koloa Sub to Waita Reservoir	0.0911	Diverter installation (Reflective)	2021
660	Koloa Sub to Waita Reservoir	0.0911	Static wire removal	2021
661	Koloa Sub to Waita Reservoir	0.1104	Diverter installation (Reflective)	2021
661	Koloa Sub to Waita Reservoir	0.1104	Static wire removal	2021
662	Koloa Sub to Waita Reservoir	0.1923	Diverter installation (Reflective)	2021
662	Koloa Sub to Waita Reservoir	0.1923	Static wire removal	2021
663	Waita Reservoir to Radio Tower	0.0135	Diverter installation (Reflective)	2022
663	Waita Reservoir to Radio Tower	0.0135	Static wire removal	2022
664	Waita Reservoir to Radio Tower	0.3061	Diverter installation (LED)	2022
665	Waita Reservoir to Radio Tower	0.1862	Diverter installation (LED)	2022
666	Waita Reservoir to Radio Tower	0.1575	Diverter installation (LED)	2022
667	Waita Reservoir to Knudsen Gap (Hwy)	0.3960	Diverter installation (Reflective)	2021
667	Waita Reservoir to Knudsen Gap (Hwy)	0.3960	Static wire removal	2021
668	Waita Reservoir to Knudsen Gap (Hwy)	0.3524	Diverter installation (LED)	2021
668	Waita Reservoir to Knudsen Gap (Hwy)	0.3524	Static wire removal	2021
669	Waita Reservoir to Knudsen Gap (Hwy)	0.1474	Static wire removal	2021
670	Waita Reservoir to Knudsen Gap (Hwy)	0.1446	Diverter installation (LED)	2021
670	Waita Reservoir to Knudsen Gap (Hwy)	0.1446	Static wire removal	2021
671	Waita Reservoir to Knudsen Gap (Hwy)	0.2597	Diverter installation (LED)	2021
671	Waita Reservoir to Knudsen Gap (Hwy)	0.2597	Static wire removal	2021
672	Waita Reservoir to Knudsen Gap (Hwy)	0.2404	Diverter installation (LED)	2021

672	Waita Reservoir to Knudsen Gap (Hwy)	0.2404	Static wire removal	2021
673	Waita Reservoir to Knudsen Gap (Hwy)	0.2536	Diverter installation (LED)	2022
674	Waita Reservoir to Knudsen Gap (Hwy)	0.1797	Diverter installation (Reflective)	2022
674	Waita Reservoir to Knudsen Gap (Hwy)	0.1797	Static wire removal	2021
675	Waita Reservoir to Knudsen Gap (Hwy)	0.4354	Diverter installation (Reflective)	2022
675	Waita Reservoir to Knudsen Gap (Hwy)	0.4354	Static wire removal	2021
676	Waita Reservoir to Knudsen Gap (Hwy)	0.2852	Diverter installation (Reflective)	2022
676	Waita Reservoir to Knudsen Gap (Hwy)	0.2852	Static wire removal	2021
677	Knudsen Gap (Hwy) to Green Energy Substation	0.1025	Diverter installation (Reflective)	2022
677	Knudsen Gap (Hwy) to Green Energy Substation	0.1025	Static wire removal	2021
678	Knudsen Gap (Hwy) to Green Energy Substation	0.1063	Diverter installation (Reflective)	2021
678	Knudsen Gap (Hwy) to Green Energy Substation	0.1063	Static wire removal	2021
679	Knudsen Gap (Hwy) to Green Energy Substation	0.0964	Diverter installation (Reflective)	2021
679	Knudsen Gap (Hwy) to Green Energy Substation	0.0964	Static wire removal	2022
680	Green Energy Substation to Fujita Tap	0.0754	Diverter installation (Reflective)	2021
681	Green Energy Substation to Fujita Tap	0.0567	Diverter installation (LED)	2022
682	Green Energy Substation to Fujita Tap	0.0753	Diverter installation (LED)	2022
683	Green Energy Substation to Fujita Tap	0.1076	Diverter installation (LED)	2022
684	Green Energy Substation to Fujita Tap	0.1073	Diverter installation (LED)	2022
686	Fujita Tap to Kilohana Tap	0.1793	Diverter installation (LED)	2022
687	Fujita Tap to Kilohana Tap	0.1350	Diverter installation (LED)	2022
688	Fujita Tap to Kilohana Tap	0.1690	Diverter installation (LED)	2022
689	Fujita Tap to Kilohana Tap	0.2173	Diverter installation (LED)	2022
690	Fujita Tap to Kilohana Tap	0.0980	Diverter installation (LED)	2022
691	Fujita Tap to Kilohana Tap	0.2095	Diverter installation (LED)	2022
692	Fujita Tap to Kilohana Tap	0.1052	Diverter installation (LED)	2022
693	Fujita Tap to Kilohana Tap	0.0798	Diverter installation (LED)	2022
694	Fujita Tap to Kilohana Tap	0.1408	Diverter installation (LED)	2022
695	Fujita Tap to Kilohana Tap	0.0815	Diverter installation (LED)	2022
696	Fujita Tap to Kilohana Tap	0.0822	Diverter installation (LED)	2022
697	Fujita Tap to Kilohana Tap	0.0800	Diverter installation (LED)	2022
698	Fujita Tap to Kilohana Tap	0.0774	Diverter installation (LED)	2022
699	Fujita Tap to Kilohana Tap	0.1060	Diverter installation (Reflective)	2021
700	Fujita Tap to Kilohana Tap	0.0892	Diverter installation (Reflective)	2021
702	Kilohana Tap to Lihue Substation(a) (LC1)	0.0728	Diverter installation (Reflective)	2021

702	Kilohana Tap to Lihue Substation(a) (LC1)	0.0728	Reconfiguration	2020
702	Kilohana Tap to Lihue Substation(a) (LC1)	0.0728	Static wire removal	2020
703	Kilohana Tap to Lihue Substation(a) (LC1)	0.0895	Diverter installation (Reflective)	2021
703	Kilohana Tap to Lihue Substation(a) (LC1)	0.0895	Reconfiguration	2020
703	Kilohana Tap to Lihue Substation(a) (LC1)	0.0895	Static wire removal	2020
704	Kilohana Tap to Lihue Substation(a) (LC1)	0.0854	Diverter installation (Reflective)	2021
704	Kilohana Tap to Lihue Substation(a) (LC1)	0.0854	Reconfiguration	2020
704	Kilohana Tap to Lihue Substation(a) (LC1)	0.0854	Static wire removal	2020
705	Kilohana Tap to Lihue Substation(a) (LC1)	0.0859	Diverter installation (Reflective)	2021
705	Kilohana Tap to Lihue Substation(a) (LC1)	0.0859	Reconfiguration	2020
705	Kilohana Tap to Lihue Substation(a) (LC1)	0.0859	Static wire removal	2020
706	Kilohana Tap to Lihue Substation(a) (LC1)	0.0834	Diverter installation (Reflective)	2021
706	Kilohana Tap to Lihue Substation(a) (LC1)	0.0834	Reconfiguration	2020
706	Kilohana Tap to Lihue Substation(a) (LC1)	0.0834	Static wire removal	2020
707	Kilohana Tap to Lihue Substation(a) (LC1)	0.1774	Diverter installation (Reflective)	2021
707	Kilohana Tap to Lihue Substation(a) (LC1)	0.1774	Reconfiguration	2020
707	Kilohana Tap to Lihue Substation(a) (LC1)	0.1774	Static wire removal	2020
708	Kilohana Tap to Lihue Substation(a) (LC1)	0.1450	Diverter installation (Reflective)	2021
708	Kilohana Tap to Lihue Substation(a) (LC1)	0.1450	Reconfiguration	2020
708	Kilohana Tap to Lihue Substation(a) (LC1)	0.1450	Static wire removal	2020
709	Kilohana Tap to Lihue Substation(a) (LC1)	0.0935	Diverter installation (Reflective)	2021
709	Kilohana Tap to Lihue Substation(a) (LC1)	0.0935	Reconfiguration	2020
709	Kilohana Tap to Lihue Substation(a) (LC1)	0.0935	Static wire removal	2020
710	Kilohana Tap to Lihue Substation(a) (LC1)	0.0916	Diverter installation (Reflective)	2022
710	Kilohana Tap to Lihue Substation(a) (LC1)	0.0916	Reconfiguration	2020
710	Kilohana Tap to Lihue Substation(a) (LC1)	0.0916	Static wire removal	2020
711	Kilohana Tap to Lihue Substation(a) (LC1)	0.1607	Diverter installation (Reflective)	2021
711	Kilohana Tap to Lihue Substation(a) (LC1)	0.1607	Reconfiguration	2020
711	Kilohana Tap to Lihue Substation(a) (LC1)	0.1607	Static wire removal	2020
712	Kilohana Tap to Lihue Substation(a) (LC1)	0.1244	Diverter installation (Reflective)	2021
712	Kilohana Tap to Lihue Substation(a) (LC1)	0.1244	Reconfiguration	2020
712	Kilohana Tap to Lihue Substation(a) (LC1)	0.1244	Static wire removal	2020
713	Kilohana Tap to Lihue Substation(a) (LC1)	0.1135	Diverter installation (Reflective)	2021
713	Kilohana Tap to Lihue Substation(a) (LC1)	0.1135	Reconfiguration	2020
713	Kilohana Tap to Lihue Substation(a) (LC1)	0.1135	Static wire removal	2020

714	Kilohana Tap to Lihue Substation(a) (LC1)	0.0964	Diverter installation (Reflective)	2021
714	Kilohana Tap to Lihue Substation(a) (LC1)	0.0964	Reconfiguration	2020
714	Kilohana Tap to Lihue Substation(a) (LC1)	0.0964	Static wire removal	2020
715	Kilohana Tap to Lihue Substation(a) (LC1)	0.2038	Diverter installation (Reflective)	2022
715	Kilohana Tap to Lihue Substation(a) (LC1)	0.2038	Reconfiguration	2020
715	Kilohana Tap to Lihue Substation(a) (LC1)	0.2038	Static wire removal	2020
716	Kilohana Tap to Lihue Substation(a) (LC1)	0.3558	Diverter installation (Reflective)	2022
716	Kilohana Tap to Lihue Substation(a) (LC1)	0.3558	Reconfiguration	2020
716	Kilohana Tap to Lihue Substation(a) (LC1)	0.3558	Static wire removal	2020
717	Kilohana Tap to Lihue Substation(a) (LC1)	0.1917	Diverter installation (Reflective)	2022
717	Kilohana Tap to Lihue Substation(a) (LC1)	0.1917	Reconfiguration	2020
717	Kilohana Tap to Lihue Substation(a) (LC1)	0.1917	Static wire removal	2020
718	Kilohana Tap to Lihue Substation(a) (LC1)	0.3056	Diverter installation (LED)	2022
718	Kilohana Tap to Lihue Substation(a) (LC1)	0.3056	Static wire removal	2020
719	Kilohana Tap to Lihue Substation(b)	0.1462	Diverter installation (LED)	2022
719	Kilohana Tap to Lihue Substation(b)	0.1462	Static wire removal	2020
720	Kilohana Tap to Lihue Substation(b)	0.1221	Diverter installation (LED)	2022
720	Kilohana Tap to Lihue Substation(b)	0.1221	Static wire removal	2020
721	Kilohana Tap to Lihue Substation(b)	0.1834	Diverter installation (LED)	2022
721	Kilohana Tap to Lihue Substation(b)	0.1834	Static wire removal	2020
722	Kilohana Tap to Lihue Substation(b)	0.1344	Diverter installation (Reflective)	2022
722	Kilohana Tap to Lihue Substation(b)	0.1344	Static wire removal	2020
723	Kilohana Tap to Lihue Substation(b)	0.2187	Diverter installation (Reflective)	2022
723	Kilohana Tap to Lihue Substation(b)	0.2187	Static wire removal	2020
724	Kilohana Tap to Lihue Substation(b)	0.3255	Diverter installation (LED)	2022
724	Kilohana Tap to Lihue Substation(b)	0.3255	Static wire removal	2020
725	Kilohana Tap to Lihue Substation(b)	0.3022	Diverter installation (Reflective)	2021
725	Kilohana Tap to Lihue Substation(b)	0.3022	Static wire removal	2020
726	Kilohana Tap to Lihue Substation(b)	0.0873	Diverter installation (LED)	2022
727	Kilohana Tap to Lihue Substation(b)	0.0737	Diverter installation (Reflective)	2021
727	Kilohana Tap to Lihue Substation(b)	0.0737	Static wire removal	2022
728	Kilohana Tap to Lihue Substation(b)	0.0797	Diverter installation (Reflective)	2022
728	Kilohana Tap to Lihue Substation(b)	0.0797	Static wire removal	2022
729	Kilohana Tap to Lihue Substation(b)	0.1046	Diverter installation (Reflective)	2021
729	Kilohana Tap to Lihue Substation(b)	0.1046	Static wire removal	2022

730	Kilohana Tap to Lihue Substation(b)	0.2566	Diverter installation (Reflective)	2022
730	Kilohana Tap to Lihue Substation(b)	0.2566	Static wire removal	2022
731	Kilohana Tap to Lihue Substation(b)	0.1121	Diverter installation (Reflective)	2022
731	Kilohana Tap to Lihue Substation(b)	0.1121	Static wire removal	2022
732	Kilohana Tap to Lihue Substation(b)	0.0911	Diverter installation (Reflective)	2022
732	Kilohana Tap to Lihue Substation(b)	0.0911	Static wire removal	2022
733	Lihue Substation to Ehiku Street	0.0543	Diverter installation (Reflective)	2022
734	Lihue Substation to Ehiku Street	0.0440	Diverter installation (Reflective)	2022
735	Lihue Substation to Ehiku Street	0.0463	Diverter installation (Reflective)	2022
736	Lihue Substation to Ehiku Street	0.0442	Diverter installation (Reflective)	2022
737	Lihue Substation to Ehiku Street	0.0213	Diverter installation (Reflective)	2022
738	Lihue Substation to Ehiku Street	0.0154	Diverter installation (Reflective)	2022
739	Lihue Substation to Ehiku Street	0.0990	Diverter installation (Reflective)	2022
740	Lihue Substation to Ehiku Street	0.0438	Diverter installation (Reflective)	2022
741	Lihue Substation to Ehiku Street	0.0863	Diverter installation (Reflective)	2022
742	Lihue Substation to Ehiku Street	0.0638	Diverter installation (Reflective)	2022
743	Lihue Substation to Ehiku Street	0.0478	Diverter installation (Reflective)	2022
744	Lihue Substation to Ehiku Street	0.0415	Diverter installation (Reflective)	2022
745	Lihue Substation to Ehiku Street	0.0407	Diverter installation (Reflective)	2022
746	Lihue Substation to Ehiku Street	0.0382	Diverter installation (Reflective)	2022
747	Lihue Substation to Ehiku Street	0.0515	Diverter installation (Reflective)	2022
748	Lihue Substation to Ehiku Street	0.0051	Diverter installation (Reflective)	2022
748	Lihue Substation to Ehiku Street	0.0051	Static wire removal	2022
749	Ehiku Street to Kapaia Substation	0.0431	Diverter installation (Reflective)	2021
749	Ehiku Street to Kapaia Substation	0.0431	Static wire removal	2021
750	Ehiku Street to Kapaia Substation	0.0593	Diverter installation (Reflective)	2021
750	Ehiku Street to Kapaia Substation	0.0593	Static wire removal	2021
751	Ehiku Street to Kapaia Substation	0.0506	Diverter installation (Reflective)	2021
751	Ehiku Street to Kapaia Substation	0.0506	Static wire removal	2021
752	Ehiku Street to Kapaia Substation	0.0538	Diverter installation (Reflective)	2021
752	Ehiku Street to Kapaia Substation	0.0538	Static wire removal	2021
753	Ehiku Street to Kapaia Substation	0.0494	Diverter installation (Reflective)	2021
753	Ehiku Street to Kapaia Substation	0.0494	Static wire removal	2021
754	Ehiku Street to Kapaia Substation	0.0449	Diverter installation (Reflective)	2021
754	Ehiku Street to Kapaia Substation	0.0449	Static wire removal	2021

755	Ehiku Street to Kapaia Substation	0.0542	Diverter installation (Reflective)	2021
755	Ehiku Street to Kapaia Substation	0.0542	Static wire removal	2021
756	Ehiku Street to Kapaia Substation	0.0527	Diverter installation (Reflective)	2021
756	Ehiku Street to Kapaia Substation	0.0527	Static wire removal	2021
757	Ehiku Street to Kapaia Substation	0.0429	Diverter installation (Reflective)	2021
757	Ehiku Street to Kapaia Substation	0.0429	Static wire removal	2021
758	Ehiku Street to Kapaia Substation	0.0543	Diverter installation (Reflective)	2021
758	Ehiku Street to Kapaia Substation	0.0543	Static wire removal	2021
759	Ehiku Street to Kapaia Substation	0.0565	Diverter installation (Reflective)	2021
759	Ehiku Street to Kapaia Substation	0.0565	Static wire removal	2021
760	Ehiku Street to Kapaia Substation	0.0436	Diverter installation (Reflective)	2021
760	Ehiku Street to Kapaia Substation	0.0436	Static wire removal	2021
761	Ehiku Street to Kapaia Substation	0.0702	Diverter installation (Reflective)	2021
761	Ehiku Street to Kapaia Substation	0.0702	Static wire removal	2021
762	Ehiku Street to Kapaia Substation	0.0606	Diverter installation (Reflective)	2021
762	Ehiku Street to Kapaia Substation	0.0606	Static wire removal	2021
763	Ehiku Street to Kapaia Substation	0.0547	Diverter installation (Reflective)	2021
763	Ehiku Street to Kapaia Substation	0.0547	Static wire removal	2021
764	Ehiku Street to Kapaia Substation	0.0532	Diverter installation (Reflective)	2021
764	Ehiku Street to Kapaia Substation	0.0532	Static wire removal	2021
765	Ehiku Street to Kapaia Substation	0.0497	Diverter installation (Reflective)	2021
765	Ehiku Street to Kapaia Substation	0.0497	Static wire removal	2021
766	Ehiku Street to Kapaia Substation	0.0578	Diverter installation (Reflective)	2021
766	Ehiku Street to Kapaia Substation	0.0578	Static wire removal	2021
767	Ehiku Street to Kapaia Substation	0.0445	Diverter installation (Reflective)	2022
767	Ehiku Street to Kapaia Substation	0.0445	Static wire removal	2022
769	Ehiku Street to Kapaia Valley	0.0355	Diverter installation (Reflective)	2022
769	Ehiku Street to Kapaia Valley	0.0355	Static wire removal	2022
770	Ehiku Street to Kapaia Valley	0.0356	Diverter installation (Reflective)	2022
770	Ehiku Street to Kapaia Valley	0.0356	Static wire removal	2022
771	Ehiku Street to Kapaia Valley	0.0193	Diverter installation (Reflective)	2022
771	Ehiku Street to Kapaia Valley	0.0193	Static wire removal	2022
772	Ehiku Street to Kapaia Valley	0.0418	Diverter installation (Reflective)	2022
772	Ehiku Street to Kapaia Valley	0.0418	Static wire removal	2022
773	Ehiku Street to Kapaia Valley	0.0427	Diverter installation (Reflective)	2022

773	Ehiku Street to Kapaia Valley	0.0427	Static wire removal	2022
774	Ehiku Street to Kapaia Valley	0.0522	Diverter installation (Reflective)	2022
774	Ehiku Street to Kapaia Valley	0.0522	Static wire removal	2022
775.1	Ehiku Street to Kapaia Valley	0.0256	Diverter installation (Reflective)	2022
775.1	Ehiku Street to Kapaia Valley	0.0256	Static wire removal	2022
775.2	Ehiku street to Kapaia valley	0.0256	Diverter installation (Reflective)	2022
775.2	Ehiku street to Kapaia valley	0.0256	Static wire removal	2022
778	Ehiku Street to Kapaia Valley	0.1301	Diverter installation (Reflective)	2022
778	Ehiku Street to Kapaia Valley	0.1301	Static wire removal	2022
779	Ehiku Street to Kapaia Valley	0.0622	Diverter installation (Reflective)	2022
779	Ehiku Street to Kapaia Valley	0.0622	Static wire removal	2022
780	Ehiku Street to Kapaia Valley	0.1375	Diverter installation (Reflective)	2022
780	Ehiku Street to Kapaia Valley	0.1375	Static wire removal	2022
781	Ehiku Street to Kapaia Valley	0.1005	Diverter installation (Reflective)	2022
781	Ehiku Street to Kapaia Valley	0.1005	Static wire removal	2022
782	Ehiku Street to Kapaia Valley	0.0424	Diverter installation (Reflective)	2022
782	Ehiku Street to Kapaia Valley	0.0424	Static wire removal	2022
783	Kapaia Valley to Lydgate Substation	0.0356	Diverter installation (Reflective)	2022
784	Kapaia Valley to Lydgate Substation	0.0223	Diverter installation (Reflective)	2022
785	Kapaia Valley to Lydgate Substation	0.0343	Diverter installation (Reflective)	2022
786	Kapaia Valley to Lydgate Substation	0.0765	Diverter installation (Reflective)	2022
787	Kapaia Valley to Lydgate Substation	0.0391	Diverter installation (Reflective)	2022
788	Kapaia Valley to Lydgate Substation	0.0405	Diverter installation (Reflective)	2022
789	Kapaia Valley to Lydgate Substation	0.0725	Diverter installation (Reflective)	2022
790	Kapaia Valley to Lydgate Substation	0.0769	Diverter installation (Reflective)	2022
791	Kapaia Valley to Lydgate Substation	0.0587	Diverter installation (Reflective)	2022
792	Kapaia Valley to Lydgate Substation	0.0490	Diverter installation (Reflective)	2022
793	Kapaia Valley to Lydgate Substation	0.0569	Diverter installation (Reflective)	2022
794	Kapaia Valley to Lydgate Substation	0.0458	Diverter installation (Reflective)	2022
795	Kapaia Valley to Lydgate Substation	0.0439	Diverter installation (Reflective)	2022
796	Kapaia Valley to Lydgate Substation	0.0552	Diverter installation (Reflective)	2022
797	Kapaia Valley to Lydgate Substation	0.0334	Diverter installation (Reflective)	2022
798	Kapaia Valley to Lydgate Substation	0.0411	Diverter installation (Reflective)	2022
799	Kapaia Valley to Lydgate Substation	0.0786	Diverter installation (Reflective)	2022
800	Kapaia Valley to Lydgate Substation	0.0694	Diverter installation (Reflective)	2022

801	Kapaia Valley to Lydgate Substation	0.0606	Diverter installation (Reflective)	2022
802.1	Kapaia Valley to Lydgate Substation	0.0275	Diverter installation (Reflective)	2022
802.2	Kapaia Valley to Lydgate Substation	0.0275	Diverter installation (Reflective)	2022
803	Kapaia Valley to Lydgate Substation	0.0551	Diverter installation (Reflective)	2022
804	Kapaia Valley to Lydgate Substation	0.0715	Diverter installation (Reflective)	2022
805	Kapaia Valley to Lydgate Substation	0.0371	Diverter installation (Reflective)	2022
806	Kapaia Valley to Lydgate Substation	0.0319	Diverter installation (Reflective)	2022
807	Kapaia Valley to Lydgate Substation	0.0713	Diverter installation (Reflective)	2022
808	Kapaia Valley to Lydgate Substation	0.0572	Diverter installation (Reflective)	2022
809	Kapaia Valley to Lydgate Substation	0.0298	Diverter installation (Reflective)	2022
810	Kapaia Valley to Lydgate Substation	0.0569	Diverter installation (Reflective)	2022
811	Kapaia Valley to Lydgate Substation	0.0356	Diverter installation (Reflective)	2022
812	Kapaia Valley to Lydgate Substation	0.0582	Diverter installation (Reflective)	2022
813	Kapaia Valley to Lydgate Substation	0.0763	Diverter installation (Reflective)	2022
814	Kapaia Valley to Lydgate Substation	0.0870	Diverter installation (Reflective)	2022
815	Kapaia Valley to Lydgate Substation	0.0835	Diverter installation (Reflective)	2022
816.1	Kapaia Valley to Lydgate Substation	0.0400	Diverter installation (Reflective)	2022
816.2	Kapaia Valley to Lydgate Substation	0.0400	Diverter installation (Reflective)	2022
817	Kapaia Valley to Lydgate Substation	0.0801	Diverter installation (Reflective)	2022
818	Kapaia Valley to Lydgate Substation	0.0800	Diverter installation (Reflective)	2022
819	Kapaia Valley to Lydgate Substation	0.0862	Diverter installation (Reflective)	2022
820	Kapaia Valley to Lydgate Substation	0.0828	Diverter installation (Reflective)	2022
821	Kapaia Valley to Lydgate Substation	0.0844	Diverter installation (Reflective)	2022
822	Kapaia Valley to Lydgate Substation	0.0838	Diverter installation (Reflective)	2022
823	Kapaia Valley to Lydgate Substation	0.0269	Diverter installation (Reflective)	2022
824	Kapaia Valley to Lydgate Substation	0.0629	Diverter installation (Reflective)	2022
825	Kapaia Valley to Lydgate Substation	0.0772	Diverter installation (Reflective)	2022
826	Kapaia Valley to Lydgate Substation	0.0780	Diverter installation (Reflective)	2022
827	Kapaia Valley to Lydgate Substation	0.0707	Diverter installation (Reflective)	2022
828	Kapaia Valley to Lydgate Substation	0.0626	Diverter installation (Reflective)	2022
829	Kapaia Valley to Lydgate Substation	0.0637	Diverter installation (Reflective)	2022
830	Kapaia Valley to Lydgate Substation	0.0622	Diverter installation (Reflective)	2022
831	Kapaia Valley to Lydgate Substation	0.0686	Diverter installation (Reflective)	2022
832	Kapaia Valley to Lydgate Substation	0.0357	Diverter installation (Reflective)	2022
833	Kapaia Valley to Lydgate Substation	0.0712	Diverter installation (Reflective)	2022

834	Kapaia Valley to Lydgate Substation	0.0424	Diverter installation (Reflective)	2022
835	Kapaia Valley to Lydgate Substation	0.0263	Diverter installation (Reflective)	2022
836	Kapaia Valley to Lydgate Substation	0.0260	Diverter installation (Reflective)	2022
837	Kapaia Valley to Lydgate Substation	0.0232	Diverter installation (Reflective)	2022
838	Kapaia Valley to Lydgate Substation	0.0424	Diverter installation (Reflective)	2022
838	Kapaia Valley to Lydgate Substation	0.0424	Static wire removal	2022
839	Kapaia Valley to Lydgate Substation	0.0465	Diverter installation (Reflective)	2022
839	Kapaia Valley to Lydgate Substation	0.0465	Static wire removal	2022
840	Kapaia Valley to Lydgate Substation	0.0904	Diverter installation (Reflective)	2022
840	Kapaia Valley to Lydgate Substation	0.0904	Static wire removal	2022
841	Kapaia Valley to Lydgate Substation	0.0890	Diverter installation (Reflective)	2022
841	Kapaia Valley to Lydgate Substation	0.0890	Static wire removal	2022
842	Kapaia Valley to Lydgate Substation	0.0908	Diverter installation (Reflective)	2022
842	Kapaia Valley to Lydgate Substation	0.0908	Static wire removal	2022
843	Kapaia Valley to Lydgate Substation	0.0923	Diverter installation (Reflective)	2022
843	Kapaia Valley to Lydgate Substation	0.0923	Static wire removal	2022
844	Kapaia Valley to Lydgate Substation	0.0951	Diverter installation (Reflective)	2022
844	Kapaia Valley to Lydgate Substation	0.0951	Static wire removal	2022
846	Lydgate Substation to Kuamoo Rd	0.0569	Diverter installation (Reflective)	2022
846	Lydgate Substation to Kuamoo Rd	0.0569	Static wire removal	2022
847	Lydgate Substation to Kuamoo Rd	0.0285	Diverter installation (Reflective)	2022
847	Lydgate Substation to Kuamoo Rd	0.0285	Static wire removal	2022
848	Lydgate Substation to Kuamoo Rd	0.0427	Diverter installation (Reflective)	2022
848	Lydgate Substation to Kuamoo Rd	0.0427	Static wire removal	2022
849	Lydgate Substation to Kuamoo Rd	0.0515	Diverter installation (Reflective)	2022
849	Lydgate Substation to Kuamoo Rd	0.0515	Static wire removal	2022
850	Lydgate Substation to Kuamoo Rd	0.0428	Diverter installation (Reflective)	2022
850	Lydgate Substation to Kuamoo Rd	0.0428	Static wire removal	2022
851	Lydgate Substation to Kuamoo Rd	0.0468	Diverter installation (Reflective)	2022
851	Lydgate Substation to Kuamoo Rd	0.0468	Static wire removal	2022
852	Lydgate Substation to Kuamoo Rd	0.0348	Diverter installation (Reflective)	2022
852	Lydgate Substation to Kuamoo Rd	0.0348	Static wire removal	2022
853	Lydgate Substation to Kuamoo Rd	0.0352	Diverter installation (Reflective)	2022
853	Lydgate Substation to Kuamoo Rd	0.0352	Static wire removal	2022
854	Lydgate Substation to Kuamoo Rd	0.0346	Diverter installation (Reflective)	2022

854	Lydgate Substation to Kuamoo Rd	0.0346	Static wire removal	2022
855	Lydgate Substation to Kuamoo Rd	0.0481	Diverter installation (Reflective)	2022
855	Lydgate Substation to Kuamoo Rd	0.0481	Static wire removal	2022
856	Lydgate Substation to Kuamoo Rd	0.0474	Diverter installation (Reflective)	2022
856	Lydgate Substation to Kuamoo Rd	0.0474	Static wire removal	2022
857	Lydgate Substation to Kuamoo Rd	0.0406	Diverter installation (Reflective)	2022
857	Lydgate Substation to Kuamoo Rd	0.0406	Static wire removal	2022
858	Lydgate Substation to Kuamoo Rd	0.0262	Diverter installation (Reflective)	2022
859	Lydgate Substation to Kuamoo Rd	0.0273	Diverter installation (Reflective)	2022
860	Lydgate Substation to Kuamoo Rd	0.0463	Diverter installation (Reflective)	2022
861	Lydgate Substation to Kuamoo Rd	0.0754	Diverter installation (Reflective)	2022
862	Lydgate Substation to Kuamoo Rd	0.0995	Diverter installation (Reflective)	2022
863	Lydgate Substation to Kuamoo Rd	0.0375	Diverter installation (Reflective)	2022
864	Lydgate Substation to Kuamoo Rd	0.0425	Diverter installation (Reflective)	2022
865	Kuamoo Rd to Kapaa Bypass Rd (Wailua widening project 2020-2021)	0.0374	Diverter installation (Reflective)	2022
866	Kuamoo Rd to Kapaa Bypass Rd (Wailua widening project 2020-2021)	0.0459	Diverter installation (Reflective)	2022
867	Kuamoo Rd to Kapaa Bypass Rd (Wailua widening project 2020-2021)	0.0451	Diverter installation (Reflective)	2022
868	Kuamoo Rd to Kapaa Bypass Rd (Wailua widening project 2020-2021)	0.0387	Diverter installation (Reflective)	2022
869	Kuamoo Rd to Kapaa Bypass Rd (Wailua widening project 2020-2021)	0.0436	Diverter installation (Reflective)	2022
870	Kuamoo Rd to Kapaa Bypass Rd (Wailua widening project 2020-2021)	0.0439	Diverter installation (Reflective)	2022
871	Kuamoo Rd to Kapaa Bypass Rd (Wailua widening project 2020-2021)	0.0352	Diverter installation (Reflective)	2022
872	Kuamoo Rd to Kapaa Bypass Rd (Wailua widening project 2020-2021)	0.0290	Diverter installation (Reflective)	2022
873	Kuamoo Rd to Kapaa Bypass Rd (Wailua widening project 2020-2021)	0.0397	Diverter installation (Reflective)	2022
874	Kuamoo Rd to Kapaa Bypass Rd (Wailua widening project 2020-2021)	0.0636	Diverter installation (Reflective)	2022
875	Kuamoo Rd to Kapaa Bypass Rd (Wailua widening project 2020-2021)	0.0613	Diverter installation (Reflective)	2022
876	Kuamoo Rd to Kapaa Bypass Rd (Wailua widening project 2020-2021)	0.0466	Diverter installation (Reflective)	2022
877	Kuamoo Rd to Kapaa Bypass Rd (Wailua widening project 2020-2021)	0.0441	Diverter installation (Reflective)	2022
878	Kuamoo Rd to Kapaa Bypass Rd (Wailua widening project 2020-2021)	0.0423	Diverter installation (Reflective)	2022
879	Kuamoo Rd to Kapaa Bypass Rd (Wailua widening project 2020-2021)	0.0364	Diverter installation (Reflective)	2022
880	Kapaa Bypass Rd to Kapaa Substation	0.0496	Diverter installation (Reflective)	2022
881	Kapaa Bypass Rd to Kapaa Substation	0.0428	Diverter installation (Reflective)	2022
882	Kapaa Bypass Rd to Kapaa Substation	0.0435	Diverter installation (Reflective)	2022
883	Kapaa Bypass Rd to Kapaa Substation	0.0406	Diverter installation (Reflective)	2022
884	Kapaa Bypass Rd to Kapaa Substation	0.0416	Diverter installation (Reflective)	2022
885	Kapaa Bypass Rd to Kapaa Substation	0.0411	Diverter installation (Reflective)	2022

886	Kapaa Bypass Rd to Kapaa Substation	0.0423	Diverter installation (Reflective)	2022
887	Kapaa Bypass Rd to Kapaa Substation	0.0414	Diverter installation (Reflective)	2022
888	Kapaa Bypass Rd to Kapaa Substation	0.0422	Diverter installation (Reflective)	2022
889	Kapaa Bypass Rd to Kapaa Substation	0.0241	Diverter installation (Reflective)	2022
890	Kapaa Bypass Rd to Kapaa Substation	0.0298	Diverter installation (Reflective)	2022
891	Kapaa Bypass Rd to Kapaa Substation	0.0329	Diverter installation (Reflective)	2022
892	Kapaa Bypass Rd to Kapaa Substation	0.0361	Diverter installation (Reflective)	2022
893	Kapaa Bypass Rd to Kapaa Substation	0.0286	Diverter installation (Reflective)	2022
894	Kapaa Bypass Rd to Kapaa Substation	0.0392	Diverter installation (Reflective)	2022
895	Kapaa Bypass Rd to Kapaa Substation	0.0347	Diverter installation (Reflective)	2022
896	Kapaa Bypass Rd to Kapaa Substation	0.0453	Diverter installation (Reflective)	2022
897	Kapaa Bypass Rd to Kapaa Substation	0.0419	Diverter installation (Reflective)	2022
898	Kapaa Bypass Rd to Kapaa Substation	0.0450	Diverter installation (Reflective)	2022
899	Kapaa Bypass Rd to Kapaa Substation	0.0313	Diverter installation (Reflective)	2022
900	Kapaa Bypass Rd to Kapaa Substation	0.0343	Diverter installation (Reflective)	2022
901	Kapaa Bypass Rd to Kapaa Substation	0.0269	Diverter installation (Reflective)	2022
902	Kapaa Bypass Rd to Kapaa Substation	0.0255	Diverter installation (Reflective)	2022
903	Kapaa Bypass Rd to Kapaa Substation	0.0264	Diverter installation (Reflective)	2022
904	Kapaa Bypass Rd to Kapaa Substation	0.0453	Diverter installation (Reflective)	2022
905	Kapaa Bypass Rd to Kapaa Substation	0.0605	Diverter installation (Reflective)	2022
906	Kapaa Bypass Rd to Kapaa Substation	0.0167	Diverter installation (Reflective)	2022
907	Kapaa Bypass Rd to Kapaa Substation	0.0231	Diverter installation (Reflective)	2022
908	Kapaa Bypass Rd to Kapaa Substation	0.0309	Diverter installation (Reflective)	2022
909	Kapaa Bypass Rd to Kapaa Substation	0.0345	Diverter installation (Reflective)	2022
910	Kapaa Bypass Rd to Kapaa Substation	0.0321	Diverter installation (Reflective)	2022
911	Kapaa Bypass Rd to Kapaa Substation	0.0629	Diverter installation (Reflective)	2022
912	Kapaa Bypass Rd to Kapaa Substation	0.0610	Diverter installation (Reflective)	2022
913	Kapaa Bypass Rd to Kapaa Substation	0.0609	Diverter installation (Reflective)	2022
914	Kapaa Bypass Rd to Kapaa Substation	0.0571	Diverter installation (Reflective)	2022
915	Kapaa Bypass Rd to Kapaa Substation	0.0586	Diverter installation (Reflective)	2022
916	Kapaa Bypass Rd to Kapaa Substation	0.0225	Diverter installation (Reflective)	2022
917	Kapaa Bypass Rd to Kapaa Substation	0.0301	Diverter installation (Reflective)	2022
919	Kapaa Bypass Rd to Kapaa Substation	0.0110	Diverter installation (Reflective)	2022
920	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0432	Static wire removal	2021
921	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0398	Diverter installation (Reflective)	2021

921	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0398	Static wire removal	2021
922	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0755	Diverter installation (Reflective)	2021
922	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0755	Static wire removal	2021
922	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0755	Static wire removal	2021
923	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0933	Diverter installation (Reflective)	2021
923	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0933	Static wire removal	2021
924	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0708	Diverter installation (Reflective)	2021
924	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0708	Static wire removal	2021
925	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0716	Diverter installation (Reflective)	2021
925	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0716	Static wire removal	2021
926	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0708	Diverter installation (Reflective)	2021
926	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0708	Static wire removal	2021
926	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0708	Static wire removal	2021
927	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0605	Diverter installation (Reflective)	2022
927	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0605	Static wire removal	2021
928	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.1740	Diverter installation (Reflective)	2022
928	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.1740	Static wire removal	2021
929	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0945	Diverter installation (Reflective)	2022
929	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0945	Static wire removal	2021
930	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.1246	Diverter installation (Reflective)	2021
930	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.1246	Static wire removal	2021
931	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.1620	Diverter installation (Reflective)	2021
931	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.1620	Static wire removal	2021
932	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0856	Diverter installation (Reflective)	2022
932	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0856	Static wire removal	2021
933	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.1090	Diverter installation (Reflective)	2022
933	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.1090	Static wire removal	2021
934	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.1098	Diverter installation (Reflective)	2022
934	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.1098	Static wire removal	2021
935	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.1602	Diverter installation (Reflective)	2022
935	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.1602	Static wire removal	2021
936	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.1119	Diverter installation (Reflective)	2022
936	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.1119	Static wire removal	2021
937	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0721	Diverter installation (Reflective)	2021
937	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0721	Static wire removal	2021

938	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0696	Diverter installation (Reflective)	2021
938	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0696	Static wire removal	2021
939	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0672	Diverter installation (Reflective)	2021
939	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0672	Static wire removal	2021
940	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0828	Diverter installation (Reflective)	2021
940	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0828	Static wire removal	2021
941	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0569	Diverter installation (Reflective)	2021
941	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0569	Static wire removal	2021
942	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0856	Diverter installation (Reflective)	2021
942	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0856	Static wire removal	2021
943	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0711	Diverter installation (Reflective)	2021
943	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0711	Static wire removal	2021
944	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0769	Diverter installation (Reflective)	2021
944	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0769	Static wire removal	2021
945	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0605	Diverter installation (Reflective)	2021
945	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0605	Static wire removal	2021
946	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.2073	Diverter installation (Reflective)	2021
946	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.2073	Static wire removal	2021
947	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0935	Diverter installation (Reflective)	2021
947	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0935	Static wire removal	2021
948	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0452	Diverter installation (Reflective)	2021
948	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0452	Static wire removal	2021
949	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0469	Diverter installation (Reflective)	2021
949	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0469	Static wire removal	2021
950	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0724	Diverter installation (Reflective)	2021
950	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0724	Static wire removal	2021
951	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0518	Diverter installation (Reflective)	2021
951	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0518	Static wire removal	2021
952	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0639	Diverter installation (Reflective)	2021
952	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0639	Static wire removal	2021
953	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0803	Diverter installation (Reflective)	2021
953	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0803	Static wire removal	2021
954	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0530	Diverter installation (Reflective)	2021
954	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0530	Static wire removal	2021
955	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0623	Diverter installation (Reflective)	2021

955	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0623	Static wire removal	2021
956	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0835	Diverter installation (Reflective)	2021
956	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0835	Static wire removal	2021
957	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0945	Diverter installation (Reflective)	2021
957	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0945	Static wire removal	2021
958	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0671	Diverter installation (Reflective)	2021
958	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0671	Static wire removal	2021
959	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0782	Diverter installation (Reflective)	2021
959	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0782	Static wire removal	2021
960	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0555	Diverter installation (Reflective)	2021
960	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0555	Static wire removal	2021
961	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0747	Diverter installation (Reflective)	2021
961	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0747	Static wire removal	2021
962	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0729	Diverter installation (Reflective)	2021
962	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0729	Static wire removal	2021
963	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0723	Diverter installation (Reflective)	2021
963	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0723	Static wire removal	2021
964	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0827	Diverter installation (Reflective)	2021
964	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0827	Static wire removal	2021
965	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0593	Diverter installation (Reflective)	2021
965	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0593	Static wire removal	2021
966	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0722	Diverter installation (Reflective)	2021
966	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0722	Static wire removal	2021
967	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.1040	Diverter installation (Reflective)	2021
967	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.1040	Static wire removal	2021
968	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.1768	Diverter installation (Reflective)	2021
968	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.1768	Static wire removal	2021
969	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.1294	Diverter installation (Reflective)	2021
969	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.1294	Static wire removal	2021
970	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0856	Diverter installation (Reflective)	2021
970	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0856	Static wire removal	2021
971	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.2212	Diverter installation (Reflective)	2021
971	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.2212	Static wire removal	2021
972	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0773	Diverter installation (Reflective)	2021
972	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.0773	Static wire removal	2021

973	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.1124	Diverter installation (Reflective)	2021
973	Kapaa Substation to Olohena/Waipouli Rd Intersection	0.1124	Static wire removal	2021
974	Olohena/Waipouli Rd Intersection to Hanahanapuni Tap	0.1767	Diverter installation (Reflective)	2022
974	Olohena/Waipouli Rd Intersection to Hanahanapuni Tap	0.1767	Static wire removal	2021
975	Olohena/Waipouli Rd Intersection to Hanahanapuni Tap	0.1964	Diverter installation (Reflective)	2022
975	Olohena/Waipouli Rd Intersection to Hanahanapuni Tap	0.1964	Static wire removal	2021
976	Olohena/Waipouli Rd Intersection to Hanahanapuni Tap	0.2155	Diverter installation (Reflective)	2022
976	Olohena/Waipouli Rd Intersection to Hanahanapuni Tap	0.2155	Static wire removal	2021
977	Olohena/Waipouli Rd Intersection to Hanahanapuni Tap	0.1273	Diverter installation (Reflective)	2022
977	Olohena/Waipouli Rd Intersection to Hanahanapuni Tap	0.1273	Static wire removal	2021
978	Olohena/Waipouli Rd Intersection to Hanahanapuni Tap	0.0892	Diverter installation (Reflective)	2022
978	Olohena/Waipouli Rd Intersection to Hanahanapuni Tap	0.0892	Static wire removal	2021
979	Olohena/Waipouli Rd Intersection to Hanahanapuni Tap	0.2038	Diverter installation (Reflective)	2022
979	Olohena/Waipouli Rd Intersection to Hanahanapuni Tap	0.2038	Static wire removal	2021
980	Olohena/Waipouli Rd Intersection to Hanahanapuni Tap	0.1911	Diverter installation (Reflective)	2022
980	Olohena/Waipouli Rd Intersection to Hanahanapuni Tap	0.1911	Static wire removal	2021
981	Olohena/Waipouli Rd Intersection to Hanahanapuni Tap	0.1090	Diverter installation (Reflective)	2022
981	Olohena/Waipouli Rd Intersection to Hanahanapuni Tap	0.1090	Static wire removal	2021
982	Olohena/Waipouli Rd Intersection to Hanahanapuni Tap	0.0504	Diverter installation (Reflective)	2022
982	Olohena/Waipouli Rd Intersection to Hanahanapuni Tap	0.0504	Static wire removal	2021
983	Olohena/Waipouli Rd Intersection to Hanahanapuni Tap	0.1576	Diverter installation (Reflective)	2022
983	Olohena/Waipouli Rd Intersection to Hanahanapuni Tap	0.1576	Static wire removal	2021
984	Olohena/Waipouli Rd Intersection to Hanahanapuni Tap	0.0688	Diverter installation (Reflective)	2022
984	Olohena/Waipouli Rd Intersection to Hanahanapuni Tap	0.0688	Static wire removal	2021
985	Olohena/Waipouli Rd Intersection to Hanahanapuni Tap	0.1703	Diverter installation (Reflective)	2022
985	Olohena/Waipouli Rd Intersection to Hanahanapuni Tap	0.1703	Static wire removal	2021
986	Olohena/Waipouli Rd Intersection to Hanahanapuni Tap	0.0654	Diverter installation (Reflective)	2022
986	Olohena/Waipouli Rd Intersection to Hanahanapuni Tap	0.0654	Static wire removal	2021
987	Olohena/Waipouli Rd Intersection to Hanahanapuni Tap	0.1399	Diverter installation (Reflective)	2022
987	Olohena/Waipouli Rd Intersection to Hanahanapuni Tap	0.1399	Static wire removal	2021
988	Olohena/Waipouli Rd Intersection to Hanahanapuni Tap	0.1470	Diverter installation (Reflective)	2022
988	Olohena/Waipouli Rd Intersection to Hanahanapuni Tap	0.1470	Static wire removal	2021
989	Olohena/Waipouli Rd Intersection to Hanahanapuni Tap	0.2306	Diverter installation (Reflective)	2022
989	Olohena/Waipouli Rd Intersection to Hanahanapuni Tap	0.2306	Static wire removal	2021
990	Olohena/Waipouli Rd Intersection to Hanahanapuni Tap	0.1058	Diverter installation (Reflective)	2022

990	Olohena/Waipouli Rd Intersection to Hanahanapuni Tap	0.1058	Static wire removal	2021
991	Olohena/Waipouli Rd Intersection to Hanahanapuni Tap	0.1094	Diverter installation (Reflective)	2022
991	Olohena/Waipouli Rd Intersection to Hanahanapuni Tap	0.1094	Static wire removal	2021
992	Olohena/Waipouli Rd Intersection to Hanahanapuni Tap	0.1181	Diverter installation (Reflective)	2022
992	Olohena/Waipouli Rd Intersection to Hanahanapuni Tap	0.1181	Static wire removal	2021
993	Olohena/Waipouli Rd Intersection to Hanahanapuni Tap	0.0808	Diverter installation (Reflective)	2022
993	Olohena/Waipouli Rd Intersection to Hanahanapuni Tap	0.0808	Static wire removal	2021
995	Kapaa Substation to Mailihuna Rd	0.0739	Diverter installation (Reflective)	2021
995	Kapaa Substation to Mailihuna Rd	0.0739	Static wire removal	2022
996	Kapaa Substation to Mailihuna Rd	0.0728	Diverter installation (Reflective)	2021
996	Kapaa Substation to Mailihuna Rd	0.0728	Static wire removal	2022
997	Kapaa Substation to Mailihuna Rd	0.0816	Diverter installation (Reflective)	2021
997	Kapaa Substation to Mailihuna Rd	0.0816	Static wire removal	2022
998	Kapaa Substation to Mailihuna Rd	0.0783	Diverter installation (Reflective)	2021
998	Kapaa Substation to Mailihuna Rd	0.0783	Static wire removal	2022
999	Kapaa Substation to Mailihuna Rd	0.0931	Diverter installation (Reflective)	2021
999	Kapaa Substation to Mailihuna Rd	0.0931	Static wire removal	2022
1000	Kapaa Substation to Mailihuna Rd	0.0969	Diverter installation (Reflective)	2021
1000	Kapaa Substation to Mailihuna Rd	0.0969	Static wire removal	2022
1001	Kapaa Substation to Mailihuna Rd	0.0129	Diverter installation (Reflective)	2021
1001	Kapaa Substation to Mailihuna Rd	0.0129	Static wire removal	2022
1002	Kapaa Substation to Mailihuna Rd	0.0846	Diverter installation (Reflective)	2021
1002	Kapaa Substation to Mailihuna Rd	0.0846	Static wire removal	2022
1003	Kapaa Substation to Mailihuna Rd	0.0753	Diverter installation (Reflective)	2021
1003	Kapaa Substation to Mailihuna Rd	0.0753	Static wire removal	2022
1004	Kapaa Substation to Mailihuna Rd	0.0807	Diverter installation (Reflective)	2021
1004	Kapaa Substation to Mailihuna Rd	0.0807	Static wire removal	2022
1005	Kapaa Substation to Mailihuna Rd	0.0846	Diverter installation (Reflective)	2021
1005	Kapaa Substation to Mailihuna Rd	0.0846	Static wire removal	2022
1006	Kapaa Substation to Mailihuna Rd	0.0404	Diverter installation (Reflective)	2021
1006	Kapaa Substation to Mailihuna Rd	0.0404	Static wire removal	2022
1007	Kapaa Substation to Mailihuna Rd	0.0464	Diverter installation (Reflective)	2022
1007	Kapaa Substation to Mailihuna Rd	0.0464	Static wire removal	2022
1008	Kapaa Substation to Mailihuna Rd	0.0350	Diverter installation (Reflective)	2022
1008	Kapaa Substation to Mailihuna Rd	0.0350	Static wire removal	2022

1009	Kapaa Substation to Mailihuna Rd	0.0358	Diverter installation (Reflective)	2022
1009	Kapaa Substation to Mailihuna Rd	0.0358	Static wire removal	2022
1010	Kapaa Substation to Mailihuna Rd	0.0315	Diverter installation (Reflective)	2022
1010	Kapaa Substation to Mailihuna Rd	0.0315	Static wire removal	2022
1011	Kapaa Substation to Mailihuna Rd	0.0034	Diverter installation (Reflective)	2022
1011	Kapaa Substation to Mailihuna Rd	0.0034	Static wire removal	2022
1012	Kapaa Substation to Mailihuna Rd	0.0240	Diverter installation (Reflective)	2022
1012	Kapaa Substation to Mailihuna Rd	0.0240	Static wire removal	2022
1013	Kapaa Substation to Mailihuna Rd	0.0264	Diverter installation (Reflective)	2022
1013	Kapaa Substation to Mailihuna Rd	0.0264	Static wire removal	2022
1014	Kapaa Substation to Mailihuna Rd	0.0259	Diverter installation (Reflective)	2022
1014	Kapaa Substation to Mailihuna Rd	0.0259	Static wire removal	2022
1015	Kapaa Substation to Mailihuna Rd	0.0325	Diverter installation (Reflective)	2022
1015	Kapaa Substation to Mailihuna Rd	0.0325	Static wire removal	2022
1016	Kapaa Substation to Mailihuna Rd	0.0374	Diverter installation (Reflective)	2022
1016	Kapaa Substation to Mailihuna Rd	0.0374	Static wire removal	2022
1017	Kapaa Substation to Mailihuna Rd	0.0359	Diverter installation (Reflective)	2023
1017	Kapaa Substation to Mailihuna Rd	0.0359	Static wire removal	2023
1018	Kapaa Substation to Mailihuna Rd	0.0247	Diverter installation (Reflective)	2023
1018	Kapaa Substation to Mailihuna Rd	0.0247	Static wire removal	2023
1019	Kapaa Substation to Mailihuna Rd	0.0241	Diverter installation (Reflective)	2023
1019	Kapaa Substation to Mailihuna Rd	0.0241	Static wire removal	2023
1020	Kapaa Substation to Mailihuna Rd	0.0305	Diverter installation (Reflective)	2023
1020	Kapaa Substation to Mailihuna Rd	0.0305	Static wire removal	2023
1021	Kapaa Substation to Mailihuna Rd	0.0116	Diverter installation (Reflective)	2023
1021	Kapaa Substation to Mailihuna Rd	0.0116	Static wire removal	2023
1022	Kapaa Substation to Mailihuna Rd	0.0289	Diverter installation (Reflective)	2023
1022	Kapaa Substation to Mailihuna Rd	0.0289	Static wire removal	2023
1023	Kapaa Substation to Mailihuna Rd	0.0417	Diverter installation (Reflective)	2023
1023	Kapaa Substation to Mailihuna Rd	0.0417	Static wire removal	2023
1024	Kapaa Substation to Mailihuna Rd	0.0340	Diverter installation (Reflective)	2023
1024	Kapaa Substation to Mailihuna Rd	0.0340	Static wire removal	2023
1025	Kapaa Substation to Mailihuna Rd	0.0368	Diverter installation (Reflective)	2023
1025	Kapaa Substation to Mailihuna Rd	0.0368	Static wire removal	2023
1026	Kapaa Substation to Mailihuna Rd	0.0397	Diverter installation (Reflective)	2022

1026	Kapaa Substation to Mailihuna Rd	0.0397	Static wire removal	2023
1027	Kapaa Substation to Mailihuna Rd	0.0368	Diverter installation (Reflective)	2022
1027	Kapaa Substation to Mailihuna Rd	0.0368	Static wire removal	2023
1028	Kapaa Substation to Mailihuna Rd	0.0391	Diverter installation (Reflective)	2022
1028	Kapaa Substation to Mailihuna Rd	0.0391	Static wire removal	2023
1029	Kapaa Substation to Mailihuna Rd	0.0352	Diverter installation (Reflective)	2022
1029	Kapaa Substation to Mailihuna Rd	0.0352	Static wire removal	2023
1030	Kapaa Substation to Mailihuna Rd	0.0362	Diverter installation (Reflective)	2022
1030	Kapaa Substation to Mailihuna Rd	0.0362	Static wire removal	2023
1031	Kapaa Substation to Mailihuna Rd	0.0445	Diverter installation (Reflective)	2022
1031	Kapaa Substation to Mailihuna Rd	0.0445	Static wire removal	2023
1032	Kapaa Substation to Mailihuna Rd	0.0380	Diverter installation (Reflective)	2023
1032	Kapaa Substation to Mailihuna Rd	0.0380	Static wire removal	2023
1033	Kapaa Substation to Mailihuna Rd	0.0407	Diverter installation (Reflective)	2023
1033	Kapaa Substation to Mailihuna Rd	0.0407	Static wire removal	2023
1034	Kapaa Substation to Mailihuna Rd	0.0327	Diverter installation (Reflective)	2023
1034	Kapaa Substation to Mailihuna Rd	0.0327	Static wire removal	2023
1035	Kapaa Substation to Mailihuna Rd	0.0472	Diverter installation (Reflective)	2023
1035	Kapaa Substation to Mailihuna Rd	0.0472	Static wire removal	2023
1036	Kapaa Substation to Mailihuna Rd	0.0472	Diverter installation (Reflective)	2023
1036	Kapaa Substation to Mailihuna Rd	0.0472	Static wire removal	2023
1037	Kapaa Substation to Mailihuna Rd	0.0328	Diverter installation (Reflective)	2023
1037	Kapaa Substation to Mailihuna Rd	0.0328	Static wire removal	2023
1038	Kapaa Substation to Mailihuna Rd	0.0270	Diverter installation (Reflective)	2023
1038	Kapaa Substation to Mailihuna Rd	0.0270	Static wire removal	2023
1039	Kapaa Substation to Mailihuna Rd	0.0345	Diverter installation (Reflective)	2023
1039	Kapaa Substation to Mailihuna Rd	0.0345	Static wire removal	2023
1040	Kapaa Substation to Mailihuna Rd	0.0343	Diverter installation (Reflective)	2022
1040	Kapaa Substation to Mailihuna Rd	0.0343	Static wire removal	2023
1041	Kapaa Substation to Mailihuna Rd	0.0326	Diverter installation (Reflective)	2023
1041	Kapaa Substation to Mailihuna Rd	0.0326	Static wire removal	2023
1042	Kapaa Substation to Mailihuna Rd	0.0402	Diverter installation (Reflective)	2023
1042	Kapaa Substation to Mailihuna Rd	0.0402	Static wire removal	2023
1043	Kapaa Substation to Mailihuna Rd	0.0432	Diverter installation (Reflective)	2023
1043	Kapaa Substation to Mailihuna Rd	0.0432	Static wire removal	2023

1044	Kapaa Substation to Mailihuna Rd	0.0381	Diverter installation (Reflective)	2023
1044	Kapaa Substation to Mailihuna Rd	0.0381	Static wire removal	2023
1045	Kealia Transmission Minimization Project	0.0443	Diverter installation (Reflective)	2023
1045	Kealia Transmission Minimization Project	0.0443	Static wire removal	2023
1046	Kealia Transmission Minimization Project	0.0624	Diverter installation (Reflective)	2022
1046	Kealia Transmission Minimization Project	0.0624	Static wire removal	2023
1047	Kealia Transmission Minimization Project	0.0356	Diverter installation (Reflective)	2022
1047	Kealia Transmission Minimization Project	0.0356	Static wire removal	2023
1048	Kealia Transmission Minimization Project	0.0785	Diverter installation (Reflective)	2022
1048	Kealia Transmission Minimization Project	0.0785	Static wire removal	2023
1049	Kealia Transmission Minimization Project	0.0822	Diverter installation (Reflective)	2022
1049	Kealia Transmission Minimization Project	0.0822	Static wire removal	2023
1050	Kealia Transmission Minimization Project	0.0784	Diverter installation (Reflective)	2022
1050	Kealia Transmission Minimization Project	0.0784	Static wire removal	2023
1051	Kealia Transmission Minimization Project	0.0459	Diverter installation (Reflective)	2022
1051	Kealia Transmission Minimization Project	0.0459	Static wire removal	2023
1052	Kealia Transmission Minimization Project	0.0549	Diverter installation (Reflective)	2022
1052	Kealia Transmission Minimization Project	0.0549	Static wire removal	2023
1053	Kealia Transmission Minimization Project	0.1110	Diverter installation (Reflective)	2022
1053	Kealia Transmission Minimization Project	0.1110	Static wire removal	2023
1054	Kealia Transmission Minimization Project	0.0365	Diverter installation (Reflective)	2022
1054	Kealia Transmission Minimization Project	0.0365	Static wire removal	2023
1055	Kealia Transmission Minimization Project	0.0443	Diverter installation (Reflective)	2022
1055	Kealia Transmission Minimization Project	0.0443	Static wire removal	2023
1056	Kealia Transmission Minimization Project	0.0806	Diverter installation (Reflective)	2022
1056	Kealia Transmission Minimization Project	0.0806	Static wire removal	2023
1057	Kealia to Anahola Substation	0.0321	Diverter installation (Reflective)	2022
1057	Kealia to Anahola Substation	0.0321	Static wire removal	2023
1058	Kealia to Anahola Substation	0.0249	Diverter installation (Reflective)	2022
1058	Kealia to Anahola Substation	0.0249	Static wire removal	2023
1059	Kealia to Anahola Substation	0.0656	Diverter installation (Reflective)	2022
1059	Kealia to Anahola Substation	0.0656	Static wire removal	2023
1060	Kealia to Anahola Substation	0.0802	Diverter installation (Reflective)	2022
1060	Kealia to Anahola Substation	0.0802	Static wire removal	2023
1061	Kealia to Anahola Substation	0.0606	Diverter installation (Reflective)	2022

1061	Kealia to Anahola Substation	0.0606	Static wire removal	2023
1062	Kealia to Anahola Substation	0.0475	Diverter installation (Reflective)	2022
1062	Kealia to Anahola Substation	0.0475	Static wire removal	2023
1063	Kealia to Anahola Substation	0.0816	Diverter installation (Reflective)	2022
1063	Kealia to Anahola Substation	0.0816	Static wire removal	2023
1064	Kealia to Anahola Substation	0.1733	Diverter installation (Reflective)	2022
1064	Kealia to Anahola Substation	0.1733	Static wire removal	2023
1065	Kealia to Anahola Substation	0.0480	Diverter installation (Reflective)	2022
1065	Kealia to Anahola Substation	0.0480	Static wire removal	2023
1066	Kealia to Anahola Substation	0.0580	Diverter installation (Reflective)	2022
1066	Kealia to Anahola Substation	0.0580	Static wire removal	2023
1067	Kealia to Anahola Substation	0.0781	Diverter installation (Reflective)	2022
1067	Kealia to Anahola Substation	0.0781	Static wire removal	2023
1068	Kealia to Anahola Substation	0.0840	Diverter installation (Reflective)	2022
1068	Kealia to Anahola Substation	0.0840	Static wire removal	2023
1069	Kealia to Anahola Substation	0.0588	Diverter installation (Reflective)	2022
1069	Kealia to Anahola Substation	0.0588	Static wire removal	2023
1070	Kealia to Anahola Substation	0.0841	Diverter installation (Reflective)	2022
1070	Kealia to Anahola Substation	0.0841	Static wire removal	2023
1071	Kealia to Anahola Substation	0.0475	Diverter installation (Reflective)	2022
1071	Kealia to Anahola Substation	0.0475	Static wire removal	2023
1072	Kealia to Anahola Substation	0.2423	Diverter installation (Reflective)	2022
1072	Kealia to Anahola Substation	0.2423	Static wire removal	2023
1075.1	Kealia to Anahola Substation	0.0569	Diverter installation (Reflective)	2022
1075.1	Kealia to Anahola Substation	0.0569	Static wire removal	2023
1075.2	Kealia to Anahola Substation	0.0569	Diverter installation (Reflective)	2022
1075.2	Kealia to Anahola Substation	0.0569	Static wire removal	2023
1076	Kealia to Anahola Substation	0.0533	Diverter installation (Reflective)	2022
1076	Kealia to Anahola Substation	0.0533	Static wire removal	2023
1077	Kealia to Anahola Substation	0.0571	Diverter installation (Reflective)	2022
1077	Kealia to Anahola Substation	0.0571	Static wire removal	2023
1078	Kealia to Anahola Substation	0.0563	Diverter installation (Reflective)	2022
1078	Kealia to Anahola Substation	0.0563	Static wire removal	2023
1079	Kealia to Anahola Substation	0.0568	Diverter installation (Reflective)	2022
1079	Kealia to Anahola Substation	0.0568	Static wire removal	2023

1080	Kealia to Anahola Substation	0.0744	Diverter installation (Reflective)	2022
1080	Kealia to Anahola Substation	0.0744	Static wire removal	2023
1081	Kealia to Anahola Substation	0.0227	Diverter installation (Reflective)	2022
1081	Kealia to Anahola Substation	0.0227	Static wire removal	2023
1082	Anahola Substation to Moloaa	0.0714	Static wire removal	2021
1083	Anahola Substation to Moloaa	0.0823	Static wire removal	2021
1084	Anahola Substation to Moloaa	0.0684	Static wire removal	2021
1085	Anahola Substation to Moloaa	0.0412	Static wire removal	2021
1086	Anahola Substation to Moloaa	0.0391	Static wire removal	2021
1087	Anahola Substation to Moloaa	0.0358	Static wire removal	2021
1088	Anahola Substation to Moloaa	0.0386	Static wire removal	2021
1089	Anahola Substation to Moloaa	0.0410	Static wire removal	2021
1090	Anahola Substation to Moloaa	0.0401	Static wire removal	2021
1091	Anahola Substation to Moloaa	0.0377	Static wire removal	2021
1092	Anahola Substation to Moloaa	0.0354	Static wire removal	2021
1093	Anahola Substation to Moloaa	0.0390	Static wire removal	2021
1094	Anahola Substation to Moloaa	0.0412	Static wire removal	2021
1095	Anahola Substation to Moloaa	0.0331	Static wire removal	2021
1096	Anahola Substation to Moloaa	0.0524	static wire removal	2023
1097	Anahola Substation to Moloaa	0.0572	static wire removal	2023
1098	Anahola Substation to Moloaa	0.1054	static wire removal	2023
1099	Anahola Substation to Moloaa	0.0975	static wire removal	2023
1100	Anahola Substation to Moloaa	0.0386	Static wire removal	2021
1101	Anahola Substation to Moloaa	0.0209	Static wire removal	2021
1102	Anahola Substation to Moloaa	0.0714	Static wire removal	2021
1103	Anahola Substation to Moloaa	0.0401	Static wire removal	2021
1104	Anahola Substation to Moloaa	0.0515	Static wire removal	2021
1105	Anahola Substation to Moloaa	0.0341	Static wire removal	2021
1106	Anahola Substation to Moloaa	0.0323	Static wire removal	2021
1107	Anahola Substation to Moloaa	0.0299	Static wire removal	2021
1108	Anahola Substation to Moloaa	0.0430	Static wire removal	2021
1109	Anahola Substation to Moloaa	0.0371	Static wire removal	2021
1110	Anahola Substation to Moloaa	0.0376	Static wire removal	2021
1111	Anahola Substation to Moloaa	0.0298	Static wire removal	2021
1112	Anahola Substation to Moloaa	0.0420	Static wire removal	2021

1113	Anahola Substation to Moloaa	0.0277	Static wire removal	2021
1114	Anahola Substation to Moloaa	0.0385	Static wire removal	2021
1115	Anahola Substation to Moloaa	0.0894	Static wire removal	2021
1116	Anahola Substation to Moloaa	0.0359	Static wire removal	2021
1117	Anahola Substation to Moloaa	0.0379	Static wire removal	2021
1118	Anahola Substation to Moloaa	0.0377	Static wire removal	2021
1119	Anahola Substation to Moloaa	0.0390	static wire removal	2023
1120	Anahola Substation to Moloaa	0.0372	static wire removal	2023
1121	Anahola Substation to Moloaa	0.0376	Static wire removal	2021
1122	Anahola Substation to Moloaa	0.0394	Static wire removal	2021
1123	Anahola Substation to Moloaa	0.0402	Static wire removal	2021
1124	Anahola Substation to Moloaa	0.0407	Static wire removal	2021
1125	Anahola Substation to Moloaa	0.0413	Static wire removal	2021
1126	Anahola Substation to Moloaa	0.0596	Static wire removal	2021
1127	Anahola Substation to Moloaa	0.0610	Static wire removal	2021
1128	Anahola Substation to Moloaa	0.0798	Static wire removal	2021
1129	Anahola Substation to Moloaa	0.0433	Static wire removal	2021
1130	Anahola Substation to Moloaa	0.0777	Static wire removal	2021
1131	Anahola Substation to Moloaa	0.0387	Static wire removal	2021
1132	Anahola Substation to Moloaa	0.0377	Static wire removal	2021
1133	Anahola Substation to Moloaa	0.0663	Static wire removal	2021
1134	Anahola Substation to Moloaa	0.1059	Static wire removal	2021
1135	Anahola Substation to Moloaa	0.0856	Static wire removal	2021
1136	Anahola Substation to Moloaa	0.0936	Static wire removal	2021
1137	Anahola Substation to Moloaa	0.0431	Static wire removal	2021
1138	Anahola Substation to Moloaa	0.0898	Static wire removal	2021
1139	Anahola Substation to Moloaa	0.0839	Static wire removal	2021
1140	Anahola Substation to Moloaa	0.0868	Static wire removal	2021
1141	Anahola Substation to Moloaa	0.0758	Static wire removal	2021
1142	Anahola Substation to Moloaa	0.0841	Static wire removal	2021
1143	Anahola Substation to Moloaa	0.0332	Static wire removal	2021
1144	Anahola Substation to Moloaa	0.0482	Static wire removal	2021
1145	Anahola Substation to Moloaa	0.0687	Static wire removal	2021
1146	Anahola Substation to Moloaa	0.0756	Static wire removal	2021
1147	Anahola Substation to Moloaa	0.0445	Static wire removal	2021

1148	Anahola Substation to Moloaa	0.0373	Static wire removal	2021
1149	Anahola Substation to Moloaa	0.0480	Static wire removal	2021
1150	Anahola Substation to Moloaa	0.0902	Static wire removal	2021
1151	Anahola Substation to Moloaa	0.0388	Static wire removal	2021
1152	Anahola Substation to Moloaa	0.0474	Static wire removal	2021
1153	Anahola Substation to Moloaa	0.0789	Diverter installation (Reflective)	2020
1153	Anahola Substation to Moloaa	0.0789	Static wire removal	2020
1154	Moloaa to Kilauea end of xmission line	0.0782	Diverter installation (Reflective)	2020
1154	Moloaa to Kilauea end of xmission line	0.0782	Static wire removal	2020
1155	Moloaa to Kilauea end of xmission line	0.0826	Diverter installation (Reflective)	2020
1155	Moloaa to Kilauea end of xmission line	0.0826	Static wire removal	2020
1156	Moloaa to Kilauea end of xmission line	0.0526	Diverter installation (Reflective)	2020
1156	Moloaa to Kilauea end of xmission line	0.0526	Static wire removal	2020
1157	Moloaa to Kilauea end of xmission line	0.0498	Diverter installation (Reflective)	2020
1157	Moloaa to Kilauea end of xmission line	0.0498	Static wire removal	2020
1158	Moloaa to Kilauea end of xmission line	0.0504	Diverter installation (Reflective)	2020
1158	Moloaa to Kilauea end of xmission line	0.0504	Static wire removal	2020
1159	Moloaa to Kilauea end of xmission line	0.0966	Diverter installation (Reflective)	2020
1159	Moloaa to Kilauea end of xmission line	0.0966	Static wire removal	2020
1160	Moloaa to Kilauea end of xmission line	0.0490	Diverter installation (Reflective)	2020
1160	Moloaa to Kilauea end of xmission line	0.0490	Static wire removal	2020
1161	Moloaa to Kilauea end of xmission line	0.0492	Diverter installation (Reflective)	2020
1161	Moloaa to Kilauea end of xmission line	0.0492	Static wire removal	2020
1162	Moloaa to Kilauea end of xmission line	0.0488	Diverter installation (Reflective)	2020
1162	Moloaa to Kilauea end of xmission line	0.0488	Static wire removal	2020
1163	Moloaa to Kilauea end of xmission line	0.0433	Diverter installation (Reflective)	2020
1163	Moloaa to Kilauea end of xmission line	0.0433	Static wire removal	2020
1164	Moloaa to Kilauea end of xmission line	0.0418	Diverter installation (Reflective)	2020
1164	Moloaa to Kilauea end of xmission line	0.0418	Static wire removal	2020
1165	Moloaa to Kilauea end of xmission line	0.0503	Diverter installation (Reflective)	2020
1165	Moloaa to Kilauea end of xmission line	0.0503	Static wire removal	2020
1166	Moloaa to Kilauea end of xmission line	0.0467	Diverter installation (Reflective)	2020
1166	Moloaa to Kilauea end of xmission line	0.0467	Static wire removal	2020
1167	Moloaa to Kilauea end of xmission line	0.0472	Diverter installation (Reflective)	2020
1167	Moloaa to Kilauea end of xmission line	0.0472	Static wire removal	2020

1168	Moloaa to Kilauea end of xmission line	0.0464	Diverter installation (Reflective)	2020
1168	Moloaa to Kilauea end of xmission line	0.0464	Static wire removal	2020
1169	Moloaa to Kilauea end of xmission line	0.0932	Diverter installation (Reflective)	2020
1169	Moloaa to Kilauea end of xmission line	0.0932	Static wire removal	2020
1170	Moloaa to Kilauea end of xmission line	0.0995	Diverter installation (Reflective)	2020
1170	Moloaa to Kilauea end of xmission line	0.0995	Static wire removal	2020
1171	Moloaa to Kilauea end of xmission line	0.0937	Diverter installation (Reflective)	2020
1171	Moloaa to Kilauea end of xmission line	0.0937	Static wire removal	2020
1172	Moloaa to Kilauea end of xmission line	0.1010	Diverter installation (Reflective)	2020
1172	Moloaa to Kilauea end of xmission line	0.1010	Static wire removal	2020
1173	Moloaa to Kilauea end of xmission line	0.0478	Diverter installation (Reflective)	2021
1173	Moloaa to Kilauea end of xmission line	0.0478	Diverter installation (Reflective)	2020
1173	Moloaa to Kilauea end of xmission line	0.0478	Static wire removal	2020
1174	Moloaa to Kilauea end of xmission line	0.0785	Diverter installation (Reflective)	2021
1174	Moloaa to Kilauea end of xmission line	0.0785	Diverter installation (Reflective)	2020
1174	Moloaa to Kilauea end of xmission line	0.0785	Static wire removal	2020
1175	Moloaa to Kilauea end of xmission line	0.0458	Diverter installation (Reflective)	2021
1175	Moloaa to Kilauea end of xmission line	0.0458	Static wire removal	2020
1176	Moloaa to Kilauea end of xmission line	0.0829	Static wire removal	2020
1177	Moloaa to Kilauea end of xmission line	0.0761	Diverter installation (Reflective)	2021
1177	Moloaa to Kilauea end of xmission line	0.0761	Static wire removal	2020
1178	Moloaa to Kilauea end of xmission line	0.0712	Diverter installation (Reflective)	2021
1178	Moloaa to Kilauea end of xmission line	0.0712	Static wire removal	2020
1179	Moloaa to Kilauea end of xmission line	0.0909	Diverter installation (Reflective)	2021
1179	Moloaa to Kilauea end of xmission line	0.0909	Static wire removal	2020
1180	Moloaa to Kilauea end of xmission line	0.0596	Diverter installation (Reflective)	2021
1180	Moloaa to Kilauea end of xmission line	0.0596	Static wire removal	2020
1181	Moloaa to Kilauea end of xmission line	0.0505	Diverter installation (Reflective)	2020
1181	Moloaa to Kilauea end of xmission line	0.0505	Static wire removal	2020
1182	Moloaa to Kilauea end of xmission line	0.1072	Diverter installation (Reflective)	2020
1182	Moloaa to Kilauea end of xmission line	0.1072	Static wire removal	2020
1183	Moloaa to Kilauea end of xmission line	0.0862	Diverter installation (Reflective)	2020
1183	Moloaa to Kilauea end of xmission line	0.0862	Static wire removal	2020
1184	Moloaa to Kilauea end of xmission line	0.0451	Diverter installation (Reflective)	2021
1184	Moloaa to Kilauea end of xmission line	0.0451	Static wire removal	2020

1185	Moloaa to Kilauea end of xmission line	0.0462	Diverter installation (Reflective)	2021
1185	Moloaa to Kilauea end of xmission line	0.0462	Static wire removal	2020
1186	Moloaa to Kilauea end of xmission line	0.1041	Diverter installation (Reflective)	2021
1186	Moloaa to Kilauea end of xmission line	0.1041	Static wire removal	2020
1187	Moloaa to Kilauea end of xmission line	0.0469	Diverter installation (Reflective)	2021
1187	Moloaa to Kilauea end of xmission line	0.0469	Static wire removal	2020
1188	Moloaa to Kilauea end of xmission line	0.0474	Diverter installation (Reflective)	2021
1188	Moloaa to Kilauea end of xmission line	0.0474	Static wire removal	2020
1189	Moloaa to Kilauea end of xmission line	0.0461	Diverter installation (Reflective)	2021
1189	Moloaa to Kilauea end of xmission line	0.0461	Static wire removal	2020
1190	Moloaa to Kilauea end of xmission line	0.1110	Diverter installation (Reflective)	2021
1190	Moloaa to Kilauea end of xmission line	0.1110	Static wire removal	2020
1191	Moloaa to Kilauea end of xmission line	0.0380	Diverter installation (Reflective)	2021
1191	Moloaa to Kilauea end of xmission line	0.0380	Static wire removal	2020
1192	Moloaa to Kilauea end of xmission line	0.0378	Diverter installation (Reflective)	2021
1192	Moloaa to Kilauea end of xmission line	0.0378	Static wire removal	2020
1193	Moloaa to Kilauea end of xmission line	0.0455	Static wire removal	2020
1194	Moloaa to Kilauea end of xmission line	0.0452	Diverter installation (Reflective)	2020
1194	Moloaa to Kilauea end of xmission line	0.0452	Static wire removal	2020
1195	Moloaa to Kilauea end of xmission line	0.0442	Diverter installation (Reflective)	2020
1195	Moloaa to Kilauea end of xmission line	0.0442	Static wire removal	2020
1196	Moloaa to Kilauea end of xmission line	0.0596	Diverter installation (Reflective)	2015
1196	Moloaa to Kilauea end of xmission line	0.0596	Static wire removal	2020
1197	Moloaa to Kilauea end of xmission line	0.0382	Diverter installation (Reflective)	2015
1197	Moloaa to Kilauea end of xmission line	0.0382	Static wire removal	2020
1198	Moloaa to Kilauea end of xmission line	0.0476	Diverter installation (Reflective)	2015
1198	Moloaa to Kilauea end of xmission line	0.0476	Static wire removal	2020
1199	Moloaa to Kilauea end of xmission line	0.0525	Diverter installation (Reflective)	2015
1199	Moloaa to Kilauea end of xmission line	0.0525	Static wire removal	2020
1200	Moloaa to Kilauea end of xmission line	0.0495	Diverter installation (Reflective)	2015
1200	Moloaa to Kilauea end of xmission line	0.0495	Static wire removal	2020
1201	Moloaa to Kilauea end of xmission line	0.0509	Diverter installation (Reflective)	2015
1201	Moloaa to Kilauea end of xmission line	0.0509	Static wire removal	2020
1202	Moloaa to Kilauea end of xmission line	0.0458	Diverter installation (Reflective)	2015
1202	Moloaa to Kilauea end of xmission line	0.0458	Static wire removal	2020

1203	Moloaa to Kilauea end of xmission line	0.0451	Diverter installation (Reflective)	2015
1203	Moloaa to Kilauea end of xmission line	0.0451	Static wire removal	2020
1204	Moloaa to Kilauea end of xmission line	0.0483	Diverter installation (Reflective)	2015
1204	Moloaa to Kilauea end of xmission line	0.0483	Static wire removal	2020
1205	Moloaa to Kilauea end of xmission line	0.0469	Diverter installation (Reflective)	2015
1205	Moloaa to Kilauea end of xmission line	0.0469	Static wire removal	2020
1206	Moloaa to Kilauea end of xmission line	0.0480	Diverter installation (Reflective)	2015
1206	Moloaa to Kilauea end of xmission line	0.0480	Static wire removal	2020
1207	Moloaa to Kilauea end of xmission line	0.0489	Diverter installation (Reflective)	2015
1207	Moloaa to Kilauea end of xmission line	0.0489	Static wire removal	2020
1208	Moloaa to Kilauea end of xmission line	0.0503	Diverter installation (Reflective)	2015
1208	Moloaa to Kilauea end of xmission line	0.0503	Static wire removal	2020
1209	Moloaa to Kilauea end of xmission line	0.0483	Diverter installation (Reflective)	2015
1209	Moloaa to Kilauea end of xmission line	0.0483	Static wire removal	2020
1210	Moloaa to Kilauea end of xmission line	0.0495	Diverter installation (Reflective)	2015
1210	Moloaa to Kilauea end of xmission line	0.0495	Static wire removal	2020
1211	Moloaa to Kilauea end of xmission line	0.0510	Diverter installation (Reflective)	2015
1211	Moloaa to Kilauea end of xmission line	0.0510	Static wire removal	2020
1212	Moloaa to Kilauea end of xmission line	0.0493	Diverter installation (Reflective)	2015
1212	Moloaa to Kilauea end of xmission line	0.0493	Static wire removal	2020
1213	Moloaa to Kilauea end of xmission line	0.0512	Diverter installation (Reflective)	2015
1213	Moloaa to Kilauea end of xmission line	0.0512	Static wire removal	2020
1214	Moloaa to Kilauea end of xmission line	0.0473	Diverter installation (Reflective)	2015
1214	Moloaa to Kilauea end of xmission line	0.0473	Static wire removal	2020
1215	Moloaa to Kilauea end of xmission line	0.0658	Diverter installation (Reflective)	2020
1215	Moloaa to Kilauea end of xmission line	0.0658	Static wire removal	2020
1216	Moloaa to Kilauea end of xmission line	0.0489	Diverter installation (Reflective)	2020
1216	Moloaa to Kilauea end of xmission line	0.0489	Static wire removal	2020
1217	Moloaa to Kilauea end of xmission line	0.0463	Diverter installation (Reflective)	2020
1217	Moloaa to Kilauea end of xmission line	0.0463	Static wire removal	2020
1218	Moloaa to Kilauea end of xmission line	0.0475	Diverter installation (Reflective)	2020
1218	Moloaa to Kilauea end of xmission line	0.0475	Static wire removal	2020
1219	Moloaa to Kilauea end of xmission line	0.0512	Diverter installation (Reflective)	2020
1219	Moloaa to Kilauea end of xmission line	0.0512	Static wire removal	2020
1220	Moloaa to Kilauea end of xmission line	0.0472	Diverter installation (Reflective)	2020

1220	Moloaa to Kilauea end of xmission line	0.0472	Static wire removal	2020
1221	Moloaa to Kilauea end of xmission line	0.0923	Diverter installation (Reflective)	2020
1221	Moloaa to Kilauea end of xmission line	0.0923	Static wire removal	2020
1222	Moloaa to Kilauea end of xmission line	0.0478	Diverter installation (Reflective)	2020
1222	Moloaa to Kilauea end of xmission line	0.0478	Static wire removal	2020
1223	Moloaa to Kilauea end of xmission line	0.0516	Diverter installation (Reflective)	2020
1223	Moloaa to Kilauea end of xmission line	0.0516	Static wire removal	2020
1224	Moloaa to Kilauea end of xmission line	0.0701	Diverter installation (Reflective)	2020
1224	Moloaa to Kilauea end of xmission line	0.0701	Static wire removal	2020
1225	Moloaa to Kilauea end of xmission line	0.0577	Diverter installation (Reflective)	2020
1225	Moloaa to Kilauea end of xmission line	0.0577	Static wire removal	2020
1226	Moloaa to Kilauea end of xmission line	0.0472	Diverter installation (Reflective)	2020
1226	Moloaa to Kilauea end of xmission line	0.0472	Static wire removal	2020
1227	Moloaa to Kilauea end of xmission line	0.0386	Diverter installation (Reflective)	2020
1227	Moloaa to Kilauea end of xmission line	0.0386	Static wire removal	2020
1228	Moloaa to Kilauea end of xmission line	0.0793	Diverter installation (Reflective)	2020
1228	Moloaa to Kilauea end of xmission line	0.0793	Static wire removal	2020
1229	Moloaa to Kilauea end of xmission line	0.0766	Diverter installation (Reflective)	2020
1229	Moloaa to Kilauea end of xmission line	0.0766	Static wire removal	2020
1230	Moloaa to Kilauea end of xmission line	0.0403	Diverter installation (Reflective)	2020
1230	Moloaa to Kilauea end of xmission line	0.0403	Static wire removal	2020
1231	Moloaa to Kilauea end of xmission line	0.0390	Diverter installation (Reflective)	2020
1231	Moloaa to Kilauea end of xmission line	0.0390	Static wire removal	2020
1232	Moloaa to Kilauea end of xmission line	0.0534	Diverter installation (Reflective)	2020
1232	Moloaa to Kilauea end of xmission line	0.0534	Static wire removal	2020
1233	Moloaa to Kilauea end of xmission line	0.0654	Diverter installation (Reflective)	2020
1233	Moloaa to Kilauea end of xmission line	0.0654	Static wire removal	2020
1234	Moloaa to Kilauea end of xmission line	0.0383	Diverter installation (Reflective)	2020
1234	Moloaa to Kilauea end of xmission line	0.0383	Static wire removal	2020
1235	Moloaa to Kilauea end of xmission line	0.0416	Diverter installation (Reflective)	2020
1235	Moloaa to Kilauea end of xmission line	0.0416	Static wire removal	2020
1236	Moloaa to Kilauea end of xmission line	0.0405	Diverter installation (Reflective)	2020
1236	Moloaa to Kilauea end of xmission line	0.0405	Static wire removal	2020
1237	Moloaa to Kilauea end of xmission line	0.0366	Diverter installation (Reflective)	2020
1237	Moloaa to Kilauea end of xmission line	0.0366	Static wire removal	2020

1238	Moloaa to Kilauea end of xmission line	0.0380	Diverter installation (Reflective)	2020
1238	Moloaa to Kilauea end of xmission line	0.0380	Static wire removal	2020
1239	Moloaa to Kilauea end of xmission line	0.0464	Diverter installation (Reflective)	2020
1239	Moloaa to Kilauea end of xmission line	0.0464	Static wire removal	2020
1240	Moloaa to Kilauea end of xmission line	0.0331	Diverter installation (Reflective)	2020
1240	Moloaa to Kilauea end of xmission line	0.0331	Static wire removal	2020
1241	Moloaa to Kilauea end of xmission line	0.0741	Diverter installation (Reflective)	2020
1241	Moloaa to Kilauea end of xmission line	0.0741	Static wire removal	2020
1242	Moloaa to Kilauea end of xmission line	0.0491	Diverter installation (Reflective)	2020
1242	Moloaa to Kilauea end of xmission line	0.0491	Static wire removal	2020
1243	Moloaa to Kilauea end of xmission line	0.0385	Diverter installation (Reflective)	2020
1243	Moloaa to Kilauea end of xmission line	0.0385	Static wire removal	2020
1244	Moloaa to Kilauea end of xmission line	0.0369	Diverter installation (Reflective)	2020
1244	Moloaa to Kilauea end of xmission line	0.0369	Static wire removal	2020
1245	Moloaa to Kilauea end of xmission line	0.0327	Diverter installation (Reflective)	2020
1245	Moloaa to Kilauea end of xmission line	0.0327	Static wire removal	2020
1246	Moloaa to Kilauea end of xmission line	0.0467	Diverter installation (Reflective)	2020
1246	Moloaa to Kilauea end of xmission line	0.0467	Static wire removal	2020
1247	Moloaa to Kilauea end of xmission line	0.0382	Diverter installation (Reflective)	2020
1247	Moloaa to Kilauea end of xmission line	0.0382	Static wire removal	2020
1248	Moloaa to Kilauea end of xmission line	0.0469	Diverter installation (Reflective)	2020
1248	Moloaa to Kilauea end of xmission line	0.0469	Static wire removal	2020
1249	Moloaa to Kilauea end of xmission line	0.0483	Diverter installation (Reflective)	2020
1249	Moloaa to Kilauea end of xmission line	0.0483	Static wire removal	2020
1250	Moloaa to Kilauea end of xmission line	0.0625	Diverter installation (Reflective)	2020
1250	Moloaa to Kilauea end of xmission line	0.0625	Static wire removal	2020
1251	Moloaa to Kilauea end of xmission line	0.0199	Diverter installation (Reflective)	2020
1251	Moloaa to Kilauea end of xmission line	0.0199	Static wire removal	2020
1252	Moloaa to Kilauea end of xmission line	0.0314	Diverter installation (Reflective)	2020
1252	Moloaa to Kilauea end of xmission line	0.0314	Static wire removal	2020
1253	Moloaa to Kilauea end of xmission line	0.0414	Diverter installation (Reflective)	2020
1253	Moloaa to Kilauea end of xmission line	0.0414	Static wire removal	2020
1254	Moloaa to Kilauea end of xmission line	0.0540	Diverter installation (Reflective)	2020
1254	Moloaa to Kilauea end of xmission line	0.0540	Static wire removal	2020
1255	Moloaa to Kilauea end of xmission line	0.0378	Diverter installation (Reflective)	2020

1255	Moloaa to Kilauea end of xmission line	0.0378	Static wire removal	2020
1256	Moloaa to Kilauea end of xmission line	0.0402	Diverter installation (Reflective)	2020
1256	Moloaa to Kilauea end of xmission line	0.0402	Static wire removal	2020
1257	Moloaa to Kilauea end of xmission line	0.0399	Diverter installation (Reflective)	2020
1257	Moloaa to Kilauea end of xmission line	0.0399	Static wire removal	2020
1258	Moloaa to Kilauea end of xmission line	0.0379	Diverter installation (Reflective)	2020
1258	Moloaa to Kilauea end of xmission line	0.0379	Static wire removal	2020
1259	Moloaa to Kilauea end of xmission line	0.0383	Diverter installation (Reflective)	2020
1259	Moloaa to Kilauea end of xmission line	0.0383	Static wire removal	2020
1260	Moloaa to Kilauea end of xmission line	0.0396	Diverter installation (Reflective)	2020
1260	Moloaa to Kilauea end of xmission line	0.0396	Static wire removal	2020
1261	Moloaa to Kilauea end of xmission line	0.0384	Diverter installation (Reflective)	2020
1261	Moloaa to Kilauea end of xmission line	0.0384	Static wire removal	2020
1262	Moloaa to Kilauea end of xmission line	0.0462	Diverter installation (Reflective)	2020
1262	Moloaa to Kilauea end of xmission line	0.0462	Static wire removal	2020
1263	Moloaa to Kilauea end of xmission line	0.0481	Diverter installation (Reflective)	2020
1263	Moloaa to Kilauea end of xmission line	0.0481	Static wire removal	2020
1264	Moloaa to Kilauea end of xmission line	0.0480	Diverter installation (Reflective)	2020
1264	Moloaa to Kilauea end of xmission line	0.0480	Static wire removal	2020
1265	Moloaa to Kilauea end of xmission line	0.0415	Diverter installation (Reflective)	2020
1265	Moloaa to Kilauea end of xmission line	0.0415	Static wire removal	2020
1266	Moloaa to Kilauea end of xmission line	0.0231	Diverter installation (Reflective)	2020
1266	Moloaa to Kilauea end of xmission line	0.0231	Static wire removal	2020
1267	Moloaa to Kilauea end of xmission line	0.0446	Diverter installation (Reflective)	2020
1267	Moloaa to Kilauea end of xmission line	0.0446	Static wire removal	2020
1268	Moloaa to Kilauea end of xmission line	0.0437	Diverter installation (Reflective)	2020
1268	Moloaa to Kilauea end of xmission line	0.0437	Static wire removal	2020
1269	Moloaa to Kilauea end of xmission line	0.0385	Diverter installation (Reflective)	2020
1269	Moloaa to Kilauea end of xmission line	0.0385	Static wire removal	2020
1270	Moloaa to Kilauea end of xmission line	0.0383	Diverter installation (Reflective)	2020
1270	Moloaa to Kilauea end of xmission line	0.0383	Static wire removal	2020
1271	Moloaa to Kilauea end of xmission line	0.0372	Diverter installation (Reflective)	2020
1271	Moloaa to Kilauea end of xmission line	0.0372	Static wire removal	2020
1272	Moloaa to Kilauea end of xmission line	0.0355	Diverter installation (Reflective)	2020
1272	Moloaa to Kilauea end of xmission line	0.0355	Static wire removal	2020

1273	Moloaa to Kilauea end of xmission line	0.0426	Diverter installation (Reflective)	2020
1273	Moloaa to Kilauea end of xmission line	0.0426	Static wire removal	2020
1274	Moloaa to Kilauea end of xmission line	0.0370	Diverter installation (Reflective)	2020
1274	Moloaa to Kilauea end of xmission line	0.0370	Static wire removal	2020
1275	Moloaa to Kilauea end of xmission line	0.0429	Diverter installation (Reflective)	2020
1275	Moloaa to Kilauea end of xmission line	0.0429	Static wire removal	2020
1276	Moloaa to Kilauea end of xmission line	0.0401	Diverter installation (Reflective)	2020
1276	Moloaa to Kilauea end of xmission line	0.0401	Static wire removal	2020
1277	Moloaa to Kilauea end of xmission line	0.0428	Diverter installation (Reflective)	2020
1277	Moloaa to Kilauea end of xmission line	0.0428	Static wire removal	2020
1278	Moloaa to Kilauea end of xmission line	0.0385	Diverter installation (Reflective)	2020
1278	Moloaa to Kilauea end of xmission line	0.0385	Static wire removal	2020
1279	Moloaa to Kilauea end of xmission line	0.0403	Diverter installation (Reflective)	2020
1279	Moloaa to Kilauea end of xmission line	0.0403	Static wire removal	2020
1280	Moloaa to Kilauea end of xmission line	0.0541	Diverter installation (Reflective)	2020
1280	Moloaa to Kilauea end of xmission line	0.0541	Static wire removal	2020
1281	Moloaa to Kilauea end of xmission line	0.0495	Diverter installation (Reflective)	2020
1281	Moloaa to Kilauea end of xmission line	0.0495	Static wire removal	2020
1282	Moloaa to Kilauea end of xmission line	0.0474	Diverter installation (Reflective)	2020
1282	Moloaa to Kilauea end of xmission line	0.0474	Static wire removal	2020
1283	Moloaa to Kilauea end of xmission line	0.0386	Diverter installation (Reflective)	2020
1283	Moloaa to Kilauea end of xmission line	0.0386	Static wire removal	2020
1284	Moloaa to Kilauea end of xmission line	0.0355	Diverter installation (Reflective)	2020
1284	Moloaa to Kilauea end of xmission line	0.0355	Static wire removal	2020
1285	Moloaa to Kilauea end of xmission line	0.0429	Diverter installation (Reflective)	2020
1285	Moloaa to Kilauea end of xmission line	0.0429	Static wire removal	2020
1286	Moloaa to Kilauea end of xmission line	0.0444	Diverter installation (Reflective)	2020
1286	Moloaa to Kilauea end of xmission line	0.0444	Static wire removal	2020
1287	Moloaa to Kilauea end of xmission line	0.0491	Diverter installation (Reflective)	2020
1287	Moloaa to Kilauea end of xmission line	0.0491	Static wire removal	2020
1288	Moloaa to Kilauea end of xmission line	0.0991	Diverter installation (Reflective)	2020
1288	Moloaa to Kilauea end of xmission line	0.0991	Static wire removal	2020
1289	Moloaa to Kilauea end of xmission line	0.0361	Diverter installation (Reflective)	2020
1289	Moloaa to Kilauea end of xmission line	0.0361	Static wire removal	2020
1290	Moloaa to Kilauea end of xmission line	0.0696	Diverter installation (Reflective)	2020

1290	Moloaa to Kilauea end of xmission line	0.0696	Static wire removal	2020
1291	Moloaa to Kilauea end of xmission line	0.0467	Diverter installation (Reflective)	2020
1291	Moloaa to Kilauea end of xmission line	0.0467	Static wire removal	2020
1292	Moloaa to Kilauea end of xmission line	0.0467	Diverter installation (Reflective)	2020
1292	Moloaa to Kilauea end of xmission line	0.0467	Static wire removal	2020
1293	Moloaa to Kilauea end of xmission line	0.0477	Diverter installation (Reflective)	2020
1293	Moloaa to Kilauea end of xmission line	0.0477	Static wire removal	2020
1294	Moloaa to Kilauea end of xmission line	0.0482	Diverter installation (Reflective)	2020
1294	Moloaa to Kilauea end of xmission line	0.0482	Static wire removal	2020
1295	Moloaa to Kilauea end of xmission line	0.0531	Diverter installation (Reflective)	2020
1295	Moloaa to Kilauea end of xmission line	0.0531	Static wire removal	2020
1296	Moloaa to Kilauea end of xmission line	0.0514	Diverter installation (Reflective)	2020
1296	Moloaa to Kilauea end of xmission line	0.0514	Static wire removal	2020
1297	Hanalei Tap to Hwy	0.0521	Diverter installation (Reflective)	2023
1298	Hanalei Tap to Hwy	0.0431	Diverter installation (Reflective)	2022
1299	Hanalei Tap to Hwy	0.0494	Diverter installation (Reflective)	2022
1300	Hanalei Tap to Hwy	0.0478	Diverter installation (Reflective)	2022
1301	Hanalei Tap to Hwy	0.0473	Diverter installation (Reflective)	2022
1302	Hanalei Tap to Hwy	0.0454	Diverter installation (Reflective)	2022
1303	Hanalei Tap to Hwy	0.0309	Diverter installation (Reflective)	2023
1304	Hwy Hanalei to Princeville Substation	0.0585	Diverter installation (Reflective)	2022
1305	Hwy Hanalei to Princeville Substation	0.0584	Diverter installation (Reflective)	2022
1306	Hwy Hanalei to Princeville Substation		Diverter installation (Reflective)	2022
1307	Hwy Hanalei to Princeville Substation	0.1123	Diverter installation (Reflective)	2022
1310	Hwy Hanalei to Princeville Substation	0.0275	Diverter installation (Reflective)	2023
1311	Hwy Hanalei to Princeville Substation	0.0275	Diverter installation (Reflective)	2023
1312	Hwy Hanalei to Princeville Substation	0.0438	Diverter installation (Reflective)	2023
1313	Hwy Hanalei to Princeville Substation	0.0689	Diverter installation (Reflective)	2022
1314	Hwy Hanalei to Princeville Substation	0.0528	Diverter installation (Reflective)	2023
1315	Hwy Hanalei to Princeville Substation	0.0575	Diverter installation (Reflective)	2023
1316	Hwy Hanalei to Princeville Substation	0.0556	Diverter installation (Reflective)	2023
1317	Hwy Hanalei to Princeville Substation	0.0561	Diverter installation (Reflective)	2023
1318	Hwy Hanalei to Princeville Substation	0.0545	Diverter installation (Reflective)	2023
1319	Hwy Hanalei to Princeville Substation	0.0365	Diverter installation (Reflective)	2023
1320	Hwy Hanalei to Princeville Substation	0.0993	Diverter installation (Reflective)	2022

1321	None		Diverter installation (Reflective)	2021
1322	Port Allen	0.0427	Diverter installation (Reflective)	2022
1323	Port Allen	0.0638	Diverter installation (Reflective)	2022
1327	Hanalei Tap	0.0088	Diverter installation (Reflective)	2023
1328	Hanalei Tap	0.0078	Diverter installation (Reflective)	2023
1329	Kekaha Substation to Waimea Canyon Dr	0.0552	Diverter installation (Reflective)	2021
1330	Kekaha Substation to Waimea Canyon Dr	0.0526	Diverter installation (Reflective)	2021
1331	Kekaha Substation to Waimea Canyon Dr	0.0583	Diverter installation (Reflective)	2022
1332	Kekaha Substation to Waimea Canyon Dr	0.0574	Diverter installation (Reflective)	2022
1333	Kekaha Substation to Waimea Canyon Dr	0.0502	Diverter installation (Reflective)	2022
1334	Kekaha Substation to Waimea Canyon Dr	0.0512	Diverter installation (Reflective)	2022
1335	Kekaha Substation to Waimea Canyon Dr	0.0540	Diverter installation (Reflective)	2022
1336	Kekaha Substation to Waimea Canyon Dr	0.0563	Diverter installation (Reflective)	2022
1337	Kekaha Substation to Waimea Canyon Dr	0.0567	Diverter installation (Reflective)	2022
1338	Kekaha Substation to Waimea Canyon Dr	0.1075	Diverter installation (Reflective)	2023
1339	Kekaha Substation to Waimea Canyon Dr	0.0423	Diverter installation (LED)	2021
1340	Kekaha Substation to Waimea Canyon Dr	0.0391	Diverter installation (LED)	2021
1341	Kekaha Substation to Waimea Canyon Dr	0.0338	Diverter installation (LED)	2021
1342	Kekaha Substation to Waimea Canyon Dr	0.0407	Diverter installation (LED)	2021
1343	Kekaha Substation to Waimea Canyon Dr	0.0517	Diverter installation (LED)	2021
1344	Kekaha Substation to Waimea Canyon Dr	0.0132	Diverter installation (LED)	2021
1345	Kekaha Substation to Waimea Canyon Dr	0.0768	Diverter installation (LED)	2021
1346	Kekaha Substation to Waimea Canyon Dr	0.0619	Diverter installation (LED)	2023
1347	Kekaha Substation to Waimea Canyon Dr	0.0487	Diverter installation (LED)	2021
1348	Kekaha Substation to Waimea Canyon Dr	0.0486	Diverter installation (LED)	2021
1349	Kekaha Substation to Waimea Canyon Dr	0.0500	Diverter installation (LED)	2021
1350	Kekaha Substation to Waimea Canyon Dr	0.0588	Diverter installation (LED)	2021
1351	Kekaha Substation to Waimea Canyon Dr	0.0401	Diverter installation (LED)	2021
1352	Kekaha Substation to Waimea Canyon Dr	0.0401	Diverter installation (LED)	2021
1353	Kekaha Substation to Waimea Canyon Dr	0.0507	Diverter installation (LED)	2021
1354	Kekaha Substation to Waimea Canyon Dr	0.0517	Diverter installation (LED)	2021
1355	Kekaha Substation to Waimea Canyon Dr	0.0472	Diverter installation (LED)	2021
1356	Kekaha Substation to Waimea Canyon Dr	0.0571	Diverter installation (LED)	2021
1357	Kekaha Substation to Waimea Canyon Dr	0.0560	Diverter installation (LED)	2021
1358	Kekaha Substation to Waimea Canyon Dr	0.0569	Diverter installation (LED)	2021

1359	Kekaha Substation to Waimea Canyon Dr	0.0637	Diverter installation (LED)	2021
1360	Kekaha Substation to Waimea Canyon Dr	0.0415	Diverter installation (LED)	2021
1361	Kekaha Substation to Waimea Canyon Dr	0.0464	Diverter installation (LED)	2021
1362	Kekaha Substation to Waimea Canyon Dr	0.0610	Diverter installation (LED)	2021
1363	Kekaha Substation to Waimea Canyon Dr	0.0397	Diverter installation (LED)	2021
1364	Kekaha Substation to Waimea Canyon Dr	0.0484	Diverter installation (LED)	2021
1365	Kekaha Substation to Waimea Canyon Dr	0.0456	Diverter installation (LED)	2021
1366	Kekaha Substation to Waimea Canyon Dr	0.0504	Diverter installation (Reflective)	2023
1367	Kekaha Substation to Waimea Canyon Dr	0.0523	Diverter installation (Reflective)	2023
1368	Kekaha Substation to Waimea Canyon Dr	0.0500	Diverter installation (Reflective)	2023
1369	Kekaha Substation to Waimea Canyon Dr	0.0500	Diverter installation (Reflective)	2021
1370	Kekaha Substation to Waimea Canyon Dr	0.0500	Diverter installation (Reflective)	2021
1371	Kekaha Substation to Waimea Canyon Dr	0.0501	Diverter installation (Reflective)	2021
1372	Kekaha Substation to Waimea Canyon Dr	0.0493	Diverter installation (Reflective)	2021
1373	Kekaha Substation to Waimea Canyon Dr	0.0575	Diverter installation (Reflective)	2021
1374	Kekaha Substation to Waimea Canyon Dr	0.0560	Diverter installation (Reflective)	2021
1375	Kekaha Substation to Waimea Canyon Dr	0.0570	Diverter installation (Reflective)	2021
1376	Kekaha Substation to Waimea Canyon Dr	0.0414	Diverter installation (Reflective)	2021
1377	Kekaha Substation to Waimea Canyon Dr	0.0523	Diverter installation (Reflective)	2021
1378	Kekaha Substation to Waimea Canyon Dr	0.0600	Diverter installation (Reflective)	2021
1379	Kekaha Substation to Waimea Canyon Dr	0.0394	Diverter installation (Reflective)	2020
1380	Kekaha Substation to Waimea Canyon Dr	0.0373	Diverter installation (Reflective)	2020
1381	Kekaha Substation to Waimea Canyon Dr	0.0519	Diverter installation (Reflective)	2020
1382	Kekaha Substation to Waimea Canyon Dr	0.0437	Diverter installation (Reflective)	2020
1383	Kekaha Substation to Waimea Canyon Dr	0.0556	Diverter installation (Reflective)	2020
1384	Kekaha Substation to Waimea Canyon Dr	0.0390	Diverter installation (Reflective)	2020
1385	Kekaha Substation to Waimea Canyon Dr	0.0422	Diverter installation (Reflective)	2020
1386	Kekaha Substation to Waimea Canyon Dr	0.0418	Diverter installation (Reflective)	2020
1387	Kekaha Substation to Waimea Canyon Dr	0.0503	Diverter installation (Reflective)	2020
1388	Kekaha Substation to Waimea Canyon Dr	0.0458	Diverter installation (Reflective)	2020
1389	Kekaha Substation to Waimea Canyon Dr	0.0466	Diverter installation (Reflective)	2020
1390	Kekaha Substation to Waimea Canyon Dr	0.0465	Diverter installation (Reflective)	2020
1391	Kekaha Substation to Waimea Canyon Dr	0.0498	Diverter installation (Reflective)	2020
1392	Kekaha Substation to Waimea Canyon Dr	0.0510	Diverter installation (Reflective)	2020
1393	Kekaha Substation to Waimea Canyon Dr	0.0605	Diverter installation (Reflective)	2020

1394	Kekaha Substation to Waimea Canyon Dr	0.0604	Diverter installation (Reflective)	2020
1395	Kekaha Substation to Waimea Canyon Dr	0.0585	Diverter installation (Reflective)	2020
1396	Kekaha Substation to Waimea Canyon Dr	0.0564	Diverter installation (Reflective)	2020
1397	Kekaha Substation to Waimea Canyon Dr	0.0563	Diverter installation (Reflective)	2020
1398	Kekaha Substation to Waimea Canyon Dr	0.0664	Diverter installation (Reflective)	2020
1399	Kekaha Substation to Waimea Canyon Dr	0.0407	Diverter installation (Reflective)	2020
1400	Kekaha Substation to Waimea Canyon Dr	0.0472	Diverter installation (Reflective)	2020
1401	Kekaha Substation to Waimea Canyon Dr	0.0558	Diverter installation (Reflective)	2020
1402	Kekaha Substation to Waimea Canyon Dr	0.0483	Diverter installation (Reflective)	2020
1403	Kekaha Substation to Waimea Canyon Dr	0.0427	Diverter installation (Reflective)	2021
1404	Waimea Canyon Dr to Canyon Overlook	0.0391	Diverter installation (Reflective)	2021
1405	Waimea Canyon Dr to Canyon Overlook	0.0566	Diverter installation (Reflective)	2021
1406	Waimea Canyon Dr to Canyon Overlook	0.0478	Diverter installation (Reflective)	2022
1407	Waimea Canyon Dr to Canyon Overlook	0.0489	Diverter installation (Reflective)	2022
1408	Waimea Canyon Dr to Canyon Overlook	0.0531	Diverter installation (Reflective)	2022
1409	Waimea Canyon Dr to Canyon Overlook	0.0438	Diverter installation (Reflective)	2022
1410	Waimea Canyon Dr to Canyon Overlook	0.0503	Diverter installation (Reflective)	2022
1411	Waimea Canyon Dr to Canyon Overlook	0.0468	Diverter installation (Reflective)	2022
1412	Waimea Canyon Dr to Canyon Overlook	0.0503	Diverter installation (Reflective)	2022
1413	Waimea Canyon Dr to Canyon Overlook	0.0518	Diverter installation (Reflective)	2022
1414	Waimea Canyon Dr to Canyon Overlook	0.0563	Diverter installation (Reflective)	2022
1415	Waimea Canyon Dr to Canyon Overlook	0.0373	Diverter installation (Reflective)	2022
1416	Waimea Canyon Dr to Canyon Overlook	0.0370	Diverter installation (Reflective)	2022
1417	Waimea Canyon Dr to Canyon Overlook	0.0714	Diverter installation (Reflective)	2023
1418	Waimea Canyon Dr to Canyon Overlook	0.0459	Diverter installation (Reflective)	2023
1419	Waimea Canyon Dr to Canyon Overlook	0.0416	Diverter installation (Reflective)	2023
1420	Waimea Canyon Dr to Canyon Overlook	0.0450	Diverter installation (Reflective)	2023
1421	Waimea Canyon Dr to Canyon Overlook	0.0927	Diverter installation (Reflective)	2023
1422	Waimea Canyon Dr to Canyon Overlook	0.0493	Diverter installation (Reflective)	2022
1423	Waimea Canyon Dr to Canyon Overlook	0.0438	Diverter installation (Reflective)	2022
1424	Waimea Canyon Dr to Canyon Overlook	0.0515	Diverter installation (Reflective)	2023
1425	Waimea Canyon Dr to Canyon Overlook	0.0582	Diverter installation (Reflective)	2023
1426	Waimea Canyon Dr to Canyon Overlook	0.0438	Diverter installation (Reflective)	2023
1427	Waimea Canyon Dr to Canyon Overlook	0.0408	Diverter installation (Reflective)	2023
1428	Waimea Canyon Dr to Canyon Overlook	0.0386	Diverter installation (Reflective)	2021

1429	Waimea Canyon Dr to Canyon Overlook	0.0378	Diverter installation (Reflective)	2021
1430	Waimea Canyon Dr to Canyon Overlook	0.0440	Diverter installation (Reflective)	2023
1431	Waimea Canyon Dr to Canyon Overlook	0.0603	Diverter installation (Reflective)	2021
1432	Waimea Canyon Dr to Canyon Overlook	0.0535	Diverter installation (Reflective)	2021
1433	Waimea Canyon Dr to Canyon Overlook	0.0492	Diverter installation (Reflective)	2021
1434	Waimea Canyon Dr to Canyon Overlook	0.0584	Diverter installation (Reflective)	2021
1435	Waimea Canyon Dr to Canyon Overlook	0.0480	Diverter installation (Reflective)	2021
1436	Waimea Canyon Dr to Canyon Overlook	0.0504	Diverter installation (Reflective)	2021
1437	Waimea Canyon Dr to Canyon Overlook	0.0945	Diverter installation (Reflective)	2023
1438	Waimea Canyon Dr to Canyon Overlook	0.0548	Diverter installation (Reflective)	2023
1439	Waimea Canyon Dr to Canyon Overlook	0.0545	Diverter installation (Reflective)	2023
1440	Waimea Canyon Dr to Canyon Overlook	0.1188	Diverter installation (Reflective)	2023
1441	Waimea Canyon Dr to Canyon Overlook	0.0893	Diverter installation (Reflective)	2023
1442	Waimea Canyon Dr to Canyon Overlook	0.0567	Diverter installation (Reflective)	2023
1443	Waimea Canyon Dr to Canyon Overlook	0.0574	Diverter installation (Reflective)	2023
1444	Waimea Canyon Dr to Canyon Overlook	0.0571	Diverter installation (Reflective)	2023
1445	Waimea Canyon Dr to Canyon Overlook	0.0521	Diverter installation (Reflective)	2023
1446	Waimea Canyon Dr to Canyon Overlook	0.0475	Diverter installation (Reflective)	2023
1447	Waimea Canyon Dr to Canyon Overlook	0.0663	Diverter installation (Reflective)	2023
1448	Waimea Canyon Dr to Canyon Overlook	0.0986	Diverter installation (Reflective)	2023
1449	Waimea Canyon Dr to Canyon Overlook	0.0708	Diverter installation (Reflective)	2023
1450	Waimea Canyon Dr to Canyon Overlook	0.1314	Diverter installation (Reflective)	2023
1451	Waimea Canyon Dr to Canyon Overlook	0.0865	Diverter installation (Reflective)	2023
1452	Waimea Canyon Dr to Canyon Overlook	0.0400	Diverter installation (Reflective)	2023
1453	Waimea Canyon Dr to Canyon Overlook	0.0476	Diverter installation (Reflective)	2023
1454	Waimea Canyon Dr to Canyon Overlook	0.0049	Diverter installation (Reflective)	2023
1455	Waimea Canyon Dr to Canyon Overlook	0.0069	Diverter installation (Reflective)	2023
1456	Waimea Canyon Dr to Canyon Overlook	0.0434	Diverter installation (Reflective)	2021
1457	Waimea Canyon Dr to Canyon Overlook	0.0697	Diverter installation (Reflective)	2023
1458	Waimea Canyon Dr to Canyon Overlook	0.0519	Diverter installation (Reflective)	2023
1459	Waimea Canyon Dr to Canyon Overlook	0.0461	Diverter installation (Reflective)	2023
1460	Waimea Canyon Dr to Canyon Overlook	0.0472	Diverter installation (Reflective)	2023
1461	Waimea Canyon Dr to Canyon Overlook	0.0426	Diverter installation (Reflective)	2023
1462	Waimea Canyon Dr to Canyon Overlook	0.0488	Diverter installation (Reflective)	2023
1463	Waimea Canyon Dr to Canyon Overlook	0.0388	Diverter installation (Reflective)	2023

1466	Waimea Canyon Dr to Canyon Overlook	0.0612	Diverter installation (Reflective)	2023
1467	Waimea Canyon Dr to Canyon Overlook	0.0502	Diverter installation (Reflective)	2023
1468	Waimea Canyon Dr to Canyon Overlook	0.0482	Diverter installation (Reflective)	2023
1469	Waimea Canyon Dr to Canyon Overlook	0.0492	Diverter installation (Reflective)	2023
1470	Waimea Canyon Dr to Canyon Overlook	0.0540	Diverter installation (Reflective)	2023
1471	Waimea Canyon Dr to Canyon Overlook	0.0557	Diverter installation (Reflective)	2023
1472	Waimea Canyon Dr to Canyon Overlook	0.0555	Diverter installation (Reflective)	2023
1473	Waimea Canyon Dr to Canyon Overlook	0.0440	Diverter installation (Reflective)	2023
1474	Waimea Canyon Dr to Canyon Overlook	0.0677	Diverter installation (Reflective)	2023
1475	Waimea Canyon Dr to Canyon Overlook	0.1154	Diverter installation (Reflective)	2023
1476	Waimea Canyon Dr to Canyon Overlook	0.0404	Diverter installation (Reflective)	2023
1477	Waimea Canyon Dr to Canyon Overlook	0.0351	Diverter installation (Reflective)	2023
1478	Waimea Canyon Dr to Canyon Overlook	0.0605	Diverter installation (Reflective)	2023
1479	Waimea Canyon Dr to Canyon Overlook	0.0448	Diverter installation (Reflective)	2023
1480	Waimea Canyon Dr to Canyon Overlook	0.0480	Diverter installation (Reflective)	2023
1481	Waimea Canyon Dr to Canyon Overlook	0.0596	Diverter installation (Reflective)	2023
1482	Waimea Canyon Dr to Canyon Overlook	0.0363	Diverter installation (Reflective)	2023
1483	Waimea Canyon Dr to Canyon Overlook	0.0427	Diverter installation (Reflective)	2023
1484	Waimea Canyon Dr to Canyon Overlook	0.0362	Diverter installation (Reflective)	2023
1485	Waimea Canyon Dr to Canyon Overlook	0.0422	Diverter installation (Reflective)	2023
1486	Waimea Canyon Dr to Canyon Overlook	0.0579	Diverter installation (Reflective)	2023
1487	Waimea Canyon Dr to Canyon Overlook	0.0572	Diverter installation (Reflective)	2023
1488	Waimea Canyon Dr to Canyon Overlook	0.0619	Diverter installation (Reflective)	2023
1489	Waimea Canyon Dr to Canyon Overlook	0.0674	Diverter installation (Reflective)	2023
1490	Waimea Canyon Dr to Canyon Overlook	0.0577	Diverter installation (Reflective)	2023
1491	Waimea Canyon Dr to Canyon Overlook	0.0693	Diverter installation (Reflective)	2023
1492	Canyon Overlook to Pua Lua	0.0680	Diverter installation (Reflective)	2023
1493	Canyon Overlook to Pua Lua	0.0401	Diverter installation (Reflective)	2023
1494	Canyon Overlook to Pua Lua	0.0293	Diverter installation (Reflective)	2023
1495	Canyon Overlook to Pua Lua	0.0482	Diverter installation (Reflective)	2023
1496	Canyon Overlook to Pua Lua	0.0545	Diverter installation (Reflective)	2023
1497	Canyon Overlook to Pua Lua	0.0788	Diverter installation (Reflective)	2023
1498	Canyon Overlook to Pua Lua	0.0660	Diverter installation (Reflective)	2023
1499	Canyon Overlook to Pua Lua	0.0613	Diverter installation (Reflective)	2023
1500	Canyon Overlook to Pua Lua	0.0376	Diverter installation (Reflective)	2023

1501	Canyon Overlook to Pua Lua	0.0560	Diverter installation (Reflective)	2023
1502	Canyon Overlook to Pua Lua	0.0625	Diverter installation (Reflective)	2023
1503	Canyon Overlook to Pua Lua	0.0563	Diverter installation (Reflective)	2023
1504	Canyon Overlook to Pua Lua	0.0483	Diverter installation (Reflective)	2023
1505	Canyon Overlook to Pua Lua	0.0534	Diverter installation (Reflective)	2023
1506	Canyon Overlook to Pua Lua	0.0420	Diverter installation (Reflective)	2023
1507	Canyon Overlook to Pua Lua	0.0469	Diverter installation (Reflective)	2023
1508	Canyon Overlook to Pua Lua	0.0960	Diverter installation (Reflective)	2023
1509	Canyon Overlook to Pua Lua	0.0633	Diverter installation (Reflective)	2023
1510	Canyon Overlook to Pua Lua	0.0500	Diverter installation (Reflective)	2023
1511	Canyon Overlook to Pua Lua	0.0517	Diverter installation (Reflective)	2023
1512	Canyon Overlook to Pua Lua	0.0539	Diverter installation (Reflective)	2023
1513	Canyon Overlook to Pua Lua	0.0441	Diverter installation (Reflective)	2023
1514	Canyon Overlook to Pua Lua	0.0726	Diverter installation (Reflective)	2023
1515	Canyon Overlook to Pua Lua	0.0645	Diverter installation (Reflective)	2023
1516	Canyon Overlook to Pua Lua	0.0737	Diverter installation (Reflective)	2023
1517	Canyon Overlook to Pua Lua	0.0655	Diverter installation (Reflective)	2023
1518	Canyon Overlook to Pua Lua	0.0667	Diverter installation (Reflective)	2023
1519	Canyon Overlook to Pua Lua	0.0311	Diverter installation (Reflective)	2023
1520	Canyon Overlook to Pua Lua	0.0516	Diverter installation (Reflective)	2023
1521	Pua Lua to NASA	0.0426	Diverter installation (Reflective)	2023
1522	Pua Lua to NASA	0.0326	Diverter installation (Reflective)	2023
1523	Pua Lua to NASA	0.0356	Diverter installation (Reflective)	2023
1524	Pua Lua to NASA	0.0324	Diverter installation (Reflective)	2023
1525	Pua Lua to NASA	0.0451	Diverter installation (Reflective)	2023
1526	Pua Lua to NASA	0.0757	Diverter installation (Reflective)	2023
1527	Pua Lua to NASA	0.0598	Diverter installation (Reflective)	2023
1530	Pua Lua to NASA	0.0437	Diverter installation (Reflective)	2023
1531	Pua Lua to NASA	0.0370	Diverter installation (Reflective)	2023
1532	Pua Lua to NASA	0.0561	Diverter installation (Reflective)	2023
1533	Pua Lua to NASA	0.0531	Diverter installation (Reflective)	2023
1534	Pua Lua to NASA	0.0599	Diverter installation (Reflective)	2023
1535	Pua Lua to NASA	0.0582	Diverter installation (Reflective)	2023
1536	Pua Lua to NASA	0.0671	Diverter installation (Reflective)	2023
1537	Pua Lua to NASA	0.0731	Diverter installation (Reflective)	2023

1538	Pua Lua to NASA	0.0732	Diverter installation (Reflective)	2023
1539	Pua Lua to NASA	0.0366	Diverter installation (Reflective)	2023
1540	Pua Lua to NASA	0.0610	Diverter installation (Reflective)	2023
1541	Pua Lua to NASA	0.0659	Diverter installation (Reflective)	2023
1542	Pua Lua to NASA	0.0745	Diverter installation (Reflective)	2023
1543	Pua Lua to NASA	0.0353	Diverter installation (Reflective)	2023
1544	Pua Lua to NASA	0.0340	Diverter installation (Reflective)	2023
1545	Pua Lua to NASA	0.0675	Diverter installation (Reflective)	2023
1546	Pua Lua to NASA	0.0689	Diverter installation (Reflective)	2023
1547	Pua Lua to NASA	0.0555	Diverter installation (Reflective)	2023
1548	Pua Lua to NASA	0.0998	Diverter installation (Reflective)	2023
1549	Pua Lua to NASA	0.0429	Diverter installation (Reflective)	2023
1550	Pua Lua to NASA	0.0373	Diverter installation (Reflective)	2023
1551	Pua Lua to NASA	0.0405	Diverter installation (Reflective)	2023
1552	Pua Lua to NASA	0.0412	Diverter installation (Reflective)	2023
1553	Pua Lua to NASA	0.0343	Diverter installation (Reflective)	2023
1554	Pua Lua to NASA	0.0594	Diverter installation (Reflective)	2023
1555	Pua Lua to NASA	0.0676	Diverter installation (Reflective)	2023
1556	Pua Lua to NASA	0.0593	Diverter installation (Reflective)	2023
1557	Pua Lua to NASA	0.0624	Diverter installation (Reflective)	2023
1558	Pua Lua to NASA	0.0525	Diverter installation (Reflective)	2023
1559	Pua Lua to NASA	0.0315	Diverter installation (Reflective)	2023
1560	Pua Lua to NASA	0.0474	Diverter installation (Reflective)	2023
1561	Pua Lua to NASA	0.0555	Diverter installation (Reflective)	2023
1562	Pua Lua to NASA	0.0392	Diverter installation (Reflective)	2023
1563	Pua Lua to NASA	0.0547	Diverter installation (Reflective)	2023
1564	Pua Lua to NASA	0.0464	Diverter installation (Reflective)	2023
1565	NASA to Kokee Nature Center	0.0366	Diverter installation (Reflective)	2023
1566	NASA to Kokee Nature Center	0.0468	Diverter installation (Reflective)	2023
1567	NASA to Kokee Nature Center	0.0373	Diverter installation (Reflective)	2023
1568	NASA to Kokee Nature Center	0.0532	Diverter installation (Reflective)	2023
1569	NASA to Kokee Nature Center	0.0671	Diverter installation (Reflective)	2023
1570	NASA to Kokee Nature Center	0.0545	Diverter installation (Reflective)	2023
1571	NASA to Kokee Nature Center	0.0434	Diverter installation (Reflective)	2023
1572	NASA to Kokee Nature Center	0.0290	Diverter installation (Reflective)	2023

1573	NASA to Kokee Nature Center	0.0470	Diverter installation (Reflective)	2023
1574	NASA to Kokee Nature Center	0.0515	Diverter installation (Reflective)	2023
1575	NASA to Kokee Nature Center	0.0509	Diverter installation (Reflective)	2023
1576	NASA to Kokee Nature Center	0.0518	Diverter installation (Reflective)	2023
1577	NASA to Kokee Nature Center	0.0638	Diverter installation (Reflective)	2023
1578	NASA to Kokee Nature Center	0.0536	Diverter installation (Reflective)	2023
1579	NASA to Kokee Nature Center	0.0568	Diverter installation (Reflective)	2023
1580	NASA to Kokee Nature Center	0.0606	Diverter installation (Reflective)	2023
1581	NASA to Kokee Nature Center	0.0580	Diverter installation (Reflective)	2023
1582	NASA to Kokee Nature Center	0.0394	Diverter installation (Reflective)	2023
1583	NASA to Kokee Nature Center	0.0609	Diverter installation (Reflective)	2023
1584	NASA to Kokee Nature Center	0.0601	Diverter installation (Reflective)	2023
1585	Kokee Nature Center to Makaha Ridge	0.0516	Diverter installation (Reflective)	2023
1586	Kokee Nature Center to Makaha Ridge	0.0532	Diverter installation (Reflective)	2023
1587	Kokee Nature Center to Makaha Ridge	0.0631	Diverter installation (Reflective)	2023
1588	Kokee Nature Center to Makaha Ridge	0.0654	Diverter installation (Reflective)	2023
1589	Kokee Nature Center to Makaha Ridge	0.0608	Diverter installation (Reflective)	2023
1590	Kokee Nature Center to Makaha Ridge	0.0615	Diverter installation (Reflective)	2023
1591	Kokee Nature Center to Makaha Ridge	0.0665	Diverter installation (Reflective)	2023
1592	Kokee Nature Center to Makaha Ridge	0.0792	Diverter installation (Reflective)	2023
1593	Kokee Nature Center to Makaha Ridge	0.0254	Diverter installation (Reflective)	2023
1594	Kokee Nature Center to Makaha Ridge	0.0461	Diverter installation (Reflective)	2023
1595	Kokee Nature Center to Makaha Ridge	0.0518	Diverter installation (Reflective)	2023
1596	Kokee Nature Center to Makaha Ridge	0.0520	Diverter installation (Reflective)	2023
1597	Kokee Nature Center to Makaha Ridge	0.0418	Diverter installation (Reflective)	2023
1598	Kokee Nature Center to Makaha Ridge	0.0521	Diverter installation (Reflective)	2023
1599	Kokee Nature Center to Makaha Ridge	0.0741	Diverter installation (Reflective)	2023
1600	Kokee Nature Center to Makaha Ridge	0.0519	Diverter installation (Reflective)	2023
1601	Kokee Nature Center to Makaha Ridge	0.0398	Diverter installation (Reflective)	2023
1602	Kokee Nature Center to Makaha Ridge	0.0396	Diverter installation (Reflective)	2023
1603	Kokee Nature Center to Makaha Ridge	0.0554	Diverter installation (Reflective)	2023
1604	Kokee Nature Center to Makaha Ridge	0.0705	Diverter installation (Reflective)	2023
1605	Kokee Nature Center to Makaha Ridge	0.0585	Diverter installation (Reflective)	2023
1606	Kokee Nature Center to Makaha Ridge	0.0535	Diverter installation (Reflective)	2023
1607	Kokee Nature Center to Makaha Ridge	0.0557	Diverter installation (Reflective)	2023

1608	Kokee Nature Center to Makaha Ridge	0.0682	Diverter installation (Reflective)	2023
1609	Kokee Nature Center to Makaha Ridge	0.0642	Diverter installation (Reflective)	2023
1610	Kokee Nature Center to Makaha Ridge	0.0588	Diverter installation (Reflective)	2023
1611	Kokee Nature Center to Makaha Ridge	0.0298	Diverter installation (Reflective)	2023
1612	Kokee Nature Center to Makaha Ridge	0.0306	Diverter installation (Reflective)	2023
1613	Kokee Nature Center to Makaha Ridge	0.0543	Diverter installation (Reflective)	2023
1614	Kokee Nature Center to Makaha Ridge	0.0601	Diverter installation (Reflective)	2023
1615	Kokee Nature Center to Makaha Ridge	0.0561	Diverter installation (Reflective)	2023
1616	Kokee Nature Center to Makaha Ridge	0.0580	Diverter installation (Reflective)	2023
1617	Kokee Nature Center to Makaha Ridge	0.0618	Diverter installation (Reflective)	2023
1618	Kokee Nature Center to Makaha Ridge	0.0626	Diverter installation (Reflective)	2023
1619	Kokee Nature Center to Makaha Ridge	0.0604	Diverter installation (Reflective)	2023
1620	Kokee Nature Center to Makaha Ridge	0.0641	Diverter installation (Reflective)	2023
1621	Kokee Nature Center to Makaha Ridge	0.0531	Diverter installation (Reflective)	2023
1622	Kokee Nature Center to Makaha Ridge	0.0439	Diverter installation (Reflective)	2023
1623	Kokee Nature Center to Makaha Ridge	0.0443	Diverter installation (Reflective)	2023
1624	Kokee Nature Center to Makaha Ridge	0.0620	Diverter installation (Reflective)	2023
1625	Kokee Nature Center to Makaha Ridge	0.0567	Diverter installation (Reflective)	2023
1626	Kokee Nature Center to Makaha Ridge	0.0299	Diverter installation (Reflective)	2023
1627	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0278	Diverter installation (Reflective)	2022
1628	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0431	Diverter installation (Reflective)	2022
1629	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0408	Diverter installation (Reflective)	2022
1630	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0878	Diverter installation (Reflective)	2022
1631	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0438	Diverter installation (Reflective)	2022
1632	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0701	Diverter installation (Reflective)	2022
1633	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0347	Diverter installation (Reflective)	2022
1634	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0327	Diverter installation (Reflective)	2022
1635	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0228	Diverter installation (Reflective)	2022
1636	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0231	Diverter installation (Reflective)	2022
1637	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0262	Diverter installation (Reflective)	2022
1638	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0250	Diverter installation (Reflective)	2022
1639	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0145	Diverter installation (Reflective)	2022
1640	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0292	Diverter installation (Reflective)	2022
1641	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0278	Diverter installation (Reflective)	2022
1642	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0217	Diverter installation (Reflective)	2022

1643	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0169	Diverter installation (Reflective)	2022
1644	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0200	Diverter installation (Reflective)	2022
1645	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0190	Diverter installation (Reflective)	2022
1646	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0286	Diverter installation (Reflective)	2022
1647	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0311	Diverter installation (Reflective)	2022
1648	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0318	Diverter installation (Reflective)	2022
1649	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0324	Diverter installation (Reflective)	2022
1650	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0284	Diverter installation (Reflective)	2022
1651	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0275	Diverter installation (Reflective)	2022
1652	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0273	Diverter installation (Reflective)	2022
1653	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0370	Diverter installation (Reflective)	2022
1654	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0295	Diverter installation (Reflective)	2022
1655	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0272	Diverter installation (Reflective)	2022
1656	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0359	Diverter installation (Reflective)	2022
1657	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0308	Diverter installation (Reflective)	2022
1658	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0277	Diverter installation (Reflective)	2022
1659	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0283	Diverter installation (Reflective)	2022
1660	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0147	Diverter installation (Reflective)	2022
1661	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0406	Diverter installation (Reflective)	2022
1662	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0637	Diverter installation (Reflective)	2022
1663	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0764	Diverter installation (Reflective)	2022
1664	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0766	Diverter installation (Reflective)	2022
1665	Kekaha Mauka 57kV to Port Allen/Kapaa	0.2129	Diverter installation (Reflective)	2022
1666.1	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0849	Diverter installation (Reflective)	2022
1666.2	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0849	Diverter installation (Reflective)	2023
1667	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0552	Diverter installation (Reflective)	2023
1670	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0437	Diverter installation (Reflective)	2023
1671	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0538	Diverter installation (Reflective)	2022
1672	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0521	Diverter installation (Reflective)	2022
1673	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0327	Diverter installation (Reflective)	2022
1674	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0432	Diverter installation (Reflective)	2022
1675	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0341	Diverter installation (Reflective)	2022
1676	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0339	Diverter installation (Reflective)	2022
1677	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0394	Diverter installation (Reflective)	2022
1678	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0496	Diverter installation (Reflective)	2022

1679	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0627	Diverter installation (Reflective)	2023
1680	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0324	Diverter installation (Reflective)	2023
1681	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0449	Diverter installation (Reflective)	2023
1682	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0383	Diverter installation (Reflective)	2023
1683	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0322	Diverter installation (Reflective)	2022
1684	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0393	Diverter installation (Reflective)	2022
1685	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0425	Diverter installation (Reflective)	2022
1686	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0456	Diverter installation (Reflective)	2022
1687	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0302	Diverter installation (Reflective)	2023
1688	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0826	Diverter installation (Reflective)	2023
1689	Kekaha Mauka 57kV to Port Allen/Kapaa	0.0454	Diverter installation (Reflective)	2023
1691	Puu Lua Kokee	0.0356	Diverter installation (Reflective)	2023
2021	Kahili	0.0739	Diverter installation (LED)	2023
2022	Kahili	0.0697	Diverter installation (LED)	2023
2023	Kahili	0.0766	Diverter installation (LED)	2023
2024	Kahili	0.0641	Diverter installation (LED)	2023
2025	Kahili	0.1053	Diverter installation (LED)	2023
2026	Kahili	0.1328	Diverter installation (LED)	2023
2027	Kahili	0.0875	Diverter installation (LED)	2023
2028	Kahili	0.0616	Diverter installation (LED)	2023
2029	Kahili	0.2727	Diverter installation (LED)	2023
2030	Kahili	0.4821	Underground	2015
2031	Kahili	0.0308	Diverter installation (LED)	2023
2032	Kahili	0.1233	Diverter installation (LED)	2023

Appendix 4C

Best Management Practices for Invasive Plan Species Control

Australian Tree Ferns- ***Cyathea cooperi****,* ATF - ATF's are widespread throughout ULP and although control has been done for years, it is still common to encounter large ferns while doing weed work. It is most common to find them in disturbed areas such as clearings and landslides although they can be present anywhere. ATFs can be identified by having many stiff, upright/horizontal fronds covered in thick white scales. Generally the fronds are far more numerous than the native hapu'u fern and form a definitive round "helicopter" top. In areas where large ferns were killed in the past there will often be many regenerating seedlings and juveniles. ATF's can be very difficult to kill. Common knowledge is that you can cut the trees down without using herbicide and the trunk or remaining crown will not re-sprout. It has been found that this is not the case in the ULP, possibly due to the wet environment.

Herbicide Used- 30% Habitat.

Control Method-

- Seedlings- For seedlings of ATF's up to one foot tall it is best to pull the plant, and hike out the remaining meristem and root ball. Fronds can be removed.
- Juveniles- The main meristem on Juvenile ATF's can almost always be reached. If this is possible first remove all fronds so that you can access the top of the meristem where new croziers (curled fronds) are sprouting up. Using a saw, cut down into the stalk about 8 inches from both sides to remove a large V-shaped wedge. It is important that you have cut far enough down to reach the starchy heart of the fern. Remove the V-shaped wedge and apply Habitat to the main stem and the wedge piece then. Following this replace the wedge back in the main stem. Replacing the wedge assists in keeping rain from washing away the herbicide and also insures that the plant dies as one unit.
- Adults- For large ATF's where you cannot reach the meristem of the plant it will be necessary to cut down the tree somewhere along the trunk. Do this where it is easiest to access as sometimes large trees can fall abruptly causing a safety hazard and you may have to move out of the way. Once you have felled the tree apply herbicide to the starchy heart that you have exposed on both sides of the cut (pic below). Do this as quickly as possible! Then move up to the main mersitem and follow the same wedge procedure as outlined for Juvenile ferns. This insures that no part of the plant will regrow.

 

ATF cut down with herbicide applied and ATF in the forest w characteristic "helicopter shaped fronds".

Himalayan Ginger- *Hedychium gardnerianum,* HEDGAR - Himalayan Ginger is widely known as one of the top threats to native Hawaiian forests. The herbaceous shrub can grow upwards of 6' tall and can completely smother the ground with thick rhizomes and an even thicker layer of canopy produced by large waxy leaves. Observations have been made of these rhizomes growing over the entrance to seabird burrows. This species is one of the most widespread and persistent weed species in ULP. Eradication is not an option for ginger only holding back the tide. The plants are always vigorous, the seeds are bird dispersed, and seedlings can sprout up in pristine areas with no disturbance. Due to this fact, the only way to insure you are doing an effective job of mitigating the threat is to searchcover all areas where the plants will sprout up, searching methodically searching every square meter of suitable area at that site in the days work area. Ginger, although it will sprout up anywhere, prefers shady open areas under trees, and wet areas along streams and gulches. It seems the seeds get stuck in Uluhe and Uluhe lau nui and desiccate slowing down sprouting in these areas. In general once you have reached an area that is open, sunny and covered in Uluhe or uluhe lau nui your search is complete. However if you see a stand of trees up the slope that appears to have a shady open area underneath you must go and check for HEDGAR. This search method is a bit esoteric to explain but with experience and dedication to comprehensively searching an area it becomes clear with time where the plants tend to grow.

Herbicide Used- 1% Escort

Control Method-

- Cut stems a couple/several inches above rhizome (on Himalayan ginger; where the pink base of the stem begins to fade to a green color) and stack stalks on the side.
- Stack all of the fronds that you remove off to the side of the patch as you will need them after treating to cover your work.
- It is important to "Undress" the patch before applying herbicide so you can clearly see all the rhizomes that need to be treated. Scrape away all leaves, dirt and debris.
- Once you have cleaned the work area make cuts in all rhizomes including the ones that you just cut the fronds off of. Each section of rhizome should get 4-6 cuts up to ¼" deep with a machete or saw, with particular focus on the nodes where new growth will be

sprouting from. Make sure to look under and around the sides of the patch to make sure you make cuts and/or stabs in rhizomes that are hiding underneath the bulk of the patch. Also be careful not to cut chunks of rhizome and send them flying into the bushes as these will surely re-sprout.

- Liberally coat all rhizomes and cuts with Escort. Don't skimp on herbicide as under-treated patches can regrow.
- Once the patch has been treated it is time to cover it or "build a hale" to prevent rain from washing away all of your hard work. The best way to do this is to remove individual leaves from your largest fronds. The leaves can then be stacked, overlapping to reduce runoff. Sometimes it is necessary to build a scaffold using leafless stems to stack your overlapping leaves on.
- Seedlings up to 1' in height can be pulled, taken back to camp and thrown in the trash. The leaves and stems can be ripped off.


HEDGAR stems cut at the proper height and a large flower stalk.

Guava Trees *Psidium cattleianum,* Strawberry Guava, PSICAT and ***Psidium guajava,*** Common Guava, PSIGUA**-** Strawberry guava seems to be appearing more often in the ULP although relative to other areas on Kauai numbers are pretty low. Trees can be found anywhere and are generally scattered, solitary individuals. Common Guava is only found at lower elevations close to basecamp and has not been seen for years. Some sources recommend applying Garlon directly to the trunk on Common Guava trees but it is believed this treatment should be avoided in the ULP due to the wet environment.

Herbicide Used- 25% Garlon 4.

Control Method-

- Cut the tree down within 1’ of the ground.
- Apply Garlon 4 to the trunk liberally.
- Apply to the cut on the tree and make sure to elevate the tree off the ground.
- Make sure to search the area for seedlings and juveniles if the tree you are treating is mature. These can usually be pulled with ease.

PPSICAT growth form, flowers, trunk and fruit.

PSIGUA fruit and smooth trunk bark.

Hardwood Trees- ***Melaleuca quinquenervia,*** Paperbark Tree, MELQUI; *and* ***Grevillea robusta,*** Silk Oak, GREROB- These trees are becoming less common in the ULP due to successful control and are mainly seen around Basecamp. They are somewhat difficult to spot. **Paperbark Tree-** This species has a very conspicuous straight trunk that is bright white with dark olive green leaves. The bark is very papery and sheds off of the tree. Leaves have a pleasant herbal fragrance.

Grevillea- This species is rarely seen in the ULP. The leaves are very lacey and the round canopy is very different from the other trees in the *Metrosideros* dominated forest however, they it can be difficult to spot unless they are large trees. The wood of this species can be toxic, and so care must be taken for anyone who cuts down this species. The flowers are bright orange and spiky, very conspicuous, even from great distances.

Herbicide Used- 30% Habitat.

Control Method-

- Cut down the tree and directly apply Habitat to the cut stump and also to the cut on the part of the tree you have felled.
- It is very important to be mindful of how and where cut materials are being disposed. Most tree species in ULP will re-root from cut pieces and grow into full trees. It is best to prop the trees in the bushes or Uluhe in a site where they will desiccate in the sun.
- It is also important to apply the herbicide quickly (within 30 sec. or as soon as the applicator can safely apply the herbicide) after the tree has been cut since some of these species can close up their wounds shortly after being damaged.

Paperbark flowers and leaves, Natalia Tangalin cuts down a tree, and treated stump.


Grevillea robusta leaves and flowers.

Softwood Trees- *Spathodea campanulata*, African Tulip, SPACAM; ***Schefflera actinophylla*,** Octopus tree, SCHACT; ***Clusia rosea*,** Autograph Tree, CLUROS-

African Tulip although beautiful, is one of the most invasive species in Hawaii. The huge orange or yellow flowers can cover these trees and the large seed pods that follow are filled with papery wind dispersed seeds. When sterile and at a distance, this species can be confused with some *Polyscias* species. The large trees will have a straight white trunk and a sparse but contained canopy of dark bluish compound leaves. These trees are quite common in the lower sections of the ULP near Basecamp.

***Schefflera*,** a very common house plant throughout the nation, has taken over a large portion of the Lower Limahuli Preserve. The bird dispersed seeds can grow epiphytically. As the trees grow they will eventually strangle their host tree. These trees have very glossy leaves on relatively sparse (thick) branches with whitish bark. Seed heads and flower spikes are bright red and resemble the outstretched arms of an octopus. From a distance this species could be confused with native *Polyscias* species (which are in the same family). Although uncommon in the ULP as compared to other weed species, this is also a very problematic species.

Autograph Tree is yet to be spotted in the ULP, but it is known from the ridges in nearby Mānoa Valley and occurs hanging on the steep cliffs of Lower Limahuli preserve. It is a matter of when and not if the species will make it into the ULP and when it does it will be a formidable foe. *Clusea* is a medium to large terrestrial or epiphytic tree with a dense canopy of dark green, waxy stiff leaves. Flowers are white-pink, large and waxy, while the fruits are greenish-brown and fleshy. The dark brown bark can become very rough on the trunk and the trees often send down adventitious root suckers similar to Banyan.

Herbicide Used- 50% RounduUp.

Control Method-

- Although these species have softer wood they are generally much more difficult to kill. Felled branches have a much higher tendency to re-root and grow into a new tree.
- To effectively remove the species use a saw or drill to make 1/2'" deep cuts/holes around all parts of the trunk on the trunk (or all trunks if there are multiple).
- Cuts should be spaced every 2-3" and be as close to the base of the tree as possible.
- It is very important to make cuts in all aerial roots and suckers as well to insure all parts of the tree die.
- On larger trees it is necessary to stop after 5 cuts and apply herbicide so that the wounds don't heal over. Or get help from a co-worker.
- Liberally apply RounduUp to all holes and cuts.

- USE EXTRA caution as the chemical is very concentrated!!
- Autograph Tree can be much more difficult to kill than the other trees in this section. It is best to make more cuts and use more herbicide to be cautious.


SPACAM leaves and flowers and the small papery, wind dispersed seeds.


SCHACT octopus-like leaves and growth habit showing bright red flowers.

CLUROS growth habit and leaf, flower, fruit and seed capsule.

Mules Foot Fern- ***Angiopteris evecta****, ANGEVE-* Mules foot fern is a new arrival to the ULP only spotted within the last 3 years. The occurrence of this very large fern seems to be increasing although of yet only juvenile plants have been found. Native to SE Asia and Australia, *Angiopteris* can grow to become massive and when they mature they have with fronds up to 7 meters in length and 3 meters in width. The base of the frond stems (stipes) appear swollen and bear two flat, rounded, dark brown, leathery growths- this section of the fern is called the "mules foot". Look for Mules Foot Fern in and around shady wet gulches. The base of the plant closely resembles that of *Marratia douglasii,* a native fern, so it is important to be aware of which taxa you are looking at before making a kill.

Herbicide Used- 30% Habitat.

Control Method-

- Remove all fronds from the fern.
- Around the scaly base of the fern make ¼- ½" deep incisions with a machete or saw, every inch or so.
- Apply 30% Habitat to the wounds as quickly as possible.
- It is good to try and cover the treated area with a nearby HEDGAR leaf or Clidemia.

ANGEVE fronds and pinna and base with fleshy stipules or "Mules Foot".

Albizia- *Falcataria moluccana,* FALMOL-
Only a few individuals of this species are known to occur within Limahuli. Unfortunately, the locations are very difficult to access. The seeds disperse easily and the incredibly fast growing tree can be difficult to cut down. The white bark and large flat/layered canopy of this tree makes it easy to spot. It is good to keep an eye out for seedlings and juveniles in landslides and other disturbed areas.

Herbicide Used- 30% Habitat

Control Method-

- Albizia can be controlled by stripping the bark from the base of the tree however it is prudent to apply Habitat to the cuts as well.
- Use a hand saw and cut in through the bark and cambium layer (approx. 1-1.5”) in a circle around the tree about 3’ from the base.
- Go down the trunk 1’ foot and cut another circle around the tree.
- Try to make a vertical cut in between your 2 previous cuts.
- With some work you can begin to pry the bark from the tree and it should come off with ease.
- Apply Habitat to the lower and upper exposed parts of the cambium.

Albizia’s large spreading trunk and leaves and flowers.

Vines/Brambles (*Rubus sp., Passiflora sp., Lantana camara*)-

Rubus argutus is a relatively new species to the upper preserve. This prickly vine can rip rain jackets and cut skin. The large black fruit are tasty and hold lots of bird dispersed seeds. This fast growing species can form large thick patches quickly and should be viewed as a very high priority for incipient removal. When in fertile, the vines are covered in white flowers.

***Passiflora* sp**. (Lilikoi, Passion Fruit) – Any species of this genus that naturalizes in the ULP could pose a huge threat to the preserve. The long, fast growing vines can smother large areas and the edible fruit is will readily dispersed by birds. Although it has only been observed a few times in the ULP, staff should be on the look-out for a uniform mat of foliage on the canopy (or fruit on the ground).

Lantana camara- Lantana is a vigorously growing shrub with recurved prickles and a strong odor when crushed. Its root system is very strong, and it gives out a new flush of shoots even after repeated cuttings. The flowers are usually orange or yellow, but can also occur in a range from red to white. Seeds are bird dispersed.

Herbicide Used- 30% Habitat.

Control Method-

- As most of the vegetative parts of these plants are growing through and on top of surrounding plants, you must first identify where the stems are growing out of the ground.
- Cut the stem and liberally apply Habitat to the fresh cut.
- Look for any signs of aerial roots growing out of the vines, if they are present cut and treat as much stem as possible, ideally placing the treated parts off the ground so that there is little chance of them rooting down.
- For **Blackberry** it is best to leave the stem intact and girdle the base by stripping it of the bark. Apply habitat to the stripped area. Blackberry will often have to be re-treated and is very difficult to kill.

Invasive Species Best Management Practices

[Photo on website]

Caption: If project activities occur in natural areas or native habitat, or have a high risk of introducing invasive species, we recommend that the following best management practices for biosecurity be incorporated into the project design as applicable.

Recommended Best Management Practices to Minimize the Introduction/Spread of Invasive Species

(Updated August 2021)

Invasive species pose a significant worldwide threat to native plants and animals, resulting in economic, ecological, cultural, and human health impacts (Lowe et al. 2004; Global Invasive Species Database (GISD) 2021). These impacts often include habitat degradation and loss, agricultural impacts, altered landscapes, increased costs associated with management of impacts to human quality of life, and loss of biodiversity, sometimes resulting in extirpations and extinctions of native species (International Union for Conservation of Nature and Natural Resources (IUCN) 2017; Ebersole 2020). Beginning with the first inadvertent introductions of invasive species by humans hundreds of years ago, all of these impacts continue to affect native species and habitats in the Hawaiian (Staples and Cowie 2001; Duffy and Martin 2019; Hawaii Invasive Species Council (HISC) and Coordinating Group on Alien Pest Species (CGAPS) 2020; National Tropical Botanical Garden 2021) and Mariana Islands (Rogers et al. 2012; Dawson et al. 2017;; Ossola 2018; College of Natural and Applied Sciences,).

In general, project activities can increase the likelihood of introducing or spreading invasive species to new areas or islands. For example, seeds of invasive plant species can be inadvertently transported on equipment or gear from a previous work site to a new site where they are not present. Likewise, equipment used in an area infected with a pathogen (i.e., Rapid ʻŌhiʻa Death (ROD) or *Ceratocystis spp.*), if not properly decontaminated, can act as a vector to introduce the pathogen into a new area (College of Tropical Agriculture, University of Hawaii 2021). Likewise, vehicles must be properly inspected and cleaned to ensure vertebrate pests do not stowaway and spread to other areas. These are just a few examples of how even well-intended project activities may inadvertently introduce invasive species.

To improve biosecurity and prevent and minimize the introduction or spread of invasive species, projects should incorporate best management practices (BMPs). In particular, vigilance is necessary when project activities occur in natural areas, including National Parks, National Wildlife Refuges, and Hawaiʻi State Natural Areas; or habitat areas containing primarily native vegetation (referred to hereafter as native habitat). We recommend that all projects occurring in natural areas or native habitat adhere to the following procedures, termed the "General Invasive Species BMPs." Activities involving a substantial amount of transportation of materials (i.e., construction materials or aggregate, etc.), vehicles, machinery, equipment, or personnel between sites have a higher risk of spreading invasive species, and should also follow the "General Invasive Species BMPs" to the extent practicable. Additional consultation is recommended if the project involves transportation of materials, equipment, vehicles, etc. between islands.

There are also a few select invasive species of concern in the Pacific Islands of which species-specific BMPs have already been developed in partnership with species experts. These species-specific BMPs are recommended for projects that occur in certain geographic areas, and / or involve an activity that is a known pathway for the spread of specific species or groups of species. Please refer to Table 1 for the current distribution of these invasive species. If your project occurs within the geographic area of any of these species, please review and incorporate the relevant species-specific BMP(s) into your project design. As new invasive species threats emerge that require development of species-specific BMPs, those may be added to this list.

General Invasive Species Best Management Practices

The following protocol is recommended to the extent practicable when the project activities occur in natural areas or native habitat. These procedures should also be applied to any project that involves a substantial amount of transportation of materials (i.e., construction materials or aggregate, etc.), vehicles, machinery, equipment, or personnel between multiple work sites. Additional consultation is recommended if the project involves transportation of materials, equipment, vehicles, etc. between islands.

1. Cleaning and treatment:

   Project applicants should assume that all project materials, vehicles, machinery, and equipment contain dirt and mud, debris, plant seeds, and other invasive species and therefore require thorough cleaning. Treatment for specific pests, for example, trapping and poison baiting for rodents, or baiting and fumigation for insects, should be considered when necessary. For effective cleaning we offer the following recommendations prior to entry into a project site:

   a. Project materials, vehicles, machinery, and equipment must be pressure washed thoroughly (preferably with hot water) in a designated cleaning area. Project materials, vehicles, machinery, and equipment should be visibly free of mud, dirt, seeds, plant debris, insects, spiders, frogs (including frog eggs), and other vertebrate species such as rats, and mice and rubbish. Areas of particular concern include bumpers, grills, hood compartments, wheel wells, undercarriage, cabs, and truck beds. Truck beds with accumulated material are prime sites for hitchhiking invasive species.

   b. The interior and exterior of vehicles, machinery, and equipment must be free of rubbish and food. The interiors of vehicles and the cabs of machinery should be vacuumed clean.

2. Inspection:

   a. Following cleaning and or treatment, project materials, vehicles, machinery, and equipment, must be visually inspected by its user, and be free of mud, dirt, debris, and invasive species prior to entry into a project site. For example, inspection for ants would include the use of ant bait attractants which could confirm the absence / presence of ants in a vehicle. Another example would be the careful visual inspection of a vehicle's tires and undercarriage for any remaining mud that could contain invasive plant seeds.

3. Re-treatment:

    a. Any project materials, machinery, vehicles, and equipment found to contain invasive species after initial cleaning including any plant material must be re-cleaned before entry to the project site. Likewise, if materials, vehicles, machinery, or any equipment contain ants, other invertebrates, or vertebrates, including rats and mice, after initial treatment, they must be re-treated for extermination (i.e., poison baiting, trapping, fumigation, etc.) before entry into the project site. Cleaning, treatment, and inspection are the responsibility of the equipment or vehicle owner and operator. However, it is ultimately the responsibility of the action agency to ensure that all project materials, vehicles, machinery, and equipment are free of mud and invasive species before entry to a project site with a natural area or native habitat site.

4. Base yards and staging areas:

    a. Base yards and staging areas should be inspected for invasive species at least weekly during the duration of the project. Invasive species found in the site must be immediately removed or treated. Vehicles should be parked within a 10 square meter buffer area free of debris and/or vegetation. Ideally, vehicles should be parked on pavement and not under trees or in tall grass and other vegetation.

    b. Temporary storage of project vehicles or equipment outside of a base yard or staging area, such as a private residence, is discouraged. If necessary, they should be kept in a pest free area.

5. For all project site personnel:

    a. Prior to departing your residence or place of employment to transit to the project site, visually inspect and clean your clothes, boots or other footwear, backpack, radio harness, tools and other personal gear and equipment for insects, seeds, soil, plant parts, , or other debris.

    b. Immediately prior to departing a project site, visually inspect and clean your clothes, boots, pack, radio harness, tools, and other personnel gear and equipment for insects, seeds, soil, plant parts, , or other debris. Seeds found on clothing, footwear, backpacks, etc., should be placed in a secure bag or similar container and discarded in the trash rather than being dropped to ground at the project site or elsewhere.

6. Additional considerations (if applicable):

    a. Conduct a risk evaluation for activities that involve an uncertain potential for invasive species introduction, and therefore require further assessment in order to determine additional prevention guidelines.

    b. When applicable, use pest-free or low-risk sources of plants, mulch, wood, animal feed or other materials to be transported to a project site.

    c. For projects involving plants from nurseries (e.g., outplanting activities, etc.), all plants should be inspected and, if necessary, appropriately cleaned or treated for invasive species prior to being transported to the project site.

    d. Avoid unnecessary exposure to invasive species at a particular site (to the extent practical) to reduce contamination and spread. For example, plan or organize timelines so that work commences in a less infested area and toward a more contaminated site as best as practical.

e. When applicable, limit ground disturbing activities while working in natural areas. For example, utilize existing trails or roadways to avoid creation of new corridors that may be exploited by opportunistic vertebrates.

f. Maintain good communication about invasive species risks between project managers and personnel working on the project site. Ensure prevention measures are communicated to the entire project team. Report any species of concern or possible introduction of invasive species to appropriate land managers.

Rapid ʻŌhiʻa Death (ROD)

Rapid ʻŌhiʻa Death (ROD) is a caused by a fungal pathogen (*Ceratocystis* spp.) that attacks and kills ʻōhiʻa trees (*Metrosideros polymorpha*). ʻŌhiʻa is endemic to the Hawaiian Islands and is the most abundant native tree species, comprising approximately 80% of Hawaiʻi's native forests.

The following decontamination protocol and BMPs are recommended for projects occurring in any natural area or native habitat where ʻōhiʻa is present on islands where ROD is currently found. If working directly with ʻōhiʻa trees (e.g., sampling suspected trees, clearing an area of ʻōhiʻa, etc.) or in area(s) known to be highly infested with ROD, additional consultation is recommended. Additional consultation is also recommended if the project involves transportation of materials, equipment, vehicles, etc. between islands.

Current Distribution of ROD: Hawaiʻi Island, Oʻahu, Kauaʻi

- For more information about ROD including current confirmed distribution, ROD science updates, and the latest on ROD protocol, please visit www.rapidohiadeath.org.

Best Management Practices for Projects on Islands with ROD

1. Never transport any part of an ʻōhiʻa tree between different areas of an island or to a different island.
2. Do not use equipment from ROD infected islands on another island unless it is very specialized equipment and follows the decontamination protocols described below.
3. Avoid wounding ʻōhiʻa trees and roots with mowers, chainsaws, weed eaters, and other tools. If an ʻōhiʻa receives a minor injury like a small broken branch, then give the injury a clean, pruning-type cut (close to the main part of the trunk or branch) to promote healing, and then spray the entire wounded area with a pruning seal.
4. Always report suspect ROD ʻōhiʻa trees. ROD is a wilt disease that cuts off the supply of water and nutrients to the tree. The primary symptom to look for is an entire canopy or a large branch with dying leaves or red discolored leaves. Please record the GPS coordinates and location and take a picture of the tree if possible. Please report suspected ROD ʻōhiʻa trees to the following agencies:

d. Kaua‘i – KISC: 808-821-1490 (kisc@hawaii.edu)

ROD Decontamination Protocol Projects on Islands with ROD

1. Clothes, footwear, backpacks, and other personal equipment
   a. Before leaving the project site, remove as much mud and other contaminants as possible. Use of a brush with soap and water to clean gear is preferred. Footwear, backpacks, and other gear must be sanitized by spraying with a solution of >70% isopropyl alcohol or a freshly mixed 10% bleach solution.
2. Vehicles, machinery, and other equipment
   a. Vehicles, machinery, and other equipment must be thoroughly hosed down with water (pressure washing preferred) and visibly free of mud and debris, then sprayed with a solution of >70 isopropyl alcohol or a freshly mixed 10% bleach solution. Use of a “pump-pot” sprayer is recommended for the solution and a hot water wash is preferred. Be sure to thoroughly clean the undercarriage, truck bed, bumpers, and wheel wells.
   b. If non-decontaminated personnel or items enter a vehicle , then the inside of the vehicle (i.e., floor mats, etc.) must be subsequently decontaminated by removing mud and other contaminants and sprayed with the one of the same aforementioned sanitizing solutions.
3. Cutting tools
   a. All cutting tools, including machetes, chainsaws, and loppers must be sanitized to remove visible mud and other contaminants. Tools must be sanitized using a solution of >70% isopropyl alcohol or a freshly mixed 10% bleach solution. One minute after sanitizing, one may apply an oil-based lubricant to chainsaw chains or other metallic parts to prevent corrosion as bleach is corrosive to metal.

NOTE: When using a 10% bleach solution, surfaces should be cleaned with a minimum contact time of 30 seconds. Bleach must be mixed daily and used within 24 hours, as once mixed it degrades. Bleach will not work to disinfect surfaces that have high levels of organic matter such as sawdust or soil. Because bleach is also corrosive to metal, a water rinse after proper sanitization is recommended to avoid corrosion.

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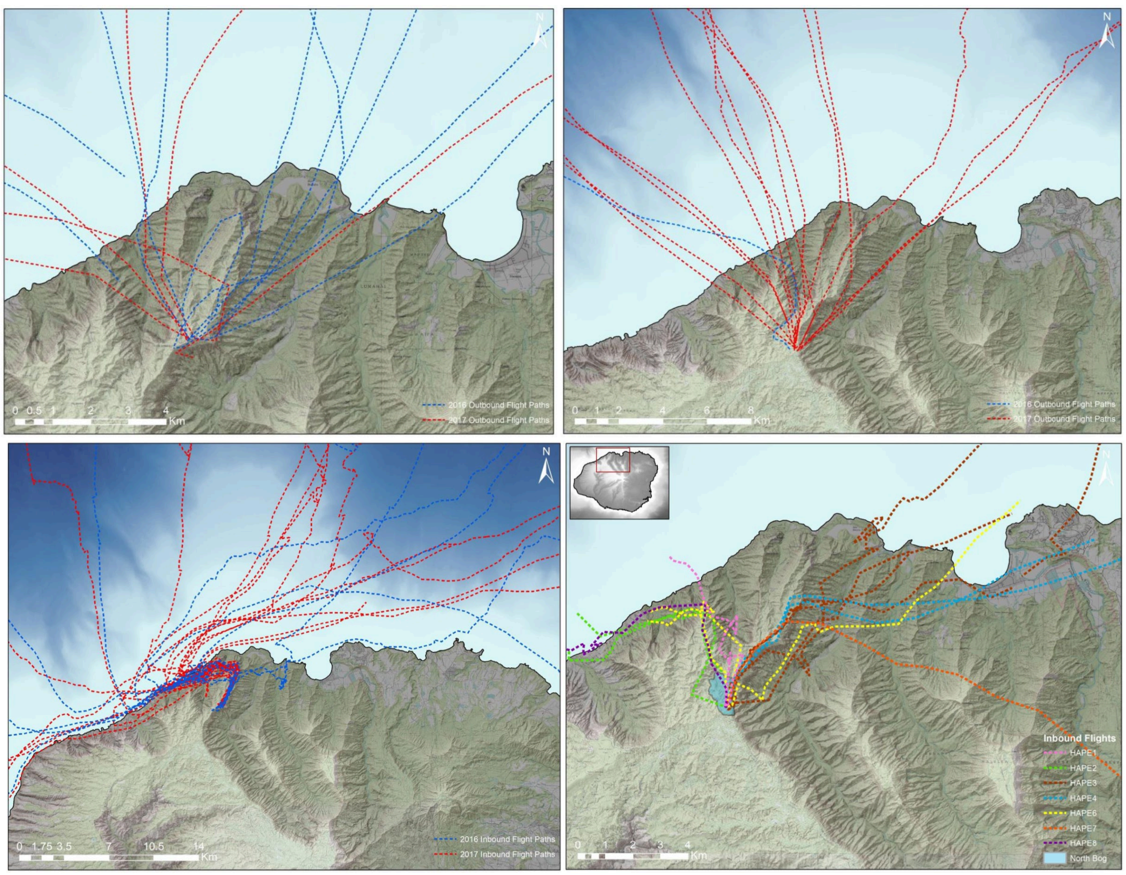
Appendix 5A

Variables Influencing Powerline Strikes

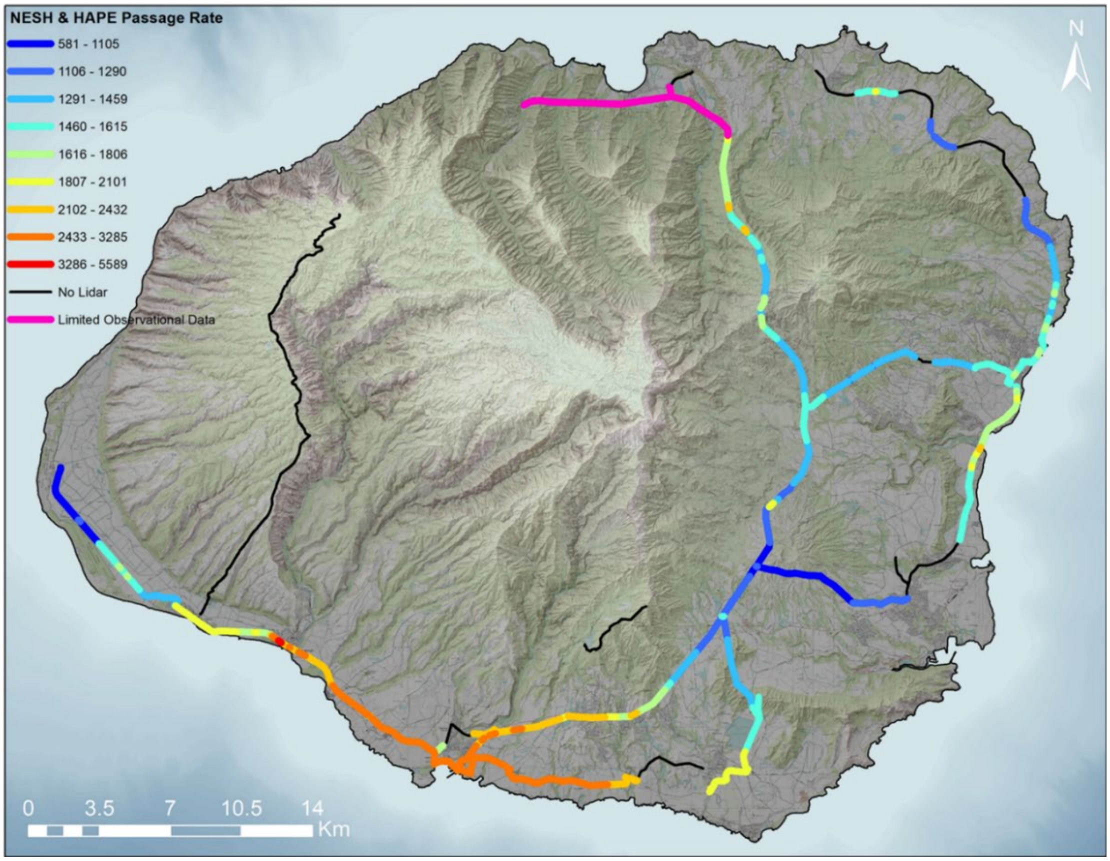
5A.1 Powerline Location

Seabirds in the colonies in the northwestern portion of Kauaʻi are thought to be relatively safe from powerline collisions because there is a lack of powerlines in that part of Kauaʻi. Recent tracking data are consistent with this assumption; most observed flight paths from colonies take relatively direct routes to and from sea that do not cross powerlines in other parts of Kauaʻi (Figure 5A-1; Raine et al. 2017). However, during the tracking study, an adult Hawaiian petrel (ʻuaʻu) breeding in North Bog was tracked crossing over the interior of Kauaʻi from the ocean back to its colony, making multiple crossings while en route of the powerlines along one of the highest collision hot spots on Kauaʻi on the Powerline Trail (Raine et al. 2017). It is not clear if this is a regular route for this bird since only one inbound route was collected, but it does indicate that some seabirds from colonies in the northwestern portion of Kauaʻi may also be at risk from powerline collisions (Figure 5A-1 lower right map; Raine et al. 2017). The tracking data indicate, therefore, that the risk of powerline collision mortalities for breeding colonies in northwestern Kauaʻi is relatively low, but not zero. Figures 5A-2 and 5A-3 show the combined passage rates and annual strikes rates for Newell's shearwaters (ʻaʻo) and Hawaiian petrels (ʻuaʻu) in the Plan Area, respectively. The results clearly show that birds in relatively safe areas such as the northwest of Kauaʻi may still have some risk of powerline collision.



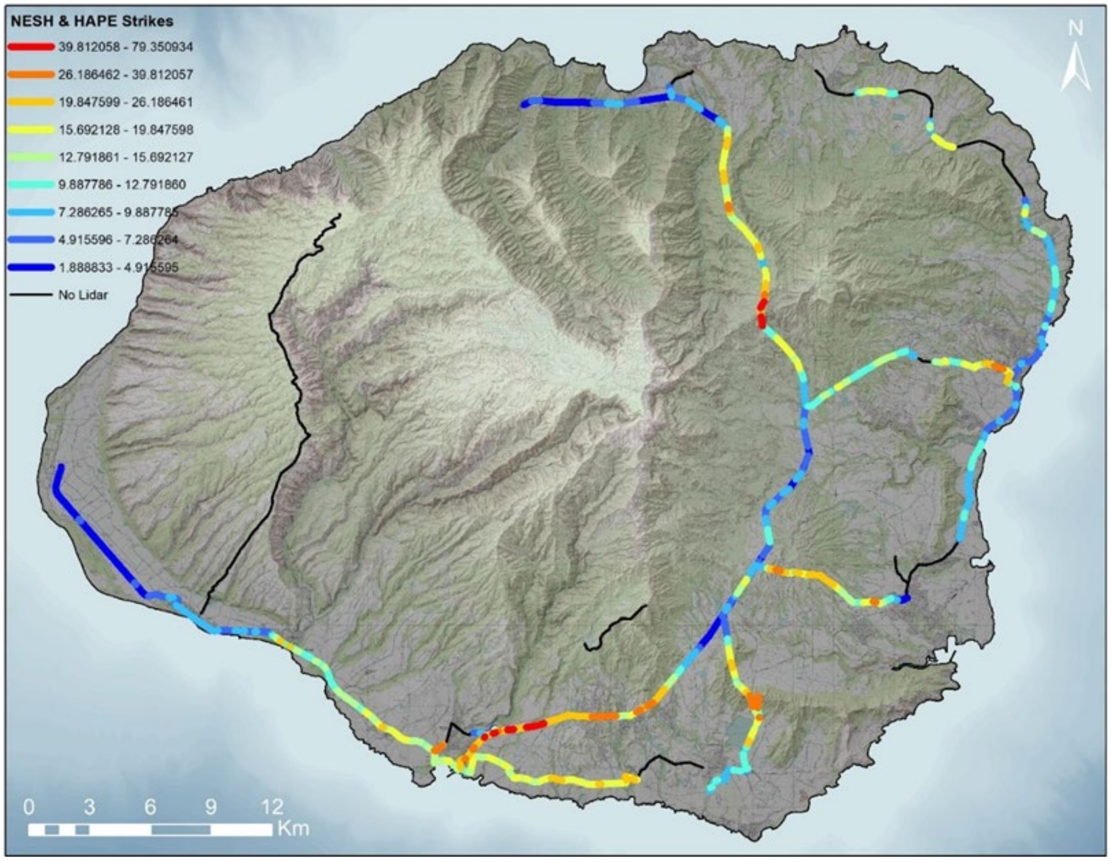
Source: Raine et al. 2017

Figure 5A-1. All recorded tracks recorded in 2016 and 2017 for Newell's shearwater (ʻaʻo) (left two maps) and Hawaiian petrel (ʻuaʻu) (right two maps). Outbound tracks are shown in the top two maps and inbound tracks are shown in the bottom two maps. Inbound tracks for Hawaiian petrel (ʻuaʻu) are only from 2017; no inbound tracks were recorded for this species in 2016.



Source: Travers et al. 2019

Figure 5A-2. Combined Passage Rates for Newell's Shearwaters ('a'o) (NESH) and Hawaiian Petrels ('ua'u) (HAPE) for Monitored Powerlines for One Season



Source: Travers et al. 2019

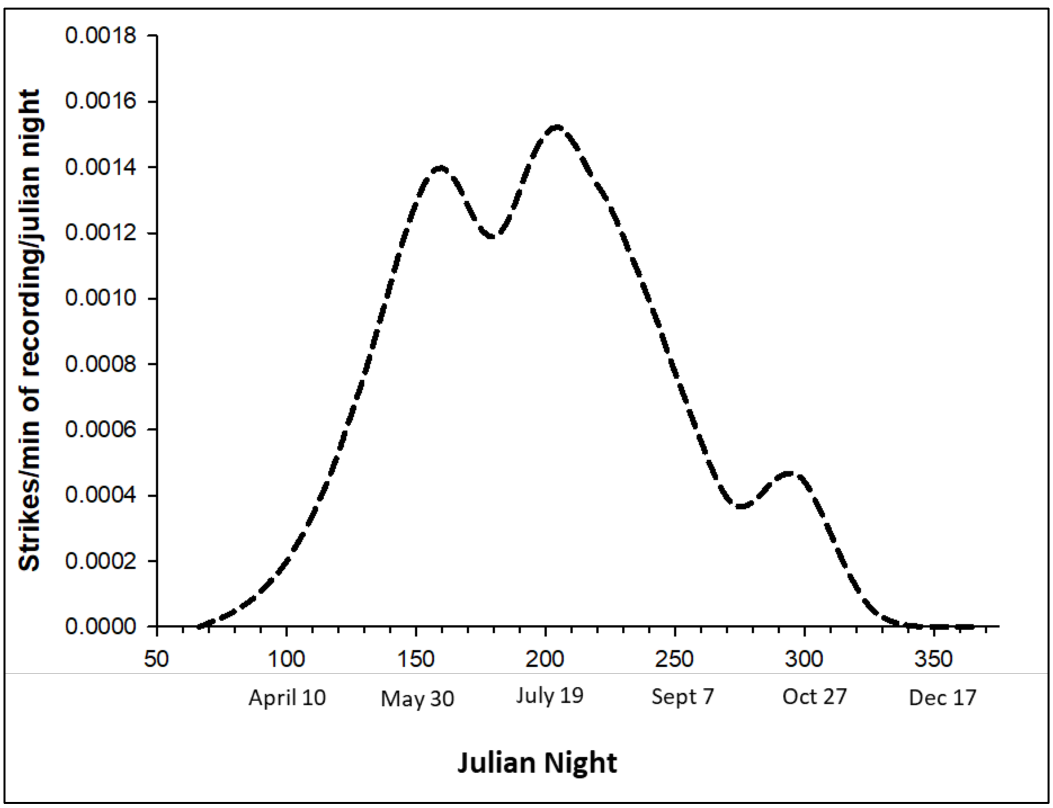
Figure 5A-3. Annual Estimated Strike Rates of Newell's Shearwaters (ʻaʻo) (NESH) and Hawaiian Petrels (ʻuaʻu) (HAPE) Colliding with Monitored Powerlines

5A.2 Seasonality

Powerline collisions occur annually in conjunction with the covered seabird breeding season and times of transition between breeding colonies and the sea. Newell's shearwaters (ʻaʻo) and Hawaiian petrels (ʻuaʻu) are at risk of powerline collisions from March to the end of December (Travers et al. 2018). This time period coincides with the Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu) breeding season. The majority of powerline collisions occur from April to the end of November (Travers et al. 2018).

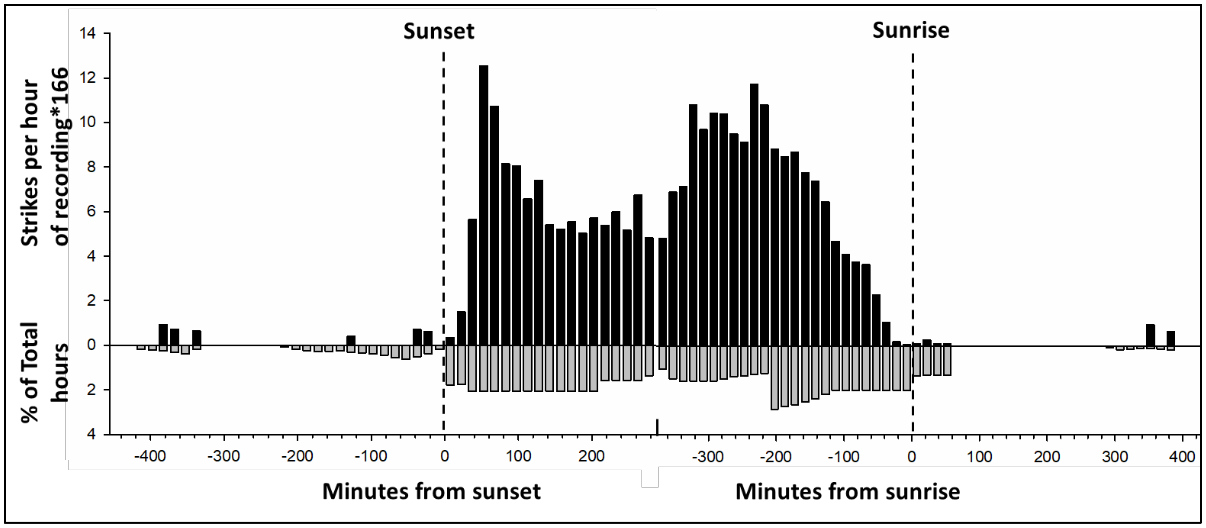
The amount of powerline collisions fluctuates throughout the breeding season. As seabirds return to their breeding grounds in March, detection of powerline collisions commences. Powerline detections fluctuate throughout the various stages of the breeding season, which on Kauaʻi is as follows; arrival (mid-April), exodus (May), incubation (May–mid July), chick rearing (late July–September), fledging (late September–mid-November for Newell's shearwaters [ʻaʻo] and November–mid-December for Hawaiian petrels [ʻuaʻu]), and ends when seabirds have left for the winter (Raine et al. 2019; Travers et al. 2014, 2019). Figure 5A-4 shows the distribution of powerline strike detection rates in relation to the time of year, with a peak during the middle of the Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu) breeding season (as described above). Thus, detection rates of powerline collisions begin to increase as Newell's shearwaters (ʻaʻo) and Hawaiian petrels (ʻuaʻu) arrive at the breeding colonies, peak in the middle of the seabird breeding season, and then decline to zero after chicks have fledged and seabirds have left for the winter (Travers et al. 2019).

Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu) movement between breeding colonies and the sea takes place during crepuscular periods (sunset to sunrise) and full darkness (Travers et al. 2019). Based on acoustic monitoring of powerline strikes and observations of the covered seabirds at monitored powerline spans, the pattern of collisions corresponds to the daily movement of Newell's shearwaters (ʻaʻo) and Hawaiian petrels (ʻuaʻu). As seen in Figure 5A-5, strike detections start to increase when seabirds transit powerlines during crepuscular periods and reach their high point during the peak movement of seabirds, which occurs during full darkness (Travers et al. 2019). Visual observations and monitoring of burrows with cameras have observed movement patterns of Newell's shearwaters (ʻaʻo) and Hawaiian petrels (ʻuaʻu) to and from breeding colonies on Kauaʻi. Breeding adult Newell's shearwater (ʻaʻo) movement is primarily restricted to near crepuscular periods, while Hawaiian petrels (ʻuaʻu) arrive and depart throughout the night (Travers et al. 2017). Newell's shearwaters (ʻaʻo) have been estimated to account for approximately 70 percent of powerline passages, compared to 30 percent of Hawaiian petrel (ʻuaʻu) (Travers et al. 2020). This observed proportion is a function of the increased frequency with which Newell's shearwaters (ʻaʻo) visit their burrows compared to Hawaiian petrels (ʻuaʻu), as well as the portion of the night during which monitoring occurred (Travers et al. 2019).



Source: Travers et al. 2019

Figure 5A-4. Seasonal Pattern of Acoustically Detected Nocturnal Powerline Strike Sounds



Source: Travers et al. 2019

Figure 5A-5. Timing of Powerline Strikes Acoustically Detected Throughout a 24-hour Period Based Upon Information Collected from 2013 to 2017

5A.3 Topography

Topography surrounding powerlines varies and may increase or decrease powerline collision risks. For example, powerlines strung across valleys increase their aboveground height. Though power poles are 75 feet (ft) (23 meters [m]) tall, placing these poles up a valley can result in powerlines 279 ft (85 m) above the ground, in the middle of seabird flight heights (Travers et al. 2019). Additionally, ridgelines above deep valleys can cause birds to fly very low as they come up and over the ridges, increasing the risk of seabirds colliding with powerlines located at ridgelines.

5A.4 Vegetation Height

The height of vegetation surrounding powerlines may increase or decrease seabird powerline collision risks. For example, trees taller than the powerlines force birds to fly over the powerlines (Travers et al. 2019), thereby reducing the risk of collision. If trees are lower than the powerlines, the lines are exposed to birds flying at the height of those wires, thereby potentially exposing them to risk of collision. For vegetation to result in an entire powerline span having zero risk of a bird collision, tall trees must shield the full length of the span to prevent a seabird from flying at the height of the wires. If there are any gaps in the tree line that expose a portion of the powerline, seabirds may fly lower and thus be exposed to the space occupied by the powerlines (Travers et al. 2019). This applies to areas where birds are flying to or from colonies. If powerlines are strung up through colonies, tree cover will not necessarily reduce collisions because birds may be flying through the trees to land at their burrows.

5A.5 Wires

Wire height and covered seabird flight height can affect the potential for a powerline collision. Wires that are taller (higher above ground) are more likely to be positioned within the bird flight height distribution (Travers et al. 2019). Therefore, within a wire array, the top wire has greater risk than the second highest wires, and the second wire has greater risk than the third wire. This factor is important for minimization planning.

The height of a powerline depends, in part, on the type of powerline: static wire, transmission line, distribution line, or communication line. Figure 2-2a and 2-2b in Chapter 2, *Covered Activities*, displays the major wire types and their relative positions on the pole. Sometimes in place of a standard static wire, there is a fiber-optic cable. Fiber-optic cable is important to identify and map because, unlike standard static wires, fiber-optic cable does not produce a strike sound when hit (Travers et al. 2014). The covered bird species may collide with any of these lines.

Wire configuration influences collision risk. For example, vertically arrayed wires have greater risk than if those same wires were constructed horizontally because the vertical array takes up more physical airspace in which birds transit, increasing the probability that birds will be flying at wire height.

Wire thickness can affect the wire's visibility to a bird transiting the area, as well as the rate of mortality if struck. Bundling wires or using thicker wires are potential minimization tools, but it is not clear what effect this would have on reducing powerline collisions (i.e., birds may see thicker wires better and thus would be more likely to avoid them, or depending on the array, bundled wires could increase collisions because it reduces the chance of avoidance) (Raine *in litt.* 2019). Using insulated wires does, however, allow the wires to be lowered closer to the ground (because they have different regulations than uninsulated wires), which in many scenarios would reduce collision risk.

The greater the number of wires the more objects that occur in the birds' flight path, thereby increasing the risk of a seabird colliding with a powerline.

5A.6 Seabird Flight Height

For the tracking study done on Kaua'i by Raine et al. (2017), described above, regarding the flight height of these species to and from two colonies in the northwest portion of the island, birds were outfitted with global positioning system (GPS) tracking tags, which recorded the location, height, distance, and speed at they traveled. A GPS-tagged Hawaiian petrel ('ua'u) was recorded crossing powerlines multiple times at low altitude, in a known high-strike area along the Powerline Trail (Raine et al. 2017). For Newell's shearwaters ('a'o) flying from their breeding colonies out to sea, birds flew high as they left the colony until they reached the sea. When coming in from the sea to the breeding colony, birds flew low over the sea until turning inland, then increased sharply in altitude and departed from sea level about 0.6 mile (mi) (1 kilometer [km]) from the coast. When flying from their breeding colony out to sea, Hawaiian petrels ('ua'u) flew high, gradually losing height and reaching sea level about 4.5 mi (7.3 km) from the coast. As they returned from the sea to their breeding colony, they flew low over the sea until approaching land and then increased sharply in altitude, departing sea level 2.5 mi (4.1 km) from the coast.

5A.7 Flight Speed and Maneuverability

Flight speed of the covered seabirds at powerlines is a function of bird direction (inland or seaward) and flight direction relative to wind direction and speed. Radar studies at powerlines indicated that seabirds transit at rates of 30 km/hour (18.6 mi/hour) to 100 km/hr (62.1 mi/hour) (Travers et al. 2014). The information herein is based on limited data available regarding movement patterns of

Newell's shearwaters (ʻaʻo) and Hawaiian petrels (ʻuaʻu) from a study by Raine et al. (2017), including flight speed of these species to and from two colonies in the northwest portion of Kauaʻi.

Table 5A-1 provides the average speed of each species as it flew over land and water on the way from its breeding colony to sea and from sea back to its breeding colony (Raine et al. 2017). The speed at which seabirds fly puts them at an increased likelihood of collision with powerlines. An observed trend is that Hawaiian petrels (ʻuaʻu) have a higher avoidance of powerline collisions, likely due to their increased flight maneuverability and sometimes slower flight speed than Newell's shearwaters (ʻaʻo) (Travers et al. 2018).

Table 5A-1. Average speed of Newell's shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu) as it flies over land and water from its breeding colonies to the sea and from the sea to its breeding colonies.

	Outbound (breeding colony to sea)	Inbound (sea to breeding colony)
Newell's shearwater (ʻaʻo)		
Land	42.9 km/hr	35.7 km/hr
Water	56.6 km/hr	42.4 km/hr
Hawaiian petrel (ʻuaʻu)		
Land	51 km/hr	34 km/hr
Water	61.4 km/hr	27.3 km/hr

Hawaiian petrels have increased flight maneuverability due to lower wing loading (weight to wing surface area ratio) and in some instances a slower flight speed than the Newell's shearwater (ʻaʻo) (Travers et al. 2018). Direct observations of powerline interactions show that Hawaiian petrels (ʻuaʻu) are better able to make large correcting maneuvers such as stalling or flaring upwards to avoid powerlines, when the wires are detected. Newell's shearwaters (ʻaʻo) struggle to make large correcting maneuvers unless flying with a steady head wind (Travers et al. 2018).

5A.8 Flight Path

The flight path of seabirds varies by the side of island and inland and seaward directions of flight as well as other factors such as wind direction and speed. For example, for inland flights seabirds on the north, east, and south to southwest shores of the island tend to take a direct flight path (Travers et al. 2019). Seabirds breeding in the Nā Pali, Waimea Canyon, and Makaweli/Olokele drainages use the lee of the island to gain elevation using calm areas or the wind that circles inland and upslope (Travers et al. 2019). Flight paths that result in lower aboveground flight height increase powerline collision risk. For example, when a flight path forces them to fly into a strong head wind, the birds fly lower. This occurs typically on the seaward flight on the east side of the island and on the inland flight on the south/west side of the island.

5A.9 Wind- and Weather-Related Factors

Seabird flight heights and flight path are influenced by wind and topography (Travers et al. 2019). Seabirds flying into a headwind fly slower and have greater lift and maneuverability, but it also causes seabirds to fly lower increasing the likelihood of flying at wire height (Travers et al. 2018). Seabirds flying with a tailwind fly higher (Travers et al. 2019) and have less maneuverability and less ability to gain elevation (Travers et al. 2013). Thereby, a seabird flying with a tailwind may fly over land at greater altitudes to avoid obstacles (Travers et al. 2013). Typically, the wind is light to moderate from the northeast direction in the summer (Travers et al. 2018), which is the peak breeding season for Newell's shearwaters (ʻaʻo) and Hawaiian petrels (ʻuaʻu). This results in varied flight directions relative to wind for the north/east, south/west, and Nā Pali Coast, further resulting in varied flight height and behaviors in these three large regions.

Heavy mist or rain may obscure powerlines from flying birds, reducing the bird's ability to detect them, and increasing the risk of collision with powerlines.

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Appendix 5B

Rapid Waterbird Powerline Collision Assessment

Underline Monitoring Project
Rapid Waterbird Powerline Collision Assessment

Marc Travers & André F. Raine

Assessment requested by KIUC on June 26, 2020
Assessment provided July 23, 2020 for comments

The Underline Monitoring Project (UMP) is part of the Kaua'i Endangered Seabird Recovery Project (KESRP), which is a joint project of the Pacific Cooperative Studies Unit of the University of Hawai'i and the Division of Forestry and Wildlife (DOFAW)/State of Hawai'i Department of Land and Natural Resources.

Preface

On June 26th, the team developing the KIUC HCP (consisting of representatives from USFWS, DOFAW, KIUC and HT Harvey) requested information from KESRP on the likelihood and frequency of waterbirds hitting KIUC powerlines. Due to the current timeline for the development of the HCP, the deadline for this information was only a couple of weeks later and took place during the peak KESRP field season. To help the HCP team meet this timeline, KESRP offered to conduct a rapid assessment with the data available. While KESRP always recommends developing research programs designed to answer specific questions, we also understand the urgency at this stage for incorporating this information into the HCP document. However, we would like to make it clear from the outset that because of this short timeline and lack of a research project to investigate this issue, the assessment presented in this document has been produced, by necessity, with numerous untested assumptions.

The regional assessments in the document have varying levels of supporting data. The information and results for Mānā are robust as we have data from both acoustic monitoring and observations. In contrast, UMP has not conducted powerline observations in Hanalei waterbird dense locations and similarly there is minimal acoustic effort in the waterbird dense locations. In the absence of observational and robust acoustic data, Hanalei powerlines should be considered to have the same risk as Mānā.

2.0 Methods

In this document we employ two levels of analysis based on the available data. The first level of analysis uses a combination of observer and acoustic based data sets to determine powerline collisions of most native waterbirds (Sections 2.1.0–2.1.3). The second separate analysis uses grounded bird detections to determine powerline collision mortalities (not strikes) of the Hawaiian gallinule (ʻalae ʻula) (*Gallinula galeata sandvicensis*) and Hawaiian coot (ʻalae keʻokeʻo) (*Fulica alai*). Neither waterbird species have supporting observational data (Section 2.2).

2.1.0 Explanation and background

For the purposes of the first analysis (which uses observation and acoustic data) we have split waterbird collisions into three areas; (i) Mānā, (ii) Hanalei National Wildlife Refuge (NWR) and surrounding wetlands and (iii) all other areas, as outlined below. The Mānā is the most data-rich waterbird area UMP has monitored. Mānā is the only waterbird area with a full range of UMP data including observation data, acoustic monitoring, acoustic detections of strikes, and modeling of acoustic strike patterns across a season. For this reason, we use Mānā data as the foundation for the determination of waterbird powerline collisions elsewhere in Sections 2.1.2 and 2.1.3.

To understand the available data and how it is utilized in this assessment, we present the following background information based on data that was collected in 2014 and 2015 for the UMP. In 2014, UMP expanded acoustic monitoring to low elevation powerlines next to highways, which included the Mānā. UMP acoustic monitoring based on strike sounds[1] detected a high rate of nocturnal powerline collisions in the Mānā area, which was unexpected given the relatively low number of seabirds moving in that area based on observer data (Travers et al. 2015).

In 2015 we identified through observer data that although there was certainly Newell’s shearwater (‘a‘o) (*Puffinus auricularis newelli*) passage in the Mānā area, the most common birds moving through the region were waterbirds (Travers et al. 2016). Given the high number of strike sounds and waterbirds in the region, we determined that waterbirds were at highest risk of hitting the powerlines and inferred that they were responsible for a large portion of the detected acoustic collisions (Travers et al. 2016). Since there was no further study to facilitate the separation of strikes in Mānā to species or provide species-specific avoidance behavior, at KIUC direction, the Bayesian Model assumes that all of the Mānā strikes are seabirds. However, as recommended by UMP in the years 2015–2020, a proportion of strikes in Mānā can be attributed to species other than Newell’s shearwaters (‘a‘o) (Hawaiian petrels [‘ua‘u] [*Pterodroma sandwichensis*] have not been observed passing over this area), and we have developed an analysis to estimate the risk to waterbirds.

Our first step in the below analysis was to develop a collision risk score that ranks each species’ relative collision risk at Mānā. We then apply that proportional risk for each species to the modeled strikes determined by the Bayesian Acoustic Strike model, obtaining an acoustic strike count for each species. Using the acoustic strike model output, we include all bird species that have a collision risk (Table 2), including the Newell’s shearwater (‘a‘o).

2.1.1 Mānā waterbird powerline collisions

To develop a rapid assessment that assigns powerline collisions to multiple species, we produced a collision risk score for each bird species based on available information. The risk score is based on a combination of the frequency of powerline crossings, above ground flight height, and whether birds were flying singly or in pairs or flocks. We have made no attempt to determine species-specific avoidance rates though waterbird species may vary considerably in their ability to avoid powerlines. This rapid assessment was requested in a 14-day timeline without additional research, and as such relies heavily on assumptions where data does not exist; therefore, we recommend updating this assessment when new information is obtained.

Calculations

Waterbird risk for powerline collisions is based on a cumulative point scale that assigns an overall species risk score. Height risk is given a score of either 0 or 1, with 0 indicating minimum risk due to high flight height, and 1 indicating increased risk due to low flight height. Flocking risk is given a score of 2. Each species risk is ranked proportional to all other species. The species-specific proportional risk is then applied to the acoustic strikes for the region to get species-specific annual strike totals.

[1] A strike sound is produced only when the vibrations, generated by a bird colliding with the powerlines, traveling along a cable makes contact with the insulator that is connecting the wire to a power pole (Travers et al. 2015)

Species risk score = Sum for each species (*height risk rank*flocking*)

- ***Height risk rank* = 1- percentile rank of above ground flight height.** This assumes a linear decrease in collision risk from the maximum risk of 1 assigned to the lowest recorded flight to the minimum risk of 0 assigned to the highest recorded flight.
- ***Flocking* = 2.** The trailing birds in pairs or flocks have increased risk of collision because in these scenarios the trailing bird is continuously following the leading bird/s and not scanning for hazards. When the leading bird sees a hazard and reacts the trailing bird's reaction is slightly delayed increasing collision risk. UMP recently observed this phenomenon when the trailing bird in a flock of three Hawaiian geese (nēnē) (*Branta sandvicensis*) collided with a powerline in the Mānā, but more generally this has been observed when flocks of Hawaiian geese (nēnē) approach powerlines, resulting in a closer encounter with the powerlines for the trailing birds. Marc Travers has also observed this phenomenon hundreds of times while studying common eider ducks in the Canadian Arctic. In Table 2, we provide the risk score without the flocking multiplier to present to readers the influence of the flocking term.

Species proportion of risk = Species risk score/Sum all species risk

Partitioning of Annual strikes = Acoustic Night Strikes (Species proportion of risk **Bayesian Acoustic Strike Estimate PMRF*) + Crepuscular strikes (Species proportion of risk**Crepuscular Collision estimate PMRF*)

- ***Bayesian Acoustic Strike Estimate PMRF = 640.*** UMPKESRP Bayesian Acoustic Model estimate for the Mānā area, which is calculated as 640 strikes annually. It should be noted that this model only estimated strike numbers for the acoustic strike night (30 min post sunset to 30 before sunrise) and does not therefore include any assessment of diurnal or crepuscular collision risk.
- ***Crepuscular Collision estimate PMRF = (Bayesian strike Estimate/Raw Night strikes)*Raw crepuscular strikes = 77.*** There is no estimate or model results for the crepuscular period as the Bayesian model was specifically designed around the acoustic night to ensure that the results were conservative. The above cross multiplication was used to adjust the raw crepuscular strikes to a strike estimate proportionally equivalent to the Bayesian Model estimate.
- **Immediate grounding = 0.13*Strikes.** This is the endangered seabird minimum grounding rate (Travers et al. 2020). Without any data on waterbird grounding rates following collision, we have used this as a proxy measure. This is possibly a conservative estimate for some slow flying waterbirds, given that seabirds fly at higher speeds than some waterbirds.

2.1.2 Hanalei National Wildlife refuge, Hanalei River, and Taro Fields

We have no observation information for the Hanalei refuge powerlines as we have not conducted nocturnal observations in this area. This is because the area has difficult land access and because we had determined it to be low collision risk for endangered seabirds. Given the complete absence of data we have been asked to apply the collision rates of Mānā powerlines to Hanalei in proportion to powerline length. That is, if Hanalei has the same length of powerlines we will apply the identical Mānā strike rate divided amongst the waterbirds. In the absence of observer data, however, we have had to assume the scenario is the same.

2.1.3 Remainder of powerlines studied by UMP

To assess collision risk outside of Mānā or Hanalei, we calculated the collision risk score for waterbirds observed at all other powerlines island-wide proportional to Mānā. Specifically, collision risk score was determined for each waterbird species and subsequently the risk scores were partitioned into the categories of Mānā or the remainder of the island. The scores were divided to determine relative risk outside of Mānā for strikes and groundings (Remainder of island risk score/Mānā risk score* Mānā strikes or Mānā Immediate grounding). This calculation was iterated separately across species. Unlike in Mānā, this estimate of waterbird strikes did not necessarily occur in areas where we had acoustic monitoring or had ever recorded acoustic strikes. For this reason, the strikes estimated in this section should not be subtracted from Newell's shearwater ('a'o) or Hawaiian petrel ('ua'u) strike totals as should be done for the Mānā/PMRF area strikes.

2.2.0 Background on the grounded bird detection analysis- Hawaiian Gallinule ('alae 'ula) & Hawaiian Coot ('alae ke'oke'o)

Hawaiian gallinules ('alae 'ula) and Hawaiian coots ('alae ke'oke'o) have rarely been documented flying during UMP observations, and therefore we have insufficient observation data to conduct an observer-based analysis for these species. However, there is sufficient evidence to show that Hawaiian gallinules ('alae 'ula) and Hawaiian coots ('alae ke'oke'o) have definitive powerline collision risk as they have been found by staff dead under powerlines, in some cases a long distance from water. In the absence of observation data, we used waterbird mortality data as a metric for powerline collisions. It should be noted that the other native waterbirds mentioned above (and of course endangered seabirds) have also been found dead under powerlines. Mortality data was not used for the remaining waterbirds assessed because we had sufficient observation and acoustic data to determine collision risk.

2.2.1 Determining detection biases and powerline mortality using dead birds

UMP ranks each detected carcass on the probability that the bird died as a result from a powerline collision. For Hawaiian gallinules ('alae 'ula) and Hawaiian coots ('alae ke'oke'o) in the UMP database, powerline collision ranking is as follows; 3 definitive powerline collisions, 5 probable, and 7 possible. Hawaiian gallinules ('alae 'ula) and Hawaiian coots ('alae ke'oke'o) were listed as definitive powerline collisions when they were found dead under powerlines with no other hazards or water nearby. For example, Hawaiian gallinules ('alae 'ula) found in the coffee fields under wires without any water nearby; that is, there is no other reason this bird would be on the ground dead. Hawaiian gallinules ('alae 'ula) were listed as probable powerline collisions when a bird was found under powerlines along or near a road with water located away from the roadway and present on only one side of the road. That is, probable collisions are cases where it is more likely that the source of mortality was the powerline than vehicle collisions given the lack of habitat across the roadway, but vehicle collision cannot be completely discounted given the roadway hazard. Hawaiian gallinules ('alae 'ula) listed as 'Possible' were birds where the carcass was found under powerlines along or near the side of the road, but water was present adjacent to the roadway or on both sides of the road and therefore there is a higher possibly that the bird was killed by a vehicle as it transited across the road between the two water sources.

Only two Hawaiian coots (ʻalae keʻokeʻo) were in the database and we categorized them both as possible powerline collisions, as per the definitions outlined above.

The carcass numbers are multiplied by the various biases that result in undercounting, which include detection bias, carcass removal, and searchable space at powerlines. Pending further research, the formula and undercounting biases and multipliers that we use for these calculations are as follows:

Estimated carcasses = found carcasses *2*8*1.3*3*1/8

- **KESRP staff frequent < half of the islands powerlines = 2.** Based on where staff live, go to work and recreate KESRP staff drive along the roads from Waimea to Līhuʻe with regularity. The roads in this area cover far less than half of the powerlines island-wide but for simplicity we have suggested a multiplier of 2.
- **Detection bias = 8.** Podolsky et al. (1998) stated their team found 1 in 4 carcasses when actively searching, with multiple biologists in the vehicle, at highway speed. The question here is what should the detection rate for a single biologist who is not actively searching while driving? Although an underestimate, for simplicity we have set this at the same rate as Podolsky et al. (1998). However, there is an addition consideration. Hawaiian gallinules (ʻalae ʻula) and Hawaiian coots (ʻalae keʻokeʻo) are harder to identify then Newell's shearwaters (ʻaʻo) while driving at highway speed. They can easily look like a dead black chicken (of which there are many road casualties), especially when flattened by a car. For this reason, we halved the detection rate, which doubles the multiplier.
- **Carcass removal = 1.3.** As outlined in previous reports, UMP found that 17% of carcasses disappeared on day 1, 33% by day 3 and 52% removed by day 10 (Travers et al. 2012). We set the bias at the 3-day removal rate because KESRP staff do not frequent all roads every day.
- **Searchable space at powerlines = 3**. UMP has conducted an analysis of the searchable space around all powerlines on the island to 30 meters on either side of the wires. We summed the square meters within the 60-meter-wide transect in which a biologist can enter to search. Roads and road shoulders make up the largest percentage of searchable space. Nearly all powerlines next to roads have inaccessible private land on one side, which results in the highest searchability, for example, 39% in the Western powerline region, and approaches zero in much of the PL Trail or central regions. Searchability within the half of the island frequented by KESRP staff is in reality far lower than a third but for simplicity we set the searchable space at 33%.
- **Annual rate = 1/8.** The carcasses used in this calculation were detected across 8 seasons.

3.0 Results

3.1.0 Analyses using observations and acoustic modeling results

3.1.1 Mānā estimate

For native bird species, black-crowned night-herons (BCNH) accounted for the largest proportion of collision risk based on flight height and passage rate, followed by Hawaiian goose (nēnē) (HAGO), Hawaiian ducks (koloa) (HAWD), Newell's shearwaters ('a'o) (NESH), Hawaiian stilts (ae'o) (HAST), and Pacific-golden plovers (PAGP) (see Table 2). Non-native species had the greatest risk during the crepuscular period but low risk during the night.

At Mānā, we have directly observed powerline collisions of the two waterbird species with the highest collision risk, the black-crowned night-heron and the Hawaiian goose (nēnē).

3.1.2 Hanalei National Wildlife Refuge and taro fields

In the absence of Hanalei specific data, and if a number is required, we recommend using the Mānā rate per km as a place holder for the Hanalei collision rate. The Hanalei section of powerlines is 7.75 km and is 95% the length of the Mānā powerlines which are 8.18 km (See Table 3 for numbers).

3.1.3 Remainder of powerlines studied by UMP

Much of the remainder of the islands powerlines studied by UMP had zero or near zero risk of waterbird powerline collisions. Overall, the remainder of the island collectively had a much lower risk of waterbird collisions than Mānā, indicating that Mānā has very high relative risk (see Table 4). Only Hawaiian goose (nēnē) and Pacific-golden plovers had more risk at the island scale and this risk was only slightly larger than Mānā for Hawaiian goose (nēnē) and amounted to 1.9 total strikes for plovers. All other species had far less risk or zero risk at all other powerlines monitored. Note that in 2015 a plover was found with a fractured wing under powerlines that cross the powerline trail near Pole 138.

3.2.0 Dead bird analysis for the Hawaiian Gallinule ('alae 'ula) and Hawaiian Coot ('alae ke'oke'o)

3.2.1 Hawaiian Gallinule ('alae 'ula)

Accounting for biases (as outlined in the Methods), there would have been 7.8, 20.8, 39.0 dead Hawaiian gallinules ('alae 'ula) annually across the entire island, considering the definitive, definitive + probable, and definitive + probable + possible powerline collisions, respectively.

3.2.2 Hawaiian Coot ('alae ke'oke'o)

Accounting for biases (as outlined in the Methods), there would have been 0, 0, 15.2 dead Hawaiian coots ('alae ke'oke'o) annually, considering the definitive, definitive + probable, and definitive + probable + possible powerline collisions, respectively.

4.0 Brief discussion

Mānā clearly has the highest documented powerline collision risk to waterbirds on Kaua'i, based on available data. We calculated Hanalei powerline collision risk in proportion to Mānā by considering relative powerline length, exposure height, and population of waterbirds. Relative to powerline length the remainder of powerlines studied by UMP have considerably lower collision risk approaching zero for most of the power grid. However, it should be noted that the scenario of wetland and powerlines in Hanalei is not the same as that for Mānā in that powerlines are distributed differently relative to the location of water and that powerlines differ in their construction heights. Therefore, there is potential Hanalei waterbirds do not follow the same collision patterns as Mānā.

The collision risk for Hawaiian goose (nēnē) was high in Mānā and, relative to other waterbird species, higher at other powerlines on the island. This is not surprising if you consider that there are an estimated 1,500 Hawaiian goose (nēnē) on Kauaʻi, most of whom move daily in or across areas with powerlines. In a single day of movement there are likely at least hundreds of Hawaiian goose (nēnē) powerline crossings across Kauaʻi as there are few areas on this island without powerlines, and this will be repeated 365 days a year. Just like with Newell's shearwaters (ʻaʻo) and Hawaiian petrels (ʻuaʻu), even if only a small percentage of crossing result in a collision there can be a large sum across the year and 208 km of major powerlines and additional hundreds of kilometers of distribution powerlines. To date, we have observed a Hawaiian goose (nēnē) collision during 210 hours of observations—observations that were not temporally centered on Hawaiian goose (nēnē) movement times. Mānā powerlines alone have ~ 370,110 hours annually in which Hawaiian goose (nēnē) regularly cross powerlines. In the 8 years UMP has been conducting research we were present in Mānā < 0.007% of the time Hawaiian goose (nēnē) regularly move, yet in that very small window of time relative to total movement, we have confirmed Hawaiian goose (nēnē) collide with powerlines, indicating a high probability of greater collision numbers.

We recommend that reflective diverters be attached to the Mānā powerlines to reduce collision for all species, and that this should also be considered for the Hanalei powerlines. Research would be required to determine diverter efficacy, but we suspect that in Mānā they would be highly effective because the dry conditions will lead to the most consistent visibility and available ambient light to reflect off of the diverters.

4.1.0 Factors not considered

We have not attempted to quantify collision risk at the >800 km of distribution powerlines UMP does not monitor.

We have not attempted to determine species specific powerline avoidance behavior or capabilities. However, based on our observations of the species and theoretical risk determine by flight ability (Bevanger 1998), Hawaiian goose (nēnē), Hawaiian ducks (koloa), Hawaiian gallinules (ʻalae ʻula), and Hawaiian coots (ʻalae keʻokeʻo) would all have relatively low avoidance capabilities, and would likely be similar to Newell's shearwaters (ʻaʻo). Plovers and stilts would likely have considerably better avoidance capabilities.

We have not attempted to determine species-specific grounding rates or mortality. We can make the following statement based on flight speed—Hawaiian ducks (koloa), Hawaiian gallinules (ʻalae ʻula) and Hawaiian coots (ʻalae keʻokeʻo) will all have transiting speeds similar to Newell's shearwater (ʻaʻo) under certain conditions. We cannot comment on the likelihood of waterbirds hitting powerlines and flying off unharmed. The Hawaiian geese (nēnē) we observed colliding and crashing into the ground did manage to take off from the ground, but with "strained flight". Newell's shearwaters (ʻaʻo) we have observed on the ground were not capable of flying away, even when there was no clear visible injury. Note though, had the Hawaiian geese (nēnē) crashed into the highway, it could have easily been hit by a car before recovering flight.

5.0 Conclusion

Lastly, it should be clear from the seabird research and waterbird data that birds found dead in the road crushed by a vehicle does not definitively indicate that the bird was killed by a car. Furthermore, for a bird to be labeled "killed by car" that bird has to be shown to behaviorally frequent landing or walking in the middle of highways or crossing highways on foot or flight that is car height. For a coot or a gallinule, low flight at car height could be considered a common behavior from water source to water source when no other obstructions exist (e.g. as seen on golf courses). However, we see this type of flight as highly unlikely if there is taller vegetation on either side of the road. Overall, we have definitive evidence from seabirds to Hawaiian geese (nēnē) to ducks to gallinules that powerlines cause these birds to crash uncontrolled to the ground. Most powerlines on the island are positioned next to roads, meaning a crash landing has a high likelihood of resulting in a bird on the road. All dead birds found in the road should be considered, at minimum, possible powerline collision victims if wires are present.

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Table 2. Mānā Waterbird Collision Risk Scores Applied to Acoustic Detected Strikes

Species	Time Period	Risk Score Flocking	n	Proportion of Risk Flocking	Bayesian Acoustic Estimate	Annual Strikes	Immediate Ground
BCNH	Acoustic Night	41	58	0.44	640	282	36.7
NENE	Acoustic Night	21	17	0.22	640	141	18.3
NESH	Acoustic Night	14	72	0.15	640	96	12.5
HAWD	Acoustic Night	12	16	0.13	640	83	10.8
HAST	Acoustic Night	4	2	0.04	640	26	3.4
Non-Native	Acoustic Night	2	2	0.02	640	13	1.7
					Crepuscular estimate		
Non-Native	Crepuscular	87	99	0.29	77	22	2.9
HAWD	Crepuscular	74	65	0.25	77	19	2.5
NENE	Crepuscular	58	47	0.2	77	15	2
BCNH	Crepuscular	51	60	0.17	77	13	1.7
HAST	Crepuscular	17	18	0.06	77	5	0.6
PAGP	Crepuscular	10	12	0.03	77	2	0.3
	Combine above two time periods						
BCNH	Sunset to Sunrise					295	38.4
NENE	Sunset to Sunrise					156	20.3
HAWD	Sunset to Sunrise					102	13.3
HAST	Sunset to Sunrise					31	4
PAGP	Sunset to Sunrise					2	0.3

*note birds that do not regularly fly in pairs or flocks have a relatively low flocking score compared with the number of Birds observed when compared to birds commonly observed in pairs or flocks.

Table 3. Hanalei waterbird collision risk proportional to Mānā collision risk by length of powerlines

Species	Time Period	Annual Strikes	Immediately Grounded
BCNH	Sunset to Sunrise	280	36.5
NENE	Sunset to Sunrise	148	19.3
HAWD	Sunset to Sunrise	97	12.6
HAST	Sunset to Sunrise	29	3.8
PAGP	Sunset to Sunrise	2	0.3

Table 4. Waterbird collision risk at all remaining powerlines monitored by UMP proportional to Mānā collision risk

	Mānā PMRF Area				Remainder of islands Powerlines monitored by UMP				
Species	multiplier	Risk Rank Flocking	Strikes	Immediately Grounded	multiplier	Risk Rank Flocking	Relative Risk	Strikes	Immediately Grounded
BCNH	118	79	295	38.4	34	13	0.16	49	6.3
NENE	64	103	156	20.3	121	107	1.04	162	21.1
HAWD	81	85	102	13.3	16	3	0.04	4	0.5
HAST	20	20	31	4	0	0	0.00	0	0
PAGP	12	12	2	0.3	106	77	6.42	13	1.9

Appendix 5C

Light Attraction Modeling

5C.1 Introduction

5C.1.1 Purpose

The purpose of this document is to describe the process for quantifying take of the covered seabirds, Newell’s shearwater (‘a‘o), Hawaiian petrel (‘ua‘u), and band-rumped storm-petrel (‘akē‘akē), on Kaua‘i resulting from attraction to Kaua‘i Island Utility Cooperative (KIUC) streetlights and facility lights for the KIUC Habitat Conservation Plan (HCP). The methods to quantify take resulting from KIUC streetlights is different from the methods used to quantify take resulting from lights associated with KIUC facilities. The methods and outcomes for both types of lights are discussed in this appendix.

5C.1.2 Mechanism of Take

Artificial lighting can attract various species in the family *Procellaridae*, including the covered seabirds. When fledglings leave their nest for the first time in the hours following sunset, they have the propensity to become attracted to artificial lights. After flying around the lights, birds attracted to artificial light can tire or inadvertently hit a structure and may become grounded, an event referred to as *fallout* (Imber 1975; Telfer et al. 1985). If the light-attracted individuals that become grounded are not rescued, they are at risk for succumbing to injury or mortality due to starvation, predation, collisions with cars, or a combination thereof. This attraction often occurs after young fledglings reach the ocean and are then attracted inland by coastal lights, which explains why they are frequently grounded in coastal areas that are quite distant from their colony (Troy et al. 2013; Rodríguez et al. 2015). There is also a potential for attraction to occur on their outbound journey prior to reaching the ocean (Troy et al. 2013). In uncommon events, adults can also exhibit light attraction (Center for Biological Diversity 2016).

Despite lacking knowledge of the exact mechanism causing attraction, it is understood that observed patterns of fallout on Kaua‘i are complex and result from various independent conditions (Troy et al. 2013). The primary source of attraction is bright lights; An early study on Kaua‘i showed that the shielding of bright lights can reduce fallout by 40 percent (Reed et al. 1985), and recent studies continue to indicate that the reduction of lateral light spillage is beneficial to reducing light-induced fallout (Rodríguez et al. 2017a, 2017b). While efforts to shield lights can effectively reduce fallout, these efforts do not appear to eliminate it. Several studies have shown that fallout patterns are also influenced by the location and brightness of artificial lights relative to seabird colonies, the proximity of lights to the coastline, and the wavelengths emitted by different light types (Troy et al. 2011, 2013; Rodrigues et al. 2012; Rodríguez et al. 2015, 2017a, 2017b, 2017c; Longcore et al. 2018).

5C.1.2.1 Streetlights

KIUC owns and operates approximately 4,150 streetlights located along roadways and in residential developments, primarily along the developed southern, eastern, and northern perimeter of Kaua‘i up to 5 miles (8.1 kilometers) inland and generally coinciding with urban centers and residential areas. KIUC streetlights are 3000K Light Emitting Diode (LED) bulbs that have been retrofitted with full-cutoff luminaries to minimize lateral light spillage (KIUC 2017). It is estimated that an additional 1,050 streetlights will be installed in the Plan Area over the 30-year permit term.

5C.1.2.2 Facility Lights

KIUC owns and operates only two facilities which maintain nighttime lights for safety and visibility; the Port Allen Generating Station and the Kapaia Generating Station. Due to the location of Port Allen Generating Station along the southern coastline of Kauaʻi, the risk of grounding is greater than at Kapaia Generating Station, which is located 2.2 miles (3.5 kilometers) inland from the nearest coastline. At the Port Allen Generating Station, KIUC installed green LED 41- and 90-watt lights (KIUC 2017). Before the fallout season in 2019, dimming capabilities were also enabled on these facility lights (KIUC 2019). Based on the significantly reduced number of birds found at the Port Allen Generating Station and Kapaia Generating Station in 2019 and 2020 relative to previous years at KIUC facilities, dimming the lights appears to have minimized light attraction.

Nighttime Lighting for Repairs

Any potential impacts related to nighttime lighting used for KIUC facility repairs are addressed in Chapter 5 but are not discussed in this appendix since they did not require any modeling. See Chapter 5, *Effects Analysis*, for the assessments of nighttime light for repairs and the associated take estimate.

5C.2 Assessment of Fallout from Streetlights

5C.2.1 Existing Streetlights

The streetlight assessment used a novel approach, developed in collaboration with the U.S. Fish and Wildlife Service, to assign fallout documented by the Save our Shearwater (SOS) program to streetlights based on the proportional contribution of those lights to the lightscape of Kauaʻi (Figure 1). This proportional assessment was developed using remotely sensed radiance, often casually called "brightness", collected by a sensor that is designed to provide global measurement of the intensity of nocturnal visible and near-infrared light on a daily basis (Cao et al. 2017); measurements of radiance made by this sensor were in units of nanowatts per square-centimeter per steradian. The process used to estimate fallout due to streetlights included the following steps:

- Partition all data associated with this assessment according to the existing spatially explicit SOS sectors that encompass all areas of the island with streetlights (Section 2.1.1, *Partitioning Data by Sector*).
- Assess island-wide satellite data of the lightscape on *Kauaʻi* (Section 2.1.2, *Assessing the Lightscape of Kauaʻi*).
- Estimate the radiance generated by a single streetlight (Section 2.1.3, *Estimating the Radiance Generated by a Single Streetlight*).
- Estimate the proportional contribution of streetlights to radiance by sector (Section 2.1.4 *Estimating the Proportional Contribution of Streetlights to Radiance by Sector*).
- Derive an estimate of fallout occurring due to streetlights in each sector (Section 2.1.5, *Uncorrected Fallout Estimate for Streetlights*).
- Apply a correction factor to account for seabirds that were grounded but not detected (Section 2.1.6, *Detectability Correction Factor for Fallout*).

The assessment included 641 SOS database records of grounded hatch-year and unknown age Newell's shearwaters ('a'o) documented from September 1 to December 31 of each year from 2015 to 2019. This assessment conservatively included all reported fallout regardless of the source of the light attraction.[1] Ideally, all birds that could not be assigned to a specific, non-streetlight light source would have been removed from this analysis. However, the radiance associated with these non-streetlight light sources could not be partitioned out of the VIIRS radiance measures due to the coarse resolution of these data (discussed in Section 2.1.2, *Assessing the Lightscape on Kaua'i*) and, therefore, it was mathematically inappropriate to remove birds without also removing the corresponding radiance.

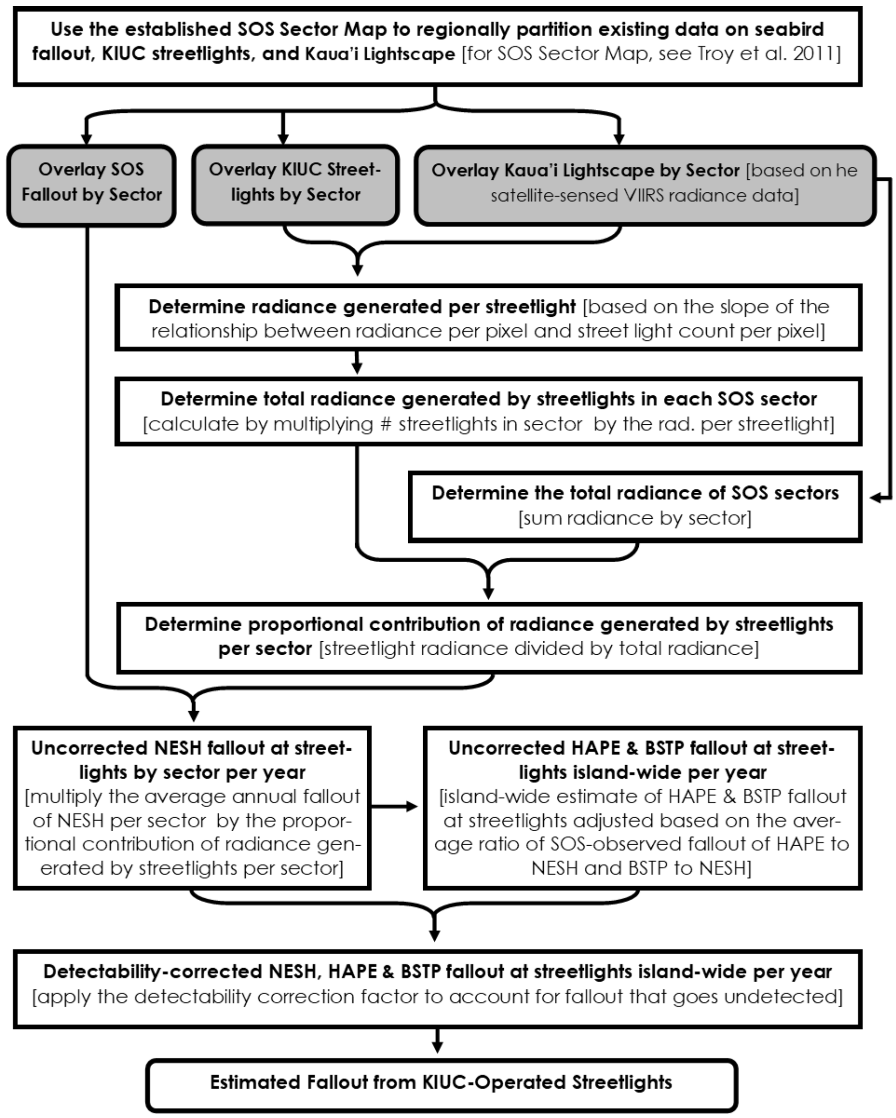

Figure 1. Conceptual schematic of the approach used to determine the proportional contribution of KIUC streetlights to the radiance of Kaua'i on a regional basis as a proxy for the proportion of annual seabird fallout resulting from these streetlights.

[1] Over half of the 641 Newell's shearwater ('a'o) fallout records in the SOS database could be assigned to non-streetlight sources (e.g., KIUC facility lights, fallout claimed by participants in the Kaua'i Seabird Habitat Conservation Plan, and other lights) (DOFAW 2020).

5C.2.1.1 Partitioning Data by Sector

All streetlights, lightscape, and fallout data used for this assessment were partitioned according to SOS sector (Figure 2) (SOS program unpubl. data, as described by Troy et al. 2013). There are 35 sectors[2] that vary in size, ranging from 1237 to 98,926 square kilometers, and cover developed areas as well as areas with no development and no artificial lighting. The benefits of partitioning fallout, lightscape, and streetlight data by SOS sector is that these sectors have been used since the 1990s to understand long-term patterns of fallout across Kauaʻi (Troy et al. 2011, 2013), and partitioning data by SOS sector enables this assessment to account for spatial heterogeneity of fallout across the Plan Area.

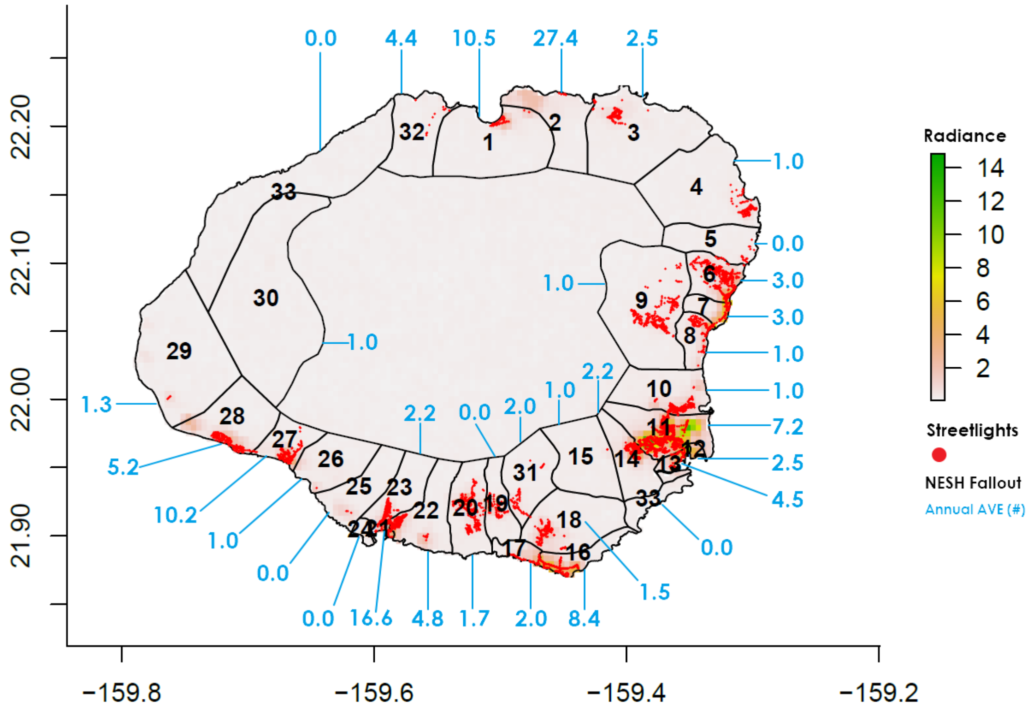

Figure 2. SOS sectors (delineated with black outlines and identified with black numbers) and the annual average (AVE) fallout of Newell's shearwater (ʻaʻo) reported by SOS over the previous 5 years (blue numbers) with the radiance and streetlights across the Plan Area. The radiance data was derived from October 2018 measurements.

5C.2.1.2 Assessing the Lightscape on Kauaʻi

The lightscape of Kauaʻi was assessed using radiance data collected via satellite, which is the only data available at an island-wide scale . Globally, radiance produced by lights at night have been remotely sensed on a daily basis by the Day-Night Band (DNB) sensor on the Visible Infrared Imaging Radiometer Suite (VIIRS) installed on the Suomi National Polar-Orbiting Partnership Satellite (Cao and Bai 2014). The DNB sensor is one of 23 sensors on the VIIRS. The purpose of the DNB sensor is to measure radiance (nanowatt (nW) per square centimeters (cm^2) per steradian (sr)) from as low as a quarter moon illumination to the brightest daylight in the 0.5 to 0.9 micrometer range of the electromagnetic spectrum (Cao and Bai 2014). For this assessment, both

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[2] A sector is a geographic area varying in size.

the October and November[3] 2018 stray-light corrected composite maps of Kaua'i's radiance were used. These maps were compiled by the National Oceanic and Atmospheric Administration's (NOAA) Earth Observation Group (2020), and provided by NOAA's National Center for Environmental Information (2018a, 2018b).

The resolution of radiance measures derived from the DNB were much lower than what would be needed to directly measure the contribution of a single streetlight. The on-board aggregation scheme allows the DNB sensor to maintain a nearly constant 0.46 miles (742 meters) resolution over the entire 186-mile (300-kilometer) sampling swath for raw images (Cao and Bai 2014; Cao et al. 2017) and NOAA's National Geophysical Data Center's Earth Observation Group uses these raw images to make monthly composites of radiance data. Due to the way the daily images are gridded using a 15 arc-second resolution, these monthly composites have greater resolution than can be measured by the DNB sensor (on the order of 430 by 460 meters [hereafter, pixel] at the latitude of Kaua'i) (Baugh et al. 2013). While this is an improvement in resolution from the DNB radiance measurements, monthly composites of radiance data are still too coarse to estimate the radiance generated by a single streetlight (e.g., a single radiance pixel can contain as many as 41 KIUC streetlights as well as numerous other light sources that inflate and/or mask the actual radiance emitted by the streetlights). Therefore, since it is not possible to directly measure the radiance generated by a single streetlight, the contribution of streetlights to radiance has been inferred by relating the degree to which radiance increased as a function of increased counts of streetlights per pixel using methods described in Section 2.1.3, *Estimating the Radiance Generated by a Single Streetlight*.

5C.2.1.3 Estimating the Radiance Generated by a Single Streetlight

To estimate the contribution of streetlights to radiance, a regression was used to describe the degree to which radiance increased as a function of increasing numbers of streetlights per pixel. Because the light generated by streetlights is difficult to separately identify when contributing to light associated with commercial and urban centers, using all radiance data in the Plan Area would not provide a meaningful estimate of the relationship between streetlights and radiance. Thus, it was necessary to restrict the data to include only the minimum radiance per streetlight count, as these darker pixels were more likely to represent areas where the light generated only by streetlights and not additional lights associated with commercial areas and urban centers. The approach to estimate the radiance generated by a single streetlight included the following steps:

- Isolate the radiance data needed to assess how radiance per pixel varied as a function of streetlight count (see Section 2.1.3.1, *Radiance Data Subset*).
- Produce a probabilistic estimate of radiance generated per streetlight that incorporates uncertainty into the estimate of slope (see Section 2.1.3.2, *Radiance Generated per Streetlight*).
- Extrapolate the proportional contribution of streetlights to total radiance by sector (Section 2.1.4, *Estimating the Proportional Contribution of Streetlights to Radiance by Sector*).

Radiance Data Subset

Visualizing the radiance for all pixels on Kaua'i in October (Figure 3A) and November (Figure 3B) as a function of streetlight count per pixel showed that there were many situations where the radiance

[3] Over the last 5 years (2015-2019), 72 percent of the fallout on Kaua'i happened during the months of October and November, with 41.2 percent occurring in October and 30.8 percent occurring in November.

of a particular pixel was unrelated to the radiance produced by streetlights. For example, in areas where there were no streetlights (streetlight count equal to zero), non-streetlight lights present in those pixels produced large radiance measures. Including radiance measures from pixels where streetlights were not present would not facilitate estimation of radiance added by streetlights. Furthermore, for pixels with the same streetlight count, the range of associated radiance per pixel varied from relatively dark to very bright; these bright pixels were associated with commercial areas that had lights that produced more radiance than streetlights, and thus masked the streetlight signal. Because of this, inclusion of radiance measures from all pixels with streetlights would have inappropriately introduced measures of various confounding light sources that mask the streetlight signal. Thus, to isolate the streetlight signal for individual streetlight radiance, the data used for this assessment was restricted to consider only the darker rural or residential areas (i.e., locations where there are relatively few non-streetlight light sources).

Assumptions were made to isolate pixels that could inform an estimate of the radiance added by streetlights. A single datapoint, the pixel with the lowest radiance, was selected for each category of streetlight count (Figure 4). For each streetlight count, the pixel with the lowest radiance was assumed to be derived from an area where there was minimal presence of non-streetlight light sources, thus there was minimal masking of the streetlight signal by other lights.

When looking at the minimum radiance for each streetlight count, there was a strong and consistent linear pattern between radiance added per increase in streetlight count (Figure 4). Notably, this strong and consistent relationship was evident for lower streetlight counts but appeared to breakdown once the count of streetlights exceeded 21 streetlights per pixel (Figure 4); this pattern was similar in both October (Figure 4A) and November (Figure 4B). We hypothesized that this apparent breakdown in the relationship was artificial, resulting in part from the fact that these larger streetlight counts per pixel were relatively rare (generally three or fewer instances on the island for a given streetlight count; Figure 3) and in part because greater densities of streetlights were more likely to be associated with urban centers and commercial areas rather than darker, residential-only areas. Thus, each pixel presented in Figure 4 with a streetlight count greater than 20 was manually reviewed using satellite imagery in Google Earth to assess if the pixel was overlapping a darker residential area or if the pixel was overlapping a brighter commercial area. Pixels characterized as residential were assumed to have a radiance that was generated primarily by streetlights (and to a lesser extent, households); all pixels categorized as residential were included in the regression (black dashes in Figure 4). Pixels characterized as commercial were assumed to have a radiance that was generated by a variety of non-streetlight light sources that likely masked the streetlight signal; all pixels categorized as commercial were excluded from the regression (red dashes in Figure 4).

In both October (Figure 4A) and November (Figure 4B), the manual review classified 8 of 15 pixels as commercial and the remaining 7 of 15 pixels as residential. The commercial pixels were brighter than the residential pixels (October: $t=4.6$, $df=7.2$, $p=0.001$; November: $t=5.1$, $df=7.4$, $p< 0.001$) and were located primarily in Lihue adjacent to the airport (the brightest spot on the island) whereas the residential areas contained between 75 and 150 houses per pixel and were distributed across multiple towns including Hanapepe, Kapaa, Wailua Homesteads, Lawai, and Kilauea.

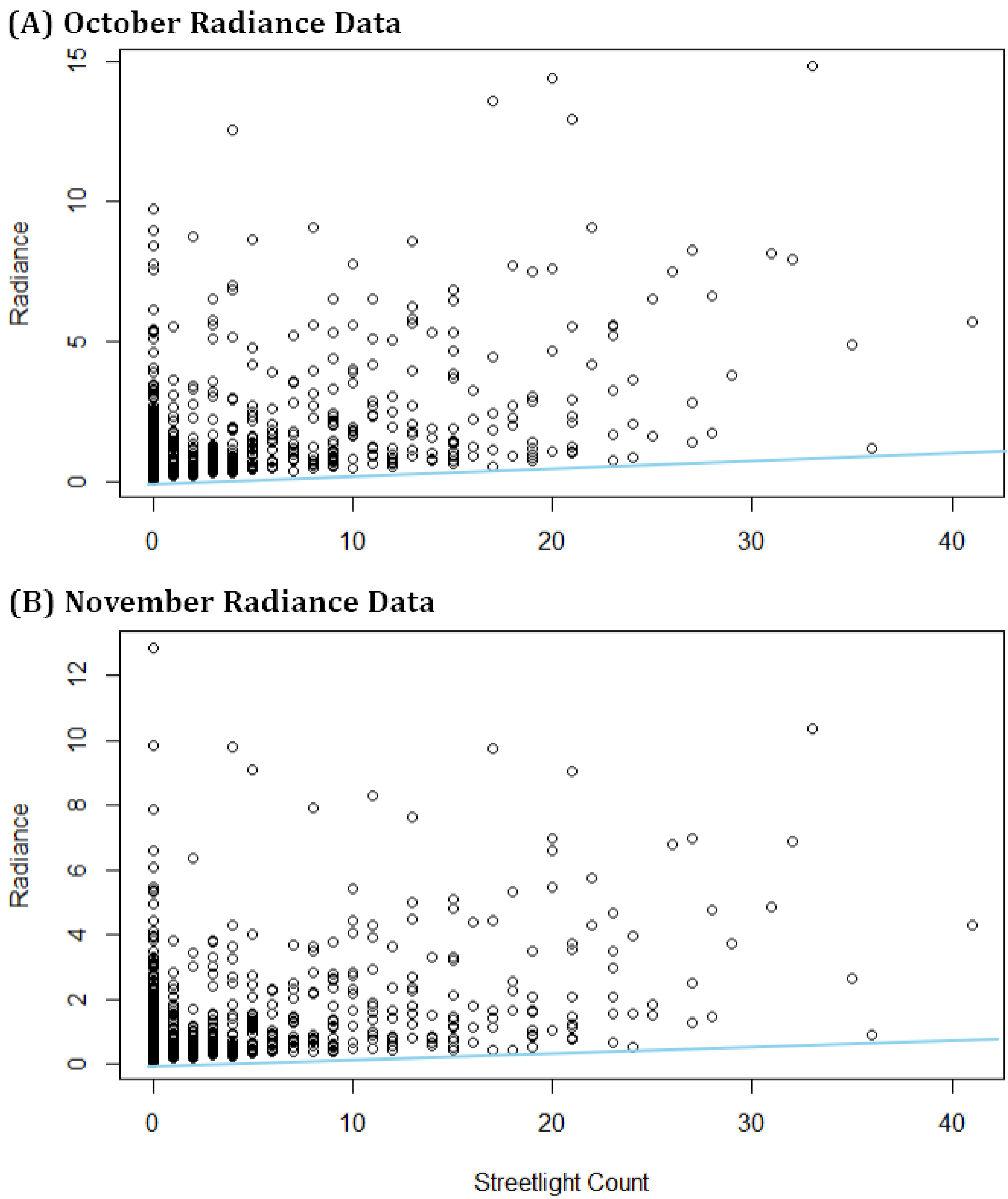

Figure 3. Radiance and streetlight count for all pixels on Kaua'i using the October (A) and November (B) based on 2018 VIIRS satellite radiance data.

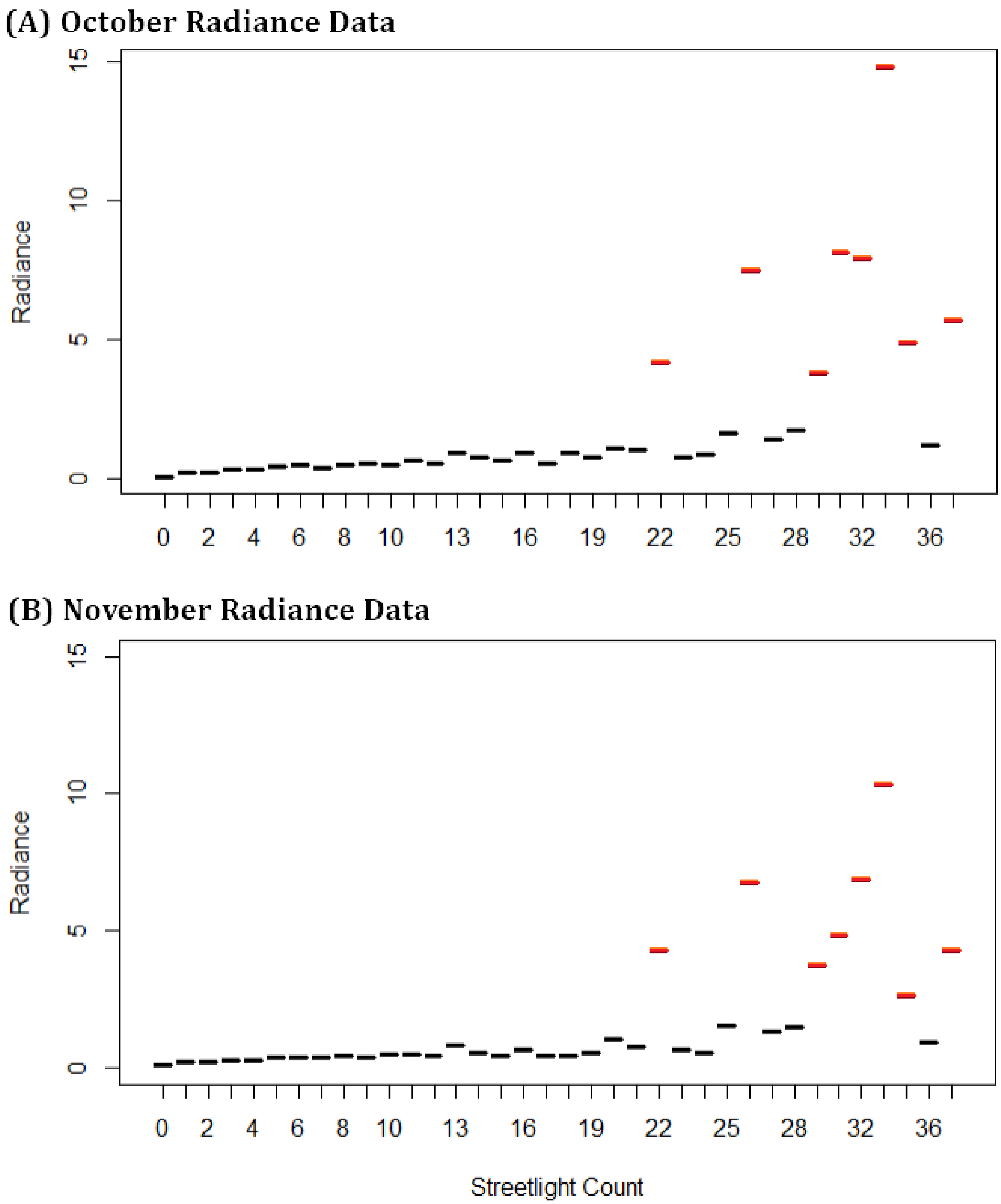

Figure 4. Subset of Plan Area radiance that includes only the darkest pixel per streetlight count for October (A) and November (B) based on 2018 VIIRS satellite radiance data. Black dashes represented pixels categorized as residential and were therefore included in the assessment of radiance added by streetlights. Red dashes represented pixels categorized as commercial and were therefore considered to be unrepresentative of radiance generated by streetlights and were excluded in the assessment of radiance added by streetlights.

Radiance Generated per Streetlight

Once the dataset relevant for quantifying the functional relationship between radiance and streetlight count was compiled, a linear regression was used to estimate how much radiance increased as the streetlight count per pixel increased. This rate of increase is also known as the slope.

Comparison of Three Analytical Approaches

Three analytical approaches for estimating the variance in radiance added by a single streetlight were explored: bootstrapping, Bayesian regression, and cross-validation. All three approaches were implemented to assess variance in radiance added per additional streetlight (i.e., the slope). Cross-validation was also used to determine model fit metrics as a means of assessing whether the predictive power of the relationship between radiance and streetlight count was similar using data from October relative to November. Below is a brief description of each approach:

- Bootstrapping, which falls under the broader class of resampling methods, uses random sampling with replacement to assign measures of accuracy (bias, variance, confidence intervals, etc.) to sample estimates (Mooney and Duval 1993).
- A linear regression within the context of Bayesian inference was also implemented for comparative purposes (Kruschke 2015).
- Cross-validation, sometimes called rotation estimation or out-of-sample testing, is a suite of similar model validation techniques generally used to assess how well the results of a statistical analysis will generalize to an independent data set (Stone 1974); specifically, leave-one-out cross-validation was used (Fushiki 2011). The most common goal of cross-validation is to estimate the expected level of fit of a model to data that is independent of the data used to create or train the regression.

Bootstrapping, Bayesian, and cross-validation approaches each have their advantages and drawbacks, but in this context were generally complimentary. Each were used to estimate the variance about the regression parameters (e.g., intercept and slope). Cross-validation had the added benefit of providing insight into how well the model predicted out-of-sample data.

Radiance and Streetlight Count

Based on the regression using October satellite imagery, the radiance emitted by a single streetlight was estimated to be 0.04 nW/cm^2/sr (95% HDI: 0.03–0.05) (Figure 5A). For comparison, Bayesian and cross-validation methods produced similar estimates of slope (Bayesian Approach: 0.04 (0.03-0.05 nW/cm^2/sr; Cross Validation Approach: 0.04 (0.03-0.05 nW/cm^2/sr). Based on the regression using November satellite imagery, the radiance emitted by a single streetlight was estimated to be 0.03 nW/cm^2/sr (95% HDI: 0.02–0.04) (Figure 5B). Again, Bayesian and cross-validation methods produced similar estimates of slope (Bayesian Approach: 0.03 (0.02-0.04 nW/cm^2/sr; Cross Validation Approach: 0.03 (0.02-0.04 nW/cm^2/sr). Thus, the estimate of radiance produced per streetlight was similar using data from October and November (i.e., overlapping confidence intervals), with the mean estimate being 0.01 nW/cm^2/sr greater in October relative to November.

Cross-validation was also used to determine model fit metrics and assess whether the predictive power of the relationship between radiance and streetlight count was similar using data from October relative to November. Leave-one-out cross-validation indicated that model fit metrics were relatively good in both months but slightly better in October (root-mean-square error = 0.21, mean absolute error = 0.15, R-squared = 0.73) relative to November (root-mean-square error = 0.23, mean absolute error = 0.17, R-squared = 0.58).

Since the October 2018 data produced a larger point estimate of the light added per streetlight and the predictive relationship between streetlight count and radiance was stronger, all estimates of streetlight take presented in Section 4.2, *Take Estimates for Covered Seabird Species* were derived using the October 2018 radiance data.

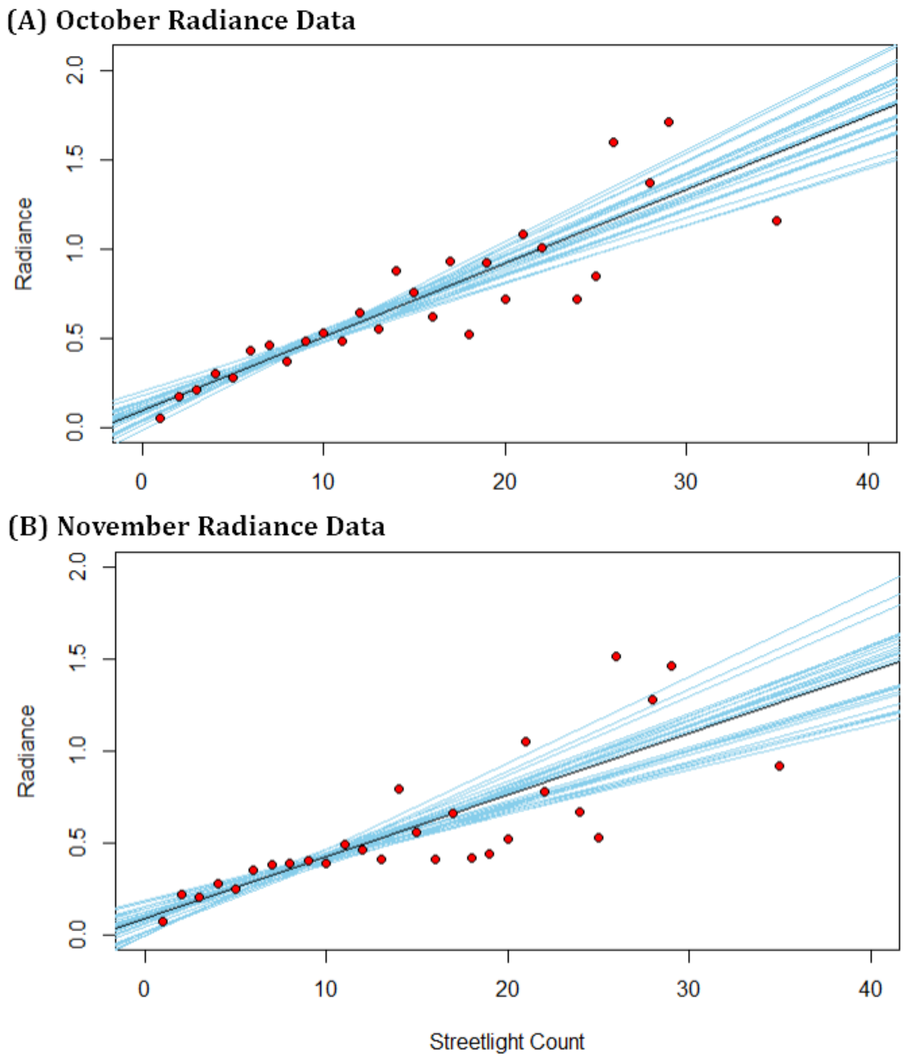

Figure 5. Radiance regressed against streetlight count per pixel using 2018 VIIRS satellite radiance data from October (A) and November (B). The black line represents the average relationship between radiance and streetlight count and the blue lines are examples of credible regression lines generated via bootstrapping.

5C.2.1.4 Estimating the Proportional Contribution of Streetlights to Radiance by Sector

Once radiance per streetlight was determined, the proportional contribution of streetlights to the total radiance was determined on a sector-by-sector basis by:

1. Extrapolating the radiance of a single streetlight to the total number of streetlights in each sector;
2. Summing the radiance of each pixel within an SOS sector; and
3. Dividing the total radiance generated by streetlights by the sum of the radiance in each sector.

Across all sectors, the proportional contribution of streetlights to sector radiance averaged 6.1 percent but the proportion of radiance added in individual sectors was variable, ranging from sectors without streetlights (and therefore having a 0 percent contribution to radiance) to sectors with streetlights intermixed non-streetlight light types (e.g., residential, commercial, etc.). Both Kapa'a and Hanapēpē were found to have the greatest proportional contribution of streetlights to overall radiance at 13.2 percent. There are no sectors that have areas of lighting that was only contributed to by a streetlight and no sectors where streetlights contribution to overall radiance was greater than non-streetlight sources .

5C.2.1.5 Uncorrected Fallout Estimate for Streetlights

Newell's Shearwater (ʻaʻo)

The average annual fallout for Newell's shearwater (ʻaʻo) was summarized by sector and multiplied by the proportional contribution of streetlights in each sector to derive an estimate of fallout attributable to KIUC streetlights. The majority (89.75 percent) of Newell's shearwater (ʻaʻo) fallout between 2015 and 2019 could be assigned to an SOS sector. The sector of fallout was not known for the remaining 10.25 percent of Newell's shearwater (ʻaʻo) because the location information was not provided by the citizen collector and not included in the SOS records. For birds where the sector of fallout was unknown, the proportional contribution of streetlights to sector radiance was averaged across all land-based sectors to proportionally assign fallout of birds with unknown locations to KIUC streetlights.

Hawaiian Petrel & Band-Rumped Storm-Petrel

Fallout of Hawaiian petrel (ʻuaʻu) and band-rumped storm-petrel (ʻakēʻakē) was too infrequent to develop a robust assessment of sector-by-sector patterns following the method used for Newell's shearwater (ʻaʻo). Due to the very limited fallout data for Hawaiian petrel (ʻuaʻu) and band-rumped storm-petrel (ʻakēʻakē), the sector-by-sector patterns determined using Newell's shearwater (ʻaʻo) were applied to these other seabird species. The total fallout estimated for Newell's shearwater (ʻaʻo) was adjusted using the ratio of each species to Newell's shearwater (ʻaʻo). For Hawaiian petrel (ʻuaʻu), these ratios were determined using the total observed fallout of Newell's shearwater (ʻaʻo) relative to Hawaiian petrel (ʻuaʻu) annually from 2015 to 2019 (Table 2) and then calculating the 5-year average. For band-rumped storm-petrel (ʻakēʻakē), the analysis used a 15-year timeseries of fallout. A single value for the annual average of Newell's shearwater (ʻaʻo) to band-rumped storm-petrel (ʻakēʻakē) fallout was calculated. The average annual ratio indicated that for every Newell's shearwater (ʻaʻo) take, an additional 0.061 Hawaiian petrel (ʻuaʻu) and 0.01 band-rumped storm-petrel (ʻakēʻakē) are estimated to occur.

Table 2. Annual number of Newell's shearwater ('a'o), Hawaiian petrel ('ua'u), and Band-rumped storm-petrel ('akē'akē) reported in the SOS database

YEAR	NESH[1]	HAPE[2]	BSTP[3]	HAPE:NESH	BSTP:NESH
2005	*	*	0	-	-
2006	*	*	1	-	-
2007	*	*	6	-	-
2008	*	*	2	-	-
2009	*	*	2	-	-
2010	*	*	2	-	-
2011	*	*	1	-	-
2012	*	*	1	-	-
2013	*	*	0	-	-
2014	*	*	3	-	-
2015	154	4	0	0.026	-
2016	100	1	1	0.010	-
2017	142	14	0	0.099	-
2018	161	4	0	0.025	-
2019	84	12	0	0.143	-
AVE	**128.2****	**7**	**1.3**	**0.061**	**0.01**

[1]NESH = Newell's shearwater ('a'o)
[2]HAPE = Hawaiian petrel ('ua'u)
[3]BSTP = Band-rumped storm-petrel ('akē'akē)
*For Newell's shearwater ('a'o) and Hawaiian petrel ('ua'u), a 5-year timeseries of data were used for these species and therefore data were only summarized for the previous 5 years (but there was fallout of both species prior to 2015.)
**Annual fluctuations in SOS numbers occur based on the moon phase during peak fallout, as well as the size of the breeding population, annual variation in breeding effort, annual variation in reproductive success, inconsistencies in observer effort, and changes to the lightscape across Kaua'i.

5C.2.1.6 Detectability Correction Factor for Streetlight Fallout

Not all grounded birds are located and turned into SOS for rehabilitation and, therefore, the SOS database does not fully represent the total number of birds that are attracted by lights in the Plan Area each year. Therefore, an estimate of detectability is needed to adjust the estimated fallout resulting from using the SOS database to account for the additional birds that were not turned into SOS.

The exact probability of a grounded Newell's shearwater (a'o') being located and turned into SOS has not been previously quantified for birds grounded at streetlights and there is a paucity of data to support making such an estimate. An accurate estimate would require specific data on the number of grounded birds that are not turned into SOS because they were not located opportunistically at their grounding location, , hid in nearby bushes where they could not be found, were removed from the site and/or consumed by predators, or were hit by vehicles and not retrieved. There are no data to inform any of these specific components that contribute to fallout.

Given the lack of data on the necessary metrics, the literature related to searching for dead and grounded seabirds on Kaua'i was reviewed to provide additional insight into the potential lower limit of detectability Specific studies reviewed were Podolsky et al. (1998), and Travers et al. (2012), which documented similar patterns described by Podolsky et al. (1998).

Podolsky et al. (1998) compared the findings of two parallel programs that located dead birds.

- searches conducted by Podolsky et al. (1998), which relied on trained biologists to intensively search for dead birds
- searches associated with the SOS program, which relied on citizens to opportunistically discover and turn in dead birds.

Podolsky et al. (1998) searched intensively for dead birds in proximity to powerlines in urban and suburban areas, inconspicuously marked all dead individuals, and coordinated with the SOS program to determine if any of these dead birds were subsequently turned in by citizens. Although Podolsky et al. (1998) did not examine the efficacy of SOS in detecting birds, information provided by the findings of these overlapping searches can inform an estimate of the lower limit of detectability.

For the purposes of calculating the efficacy of SOS searchers in locating birds, it was assumed that all the dead birds available to be found by these two concurrent efforts were located by the overlapping intensive surveys and opportunistic observations (an assumption that is uncertain and has not been investigated). In total, 50 dead birds were located, 8 of which were found by citizens and turned into SOS (Podolsky et al. 1998). Based on the assumption that all dead birds were located, this would indicate that SOS had a 16 percent (8 SOS birds/50 total dead birds) discovery rate of dead birds. Given that the detection probabilities reported by Podolsky et al. (1998) only applied to dead birds, this detectability is likely a worst-case scenario for the detectability of live birds because the literature indicates that citizens are more inclined to turn in live birds to SOS. Travers et al. (2012) specifically noted that "residents are extremely unlikely to pick up a dead bird and pass it on to [SOS] thus resulting in an underestimate of this cohort". Podolsky et al. (1998) reached a similar conclusion regarding residents' preference to submit live birds to the SOS program. Thus, a minimum detection rate of 16 percent for live birds (as determined using dead birds) was the best conservative estimate that could be empirically derived at this time.

However, it is important to note that there are confounding factors that may interfere with the estimation of detectability of live birds (i.e., their mobility and ability to hide) relative to dead birds, which cannot be quantified based on the information available to date. Thus, we attempted to further adjust the discovery rate downwards as a way of accounting for these additional confounding factors.

To do this, we assumed that the 50 dead birds described in Podolsky et al. (1998) were actually alive and that there were an unknown number of additional dead birds that would remain undiscovered and would never be turned into SOS (equivalent to a detectability of zero percent). The percent of grounded birds that were found dead when trained searchers intensively surveyed for all grounded birds (live or dead) was used to calculate the number of additional dead birds that would go undiscovered. Podolsky et al. (1998) reported that 43 percent of the birds they located when searching for grounded birds were dead and more recent data from Travers et al. (2012) indicated that 35 percent of the grounded birds were dead. In both cases, Travers et al. (2012) noted that these percentages of dead birds were likely an overestimate of the actual proportion of the cohort that was dead versus alive because residents collect live birds prior to searchers arriving.

Knowing the number of documented live birds (50) and the ratio of birds that are alive (100 percent minus 43 percent based on Podolsky et al. 1998, or 100 percent minus 35 percent based on Travers et al. 2012) allows the additional number of grounded birds that are dead and will remain undetected by SOS searcher to be calculated using the following equation:

$$count\ of\ dead\ birds\ = \frac{count\ of\ live\ birds * percent\ of\ birds\ found\ dead}{percent\ of\ birds\ found\ live}$$

Using the percent of dead birds reported by Podolsky et al. (1998), an estimated 37.7 dead birds in addition to the 50 live birds would go undetected by searchers associated with the SOS program.

$$count\ of\ dead\ birds\ = \frac{50\ live\ birds * 43\ percent\ of\ birds\ found\ dead}{57\ percent\ of\ birds\ found\ live} = 37.7$$

In this hypothetical scenario, there would be a total of 87.7 birds (live (50) and dead (37.7)) available to be discovered and submitted to SOS with just 8 ultimately being turned into SOS; thus, the overall detectability rate for SOS at streetlights would be 9.2 percent. If we do the same calculation using the more recent information from Travers et al. (2012), an estimated 26.9 dead birds in addition to the 50 live birds would go undetected by searchers associated with the SOS program.

$$count\ of\ dead\ birds\ = \frac{50\ live\ birds * 35\ percent\ of\ birds\ found\ dead}{65\ percent\ of\ birds\ found\ live} = 26.9$$

In this hypothetical scenario, there would be a total of 76.9 birds (live (50) and dead (26.9)) available to be discovered and submitted to SOS, with just 8 ultimately being turned into SOS; thus, the overall detectability rate for SOS at streetlights would be 10.4 percent (8 found birds divided by 76.9 grounded birds). Given the conservative nature of these calculations, for purposes of correcting the detectability estimate of SOS estimated fallout resulting from KIUC streetlights, the light attraction model used a detectability rate of 10.4 percent as the worst-case estimate for all three covered seabird species.

5C.2.1.7 Sensitivity Analysis

To assess if the output of this assessment was stable across months, separate estimates of the radiance added per streetlight were made for October and November. All other inputs used to estimate the proportional contribution of radiance to streetlights were multiplicative processes and are thus scaled 1:1 input to output at the level of the SOS sector. Thus, on a sector-by-sector basis, a 10 percent change in one input (e.g., streetlight count per sector, detectability correction factor, etc.) would result in a 10 percent change in the output (e.g., estimated fallout per sector).

5C.2.2 Future Streetlights

In addition to quantifying the annual fallout occurring at the existing streetlights, quantifying the anticipated additional fallout associated with the estimated 1,754 future streetlights over the 30-year permit term of the HCP was also necessary. These future streetlights will not be uniformly distributed across the island, but rather are expected to be installed in a manner that is proportional to the growth expected in Kaua'i's Planning Districts (Figure 6, copied from the Kaua'i General Plan; County of Kaua'i 2018). So, for example, if there were 1,050 future streetlights, then 2 percent (or a total of 20 streetlights) would be installed in the North Shore Planning District, 13 percent (or a total of 130 streetlights) would be installed in the East Kauai Planning District, and so on.

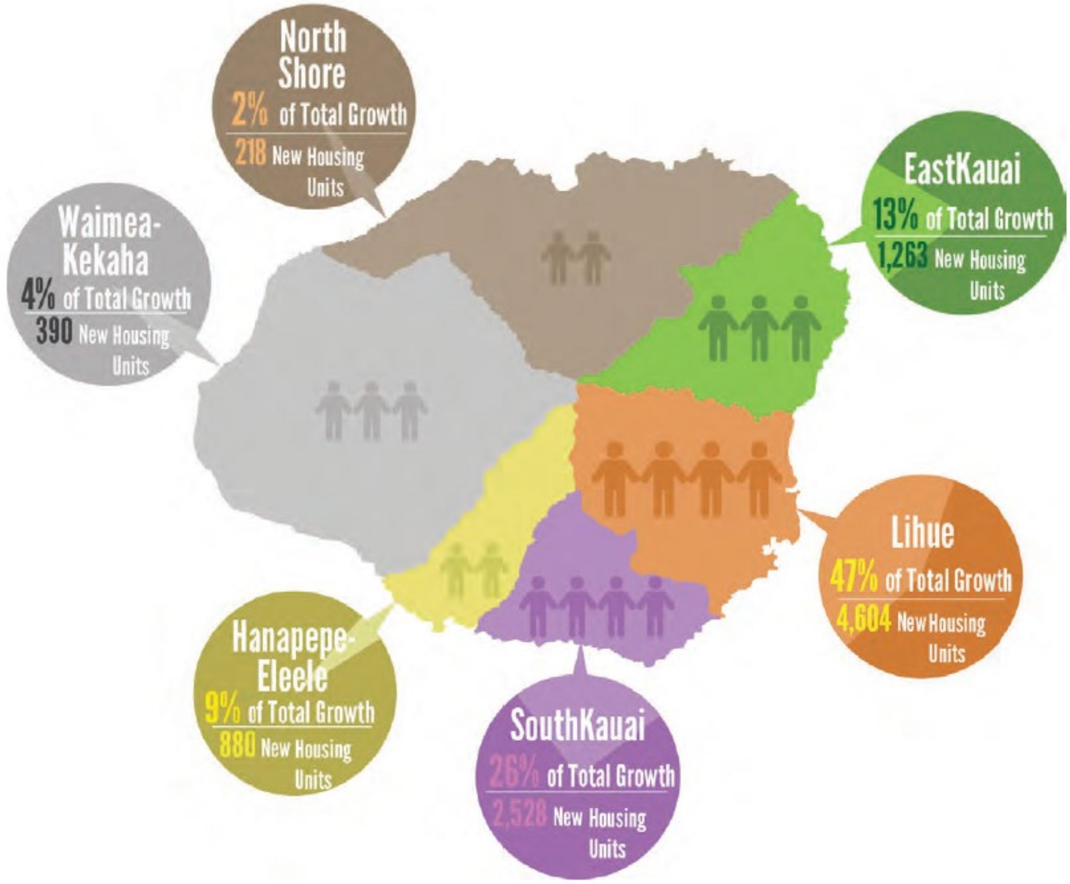

Figure 6. Growth allocations by Planning District from the Kaua'i General Plan (Kaua'i County 2018)

However, these Planning Districts are large and encompass multiple SOS sectors (Figure 2). Thus, for a given Planning District, future streetlights were further partitioned to SOS sectors based on the proportion of streetlights currently present in each SOS sector. So, for example, in the North Shore Planning District there are four SOS sectors that currently have a total of 161 streetlights; 24.8 percent (n=40) of these streetlights are in SOS sector 1, 3.1 percent (n=5) are in SOS sector 2, 64.6 percent (n=104) are in SOS sector 3, and 7.5 percent (n=12) are in SOS sector 32. Thus, of the 20 future streetlights expected in the North Shore Planning District, 24.8 percent were added to SOS sector 1, 3.1 percent were added to SOS sector 2, 64.6 were added to SOS sector 3, and 7.5 percent were added to SOS sector 32. These calculations were repeated for each Planning District on Kaua'i to determine the number of estimated streetlights to be added to each SOS sector in the future.

Once the number of estimated future streetlights to be added to each SOS sector were identified using the method described above, the estimate of radiance generated by a single streetlight could be scaled up to estimate the total radiance added to each SOS sector by the addition of these future streetlights. Similar to the assessment of fallout occurring at existing streetlights, the proportional contribution of future streetlights to SOS sector radiance was used to partition observed fallout into streetlights and non-streetlight and then corrected for detectability using the same logic presented in Section 2.1, *Existing Streetlights* (e.g., assuming a detectability rate of 10.4 percent at streetlights, etc.).

Although we can project the total number and general location of future streetlights with some accuracy based on the existing distribution of streetlights and future growth projections summarized in the Kaua'i General Plan, the same is not true for projecting the magnitude and distribution of future fallout and radiance on the island. It is unknown if and to what extent fallout and overall radiance will change in the future. As such, for purposes of this assessment, we assumed that the current patterns of fallout and radiance will persist into the future.

5C.2.3 Limitations

There were several limitations related to the estimation of fallout occurring at current and future streetlights that should be considered:

- Although the resolution of the radiance data was too coarse to directly measure the radiance added by single streetlight, recently published study (Kyba et al. 2020) successfully measured the proportional contribution of streetlights to nighttime radiance in Tucson, Arizona using the VIIRS DNB radiance data, providing support for validity the approach described here to estimate the proportional contribution of streetlights.
- For purposes of this assessment, it was assumed that the proportional contribution of streetlights to radiance was equal to the proportional contribution of streetlights to the annual rate of fallout. Light intensity and region are the only factors that can be accounted for using the approach presented here and it does not account for other factors known to contribute to patterns in fallout such as differential attraction by different wavelengths or distance from the coastline. It is possible that the intensity of the various light sources on Kaua''i as sensed from space may not match the perceived attractiveness of these light sources to newly fledged seabirds.
- Certain bulb types may be more attractive to shearwaters than others due to the spectrum of wavelengths emitted. Based on preliminary reports, the visual system of Newell's shearwaters (a'o') may be sensitive to violet and ultraviolet wavelengths (Moon et al. 2019), and these attractive wavelengths are more prevalent in "cool" light (e.g., 5000K LED) and less prevalent in "warm" light (e.g., 3000K LED) (Figure 1 in Longcore et al. 2018). There have been two recent studies that specifically characterized the attractiveness of LED lights to shearwaters relative to other light types. Rodríguez et al. (2017c) experimentally attracted shearwaters using unshielded 5000K LED, high pressure sodium, and metal halide bulbs. . They recorded average fallout rates of 1.7 birds per hour at high pressure sodium lights, 2.1 birds per hour at LED lights and 3.3 birds per hour at metal halide lights and concluded that "metal halide multiplied the mortality risk by a factor of 1.6 and 1.9 respectively in comparison with LED and high-pressure sodium lights". Despite having observed fallout of 125 birds in 66 hours at 5000K LED and high pressure sodium lights, the variability in fallout rates at these two light types overlapped enough that it was not possible to conclude that there were differences in the attractiveness of LEDs and high pressure sodium lights (Rodríguez et al. 2017c).. Longcore et al. (2018) created a model that inferred potential attractiveness of a more extensive list of lights based on the visual sensitivity of Newell's shearwater (a'o') reported by an thesis (Reed 1986). Results presented in Longcore et al. (2018) represent predictions rather than actual data on attractiveness of lights to shearwaters, and shortcomings were highlighted in their discussion. Furthermore, the re-analysis of Rodríguez et al. (2017c) by Longcore et al. (2018) showed that using actinic power per lux to predict attraction may overestimate the attractiveness of LED lights based on findings reported by Rodríguez et al. (2017c) (see Figure 5, Longcore et al. 2018). Importantly, the

Longcore et al. (2018) assessment lacked critical information needed to understand if apparent differences presented for various light types were statistically significant.

- The SOS database did not provide sufficient detail regarding fallout location to conclusively link fallout to streetlights. Therefore, the SOS data could not be used to validate the outcome of the analysis. In addition, the surrounding urban lightscape prohibits isolating a single light source as the cause of fallout. Since light attraction likely results from multiple light sources, directly quantifying the true contribution of streetlights to fallout would require an experimental study where various light sources are manipulated and the impact on fallout is measured.
- Data on detectability of seabirds grounded under streetlights does not exist. The 10.4 percent used here is intentionally conservative and lower than what has been documented for other situations. A review of 294 infrastructure-driven mortality studies based on carcass searches found that body mass was the most important variable influencing the detectability of a carcass to searchers (Barrientos et al. 2018); Newell's shearwaters (a'o') range in mass from 342 to 425 grams (Ainley et al. 2020) and the review by Barrientos et al. (2018) suggested that a bird of that size would have an overall detectability rate of about 80 percent for trained observers across the habitat types of interest (fences, powerlines, roads, solar plants, and wind farms).
- The actual distribution of future streetlights may not match what was projected in the Kaua'i General Plan (County of Kaua'i 2018). Further, future fallout and radiance patterns are unknown. If future fallout and radiance patterns are determined to differ from what has been projected by this assessment, differences can be addressed through adaptive management.

5C.3 Assessment of Fallout from Facility Lights

For the two covered facilities in the KIUC HCP, Port Allen Generating Station and the Kapaia Generating Station, take was directly enumerated using the average number of downed birds located at each facility, as documented in KIUC monitoring logs (KIUC 2019) and the SOS database. KIUC staff have monitored and maintained inspection logs for these facilities during the seabird fallout season (September 15 through December 15) since 2011.

The take estimate for KIUC facilities is based on 5-year average (2016-2020) for Newell's shearwater ('a'o) and) a 9-year average (2011-2020) for rarer species (i.e., Hawaiian petrel ('ua'u) and band-rumped storm-petrel ('akē'akē)).. The take estimate that encompassed observations prior to and following full minimization was calculated to be consistent with methods used to estimate facility take elsewhere on the island by participants in the Kaua'i Seabird HCP (DOFAW 2020).

The take estimate for fallout from facility lights used a detectability factor of 50 percent. While this detectability factor is greater than the detectability factor for streetlights, it matches the detectability rate used for facilities covered in the Kaua'i Seabird HCP (DOFAW 2020). Also, KIUC facilities, PAGS and Kapaia, are fenced and monitored for pest. Regular pest control methods such as traps and pest control services are used for rats and mice. Any stray cats that make it into the fenced facilities are captured using live traps and removed from the property. KIUC trains staff to identify and search for covered species and these trained staff conduct searches for downed seabirds during the seabird fallout season twice daily (see Chapter 6, *Monitoring and Adaptive Management*). Searchers are equipped with Oppenheimer Seabird Recovery Kit and recovered birds are transported to an SOS Aid Station.

5C.4 Conclusions

5C.4.1 Summary of Streetlight, Lightscape, and Fallout by Sector

A complete summary of the proportional contribution of 4,150 streetlights, used for this assessment, to radiance and the average annual fallout for Newell's shearwater (ʻaʻo) was summarized on a sector-by-sector basis (Table 3). This is based on radiance data from October 2018.

Table 3. Model output for each SOS sector

Sector ID	Sector Name	Streetlight count (#)	Total streetlight radiance	Sector radiance	Proportional contribution of streetlights	AVE Total NESH[1] fallout (#/year)	AVE Streetlight NESH[1] fallout (#/year)
1	Hanalei	40	1.6	87.5	0.018	10.5	0.20
2	Princeville	5	0.2	83.8	0.002	27.4	0.06
3	Kīlauea	104	4.1	82.7	0.050	2.5	0.13
4	Anahola	91	3.6	69.6	0.052	1.0	0.05
5	Kealia	19	0.7	29.9	0.023	0.0	0.00
6	Kapaʻa	368	14.5	110.2	0.132	3.0	0.40
7	Waipouli	49	1.9	89.9	0.021	3.0	0.06
8	Wailua	115	4.5	61.4	0.073	1.0	0.07
9	Wailua Homesteads	278	10.9	98.6	0.111	1.0	0.11
10	Hanamaulu-Kapaia	180	7.1	94.0	0.076	1.0	0.08
11	Līhuʻe	1000	39.3	473.6	0.083	7.2	0.60
12	Marriott	0	0.0	46.8	0.000	2.5	0.00
13	Nawiliwili	56	2.2	78.5	0.028	4.5	0.13
14	Puhi	290	11.4	99.6	0.115	2.2	0.25
15	Kipu	2	0.1	46.4	0.002	1.0	0.00
16	Poipu	146	5.7	115.6	0.049	8.4	0.41
17	Kukuiula	37	1.5	37.5	0.040	2.0	0.08
18	Kōloa	151	5.9	85.7	0.069	1.5	0.10
19	Lāwaʻi	103	4.0	40.5	0.099	0.0	0.00
20	Kalaheo	266	10.4	71.0	0.147	1.7	0.25
21	Port Allen	43	1.7	44.7	0.038	16.6	0.63
22	ʻEleʻele	211	8.3	81.2	0.102	4.8	0.49
23	Hanapēpē	149	5.9	44.7	0.132	2.2	0.29
24	Salt Ponds	0	0.0	6.6	0.000	0.0	0.00
25	Olokele-Kaumakani	3	0.1	40.9	0.002	0.0	0.00
26	Pakala	1	0.0	45.8	0.000	1.0	0.00
27	Waimea	155	6.1	57.6	0.106	10.2	1.08

Sector ID	Sector Name	Streetlight count (#)	Total streetlight radiance	Sector radiance	Proportional contribution of streetlights	AVE Total NESH[1] fallout (#/year)	AVE Streetlight NESH[1] fallout (#/year)
28	Kekaha	169	6.6	86.0	0.077	5.2	0.40
29	PMRF[2]	5	0.2	84.0	0.002	1.3	0.003
30	Kokeʻe	0	0.0	103.4	0.000	1.0	0.00
31	Omao-Maluhia	57	2.2	39.4	0.056	2.0	0.11
32	Haena-Wainiha	12	0.5	34.4	0.015	4.4	0.07
33	Kipukai, Nā Pali	0	0.0	90.9	0.000	2.0	0.00
34	At sea	0	0.0	0.0	0.000	1.0	0.00
35	Unknown[3]	(124.4)	(4.9)	(80.7)	0.061	15.2	0.93
Total	**--**	**4,105[4]**	**161.2[4]**	**2662.4[4]**	**0.061[5]**	**133.1**	**6.9[6]**

[1]NESH = Newell's shearwater (ʻaʻo)

[2]PMRF = Pacific Missile Range Facility

[3]Sector 35 is called "unknown" and as not all birds turned into SOS are assigned to sector, and the only way to account for birds in this category is to calculate island-wide averages. See Section 2.1.5.1, *Newell's shearwater (ʻaʻo)*, for more information.

[4]Streetlight count, streetlight radiance, and sector radiance totals exclude the numbers in parenthesis from Sector 35 (Unknown) as the values, while they are included in the model and calculations, are in addition to the real island-wide totals.

[5]The proportional contribution of streetlights column cannot be summed because they are proportions and as such, are not additive. Rather the value in the row titled Total represents the island-wide average which is calculated by dividing the streetlight radiance for the entire island by the sector radiance for the entire island (161.2/2662.4)=0.061.

[6]The AVE Streetlight NESH Fallout (#/year) is the summed total of all the rows, including unknown.

5C.4.2 Take Estimates for Covered Seabird Species

5C.4.2.1 Existing Streetlights

Assuming a detectability scenario of 10.4 percent, annual fallout by Newell's shearwater (ʻaʻo), Hawaiian petrel (ʻuaʻu) and band-rumped storm-petrel (ʻakēʻakē) attributed to the 4,150 streetlights used for this assessment are summarized in Table 4. These estimates are based on the proportional contribution of radiance estimated for existing streetlights to the radiance of all night-time lights on Kauaʻi.

Below is the equation used to calculate the total fallout of Newell's shearwater (ʻaʻo) using the total fallout observed per year that is attributable to streetlights. This number is equal to 6.957 without rounding errors and is derived by adding up the annual average of Newell's shearwater (ʻaʻo) fallout at streetlights in each sector (Table 3 – note that the total value of Newell's shearwater (ʻaʻo) fallout at streetlights calculated from sector-specific numbers presented in Table 3 is 6.983 due to compounding rounding errors). This total of Newell's shearwater (ʻaʻo) fallout is then corrected using a detection probability of 10.4%.

$$\frac{6.957\ birds\ found}{0.104\ detectability\ correction\ factor} = 66.9\ birds\ after\ correcting\ for\ detectability$$

The estimates for Hawaiian petrel (‘ua‘u) and band-rumped storm-petrel (‘akē‘akē) are then derived from the detectability corrected estimate of Newell’s shearwater (‘a‘o) using the ratios of occurrence in the fallout database averaged over 5 years for Hawaiian petrel (‘ua‘u) and 10 years for band-rumped storm-petrel (‘akē‘akē). Per Table 2, for every Newell’s shearwater (‘a‘o) in the SOS database, there has been a long-term average of 0.061 Hawaiian petrel (‘ua‘u) and 0.01 band-rumped storm-petrel (‘akē‘akē). Thus, the estimated fallout for Newell’s shearwater (‘a‘o) is multiplied by these ratios resulting in an estimated 4.05 Hawaiian petrel (‘ua‘u) (=66.9 x 0.061) and 0.669 band-rumped storm-petrel (‘akē‘akē) (=66.9 x 0.01) fallout at streetlights per year.

Table 4. Estimates of take per year for Newell’s shearwater (‘a‘o), Hawaiian petrel (‘ua‘u), and Band-rumped storm-petrel (‘akē‘akē) assuming that the SOS data includes only 10.4 percent of birds that fallout at streetlights.

Species	Estimate	Lower 95% CI	Upper 95% CI
NESH[1]	66.9	51.7	86.8
HAPE[2]	4.0	3.1	5.3
BSTP[3]	0.7	0.5	0.8

[1]NESH = Newell’s shearwater (‘a‘o)
[2]HAPE = Hawaiian petrel (‘ua‘u)
[3]BSTP = Band-rumped storm-petrel (‘akē‘akē)

5C.4.2.2 Future Streetlights

Assuming a detectability scenario of 10.4 percent, additional annual fallout anticipated with the addition of 1,754 future streetlights by Newell’s shearwater (‘a‘o), Hawaiian petrel (‘ua‘u) and band-rumped storm-petrel (‘akē‘akē) are summarized in Table 5. These estimates are based on the proportional contribution of radiance estimated for existing streetlights to the radiance of all night-time lights on Kaua‘i.

Table 5. Estimates of take per year for Newell’s shearwater (‘a‘o), Hawaiian petrel (‘ua‘u), Band-rumped storm-petrel (‘akē‘akē) if the SOS data includes only 10.4 percent of birds that will fallout at future streetlights.

Species	Estimate[1]	Lower 95% CI	Upper 95% CI
NESH[1]	20.5	15.9	26.7
HAPE[2]	1.2	1.0	1.7
BSTP[3]	0.2	0.1	0.3

[1]NESH = Newell’s shearwater (‘a‘o)
[2]HAPE = Hawaiian petrel (‘ua‘u)
[3]BSTP = Band-rumped storm-petrel (‘akē‘akē)
[1] These are the additional birds that will be taken each year once all the 1,050 estimated streetlights are added.

5C.4.2.3 Facility Lights

Following a similar approach of the Kaua'i Seabird Habitat Conservation Plan (DOFAW 2020), included in this assessment is the 5-year average for Newell's shearwater ('a'o) and the 9-year average (the extent of the data available) for the rarer Hawaiian petrel ('ua'u) and band-rumped storm-petrel ('akē'akē) (Table 7).

All fallout of covered seabirds reported in Table 7 occurred at the Port Allen Generating Station. After applying the detection correction of 50 percent to the annual average fallout over the full time period the annual take is estimated to be 8.4 Newell's shearwater ('a'o), 0.2 Hawaiian petrel ('ua'u), and 0 band-rumped storm-petrel ('akē'akē).

Table 7. Fallout of covered seabirds documented at covered KIUC facilities. Note that light minimization efforts occurred at the Port Allen Generation Facility prior to the fallout season in 2019 and less birds were found in the two fallout seasons after these measures were implemented.

Year	NESH[1]	HAPE[2]	BSTP[3]
2020[4]	2	0	0
2019[4]	0	0	0
2018	10	0	0
2017	4	0	0
2016	6	0	0
2015	*	0	0
2014	*	0	0
2013	*	0	0
2012	*	1	0
2011	*	0	0
AVE	**4.2**	**0.1**	**0**
50% detectability	**8.4**	**0.2**	**0**

[1]NESH = Newell's shearwater ('a'o)
[2]HAPE = Hawaiian petrel ('ua'u)
[3]BSTP = Band-rumped storm-petrel ('akē'akē)
[4]Light minimization measures were fully implemented in 2019 and 2020

5C.4.2.4 Combined Take Estimate

Combining the take estimates for existing streetlights, future streetlights, and KIUC's covered facilities from Tables 4, 5, and 6, results in an estimated annual take of 95.8 Newell's shearwaters ('a'o) (=66.9+20.5+8.4), 5.4 Hawaiian petrel ('ua'u) (=4.1+1.2+0.2), and 0.9 band-rumped storm-petrel ('akē'akē) (=0.7+0.2+0.0) for the KIUC HCP.

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Appendix 5D

Bayesian Acoustic Strike Model

Underline Monitoring Project
Review Draft- Bayesian Acoustic Strike Model

Marc Travers, M. Tim Tinker, Scott Driskill, André F. Raine

Provided June 16, 2020

The Underline Monitoring Project (UMP) is part of the Kauaʻi Endangered Seabird Recovery Project (KESRP), which is a joint project of the Pacific Cooperative Studies Unit of the University of Hawaiʻi and the Division of Forestry and Wildlife (DOFAW)/State of Hawaiʻi Department of Land and Natural Resources.

Estimating rates of power line collisions for seabirds using acoustic monitoring

This document outlines the method and results for a Bayesian model created to assist in the development of the KIUC Long Term Habitat Conservation Plan to estimate rates of power line collisions of two endangered seabirds on the island of Kaua'i – the Newell's Shearwater *Puffinus newelli* and the Hawaiian Petrel *Pterodroma sandwichensis* - using acoustic monitoring. The document has been created with the intention of helping reviewers of the model understand the parameters, decision points and results of the model and accompanies the R code and data for the model. We assume that reviewers already have a high level of understanding of the acoustic monitoring process that has formed the backbone of take monitoring on Kauai since 2011, so have truncated a description of portions of the methodologies – we encourage readers to review any of the Underline Monitoring Project Annual Reports for a full description of field methods and previous key results.

This model was created by KESRP (a project administered by the Research Corporation of the University of Hawaii's Pacific Co-operative Studies Unit) and Tim Tinker of Nhydra and should be considered the intellectual property of its creators. The R code, data, and any other materials will be sent to other parties for the explicit purposes of review only, and the use of this model is bound by the terms of the data sharing agreement, which are that reviewers will not seek to publish the model or aspects of it themselves, nor use it for their own financial gain.

Methods

Study Area

Power lines occur around the perimeter of Kaua'i as well as along inland roads or valleys in several areas. For the purpose of this study we divided the landscape up into 8 regions (*reg*), which we used as a spatial random effect in statistical analyses (Figure 1). We also further divide power lines in into areas within the regions. These regions and areas were delineated based on power line construction type and environment type. Power lines within each region are divided into spans that occur between two sets of adjacent poles, and for this study each span received a unique identifier, or spanID. A span consists of an array of wires, which can be further divided into one or more "levels" of wires (wires within a single level are at the same approximate height above ground, ABG). Birds that fly through an array of wires can potentially strike a wire; however, the likelihood of a bird flying at the same height of the wires depends on several factors, including the presence of "obstacles" (e.g. trees, buildings) which birds must fly above. For example, in a coastal area with tall trees, if the height of the entire wire array is lower than the height of the treetops, birds will in all likelihood fly above the treetop obstacle and thus above the wire array, leading to a near zero likelihood of collision.

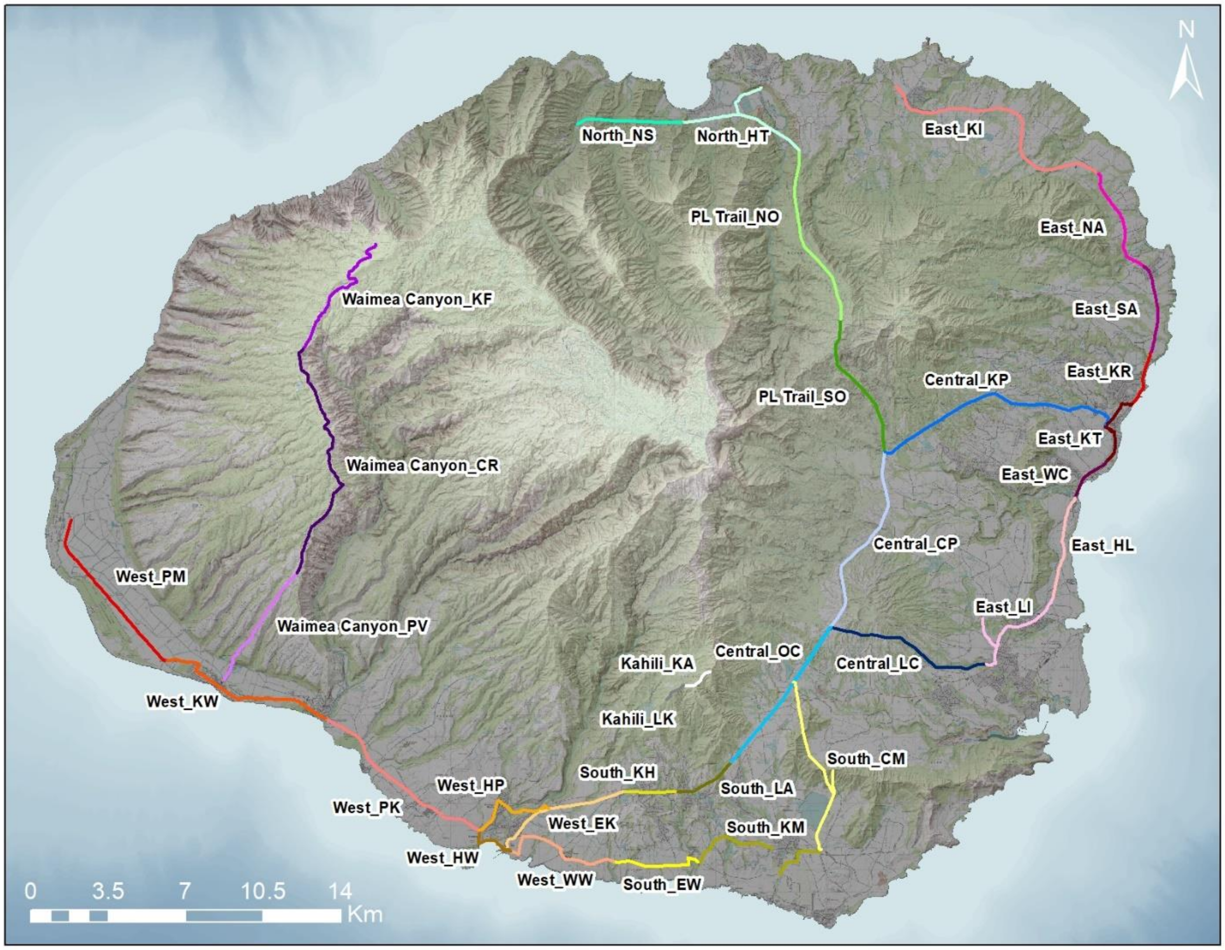

Figure 1. UMP power line regions and areas.

Spans are of varying length, depending on landscape configuration, and have several other defining characteristics or attributes. The structural attributes recorded for a given span include the distance (m) between poles or span length (*Lng*), variance in wire exposure (exsd), percent of span exposed (pcex), space between wire layers (sbwl), and number of wire layers (wlyr).

In addition to structural attributes, each span is associated with several geographic and environmental attributes that can affect bird passage rates or collision likelihood. Geographic and environmental attributes include distance from ocean (*dstoc*) and landscape gradient (grad).

Data Collection

To acoustically record power line strike sounds, Song Meter SM2+ (Wildlife Acoustics, Boston, MA) sensors were deployed at either 1) the base of power poles in quiet soundscapes (typically higher elevation sites) or 2) were mounted on the power pole just below the lowest transmission lines when the pole was near traffic sounds. Units deployed at the base of the poles had two SMX-II microphones positioned on the side of the unit, and the units were placed beneath vegetation to protect the microphone from wind and to reduce the likelihood that units would be tampered with by the public. The pole-mounted units had one Night Flight Microphone mounted on the pole as close to the lowest transmission wire as possible. We had five recording schedules, 1) peak time recording, 2) off-peak recording, 3) check time recording, 4) all3, and 5) every night (see Table 1). These recording schedules were as follows:

- "Peak" time units record acoustic data during two periods, starting at sunset and running for 3.5 hours and then starting again 3.5 hours before sunrise and ending at sunrise, for a total of 7 hours each night. This time period was named "peak" because it includes the peak pulse of passage rates observed at power lines (Travers et al. 2012 and 2013).
- "Off-peak" units record throughout the portion of the night not covered by the peak time units outlined above. They also recorded for 2.5 hours during the day (1 hour before and after sunset and sunrise, respectively, and for one half hour during midday).
- "Check" units recorded all night and thus covered the full nocturnal collision monitoring period (half hour after sunset to half hour before sunrise) every second night. Note to be conservative, the period encompassing the first half hour after sunset and the first half hour before sunrise, was removed from consideration. Although the target seabirds do fly during these periods, their likelihood of colliding with wires during day light is low compared to darker periods.
- "All3" units record every third night for the entire night.
- "Every night" units record every night for the entire night.

These schedules allowed us to deploy each unit type for one month before the batteries and SD cards needed to be changed.

Table 1. UMP Acoustic recording strategy and schedules

Recording Strategy	Recording Schedule	Frequency	PM Night Monitoring	AM Night Monitoring	Day Light Monitoring
Static (Seasonal)	Peak	Every Night	SS to 3.5 h after	-3.5 to SR	None
Static (Seasonal)	Off-peak	Every Night	SS+3.5 h to 23:59	00:00 to SR-3.5 h	SR to 1 h, 12:00 to 12:30, -1 h to SS
Static (Seasonal) Reduced Cost	All 3	Every 3rd Night	SS to 23:59	00:00 to SR	None
Static (Minimization)	Every	Every Night	SS to 23:59	00:00 to SR	None
Check (Re-sampling)	Check	Every 2nd Night	SS to 23:59	00:00 to SR	None
Rover (Randomized)	Peak	Every Night	SS to 3.5 h after	-3.5 to SR	None

We had three sampling strategies that employed the above recording schedules. First, we had seasonal monitoring which typically covered the full seabird breeding season from March 1 to January 1. In order to reduce costs to KIUC, from 2016 we began reducing some of the seasonal monitoring to April 1-November 1. Seasonal monitoring sites typically had two Song Meter units at each location: one for peak time recording and one for off-peak recording.

The seasonal units were deployed at 'static' sites (sites monitored every year) to measure the variation of strikes across the season, which includes identifying the start and end of the strike season and the increase and decrease in the strike rate which coincides with the seasonal variation in passage rates of the target seabirds[1]. The off-peak units were deployed to identify the frequency of strikes in the middle portion of the night and variation across the season. The ratio of off-peak strikes to peak strikes measured at full season monitoring sites is used to develop correction factors or model middle of the night strikes for locations that only had partial night monitoring (i.e. rover peak monitoring described below). For seasonal monitoring locations we deliberately selected sites with the highest known strikes. The consistently elevated strike rates are required to reliably detect the seasonal patterns.

Secondly, we deployed 'check' units at sites that recorded strikes in previous seasons (see previous UMP Annual Reports for details) or areas that had high collision risk characteristics. Check units record all night every second night. This schedule was designed to provide data on the full night without the need for increased equipment and analysis time (i.e. to lower monitoring costs). Firstly, these units are used to provide additional information on the variation in strike across the night. Again, this allows for development of correction multipliers for locations that only had partial night monitoring (i.e. rover peak monitoring described below). Secondly, check units being deployed at sites with previously detected strikes allow for measuring strike change across years and at different times of the season.

Thirdly, we employed a random stratified sampling protocol for all other acoustic monitoring (May 15 to September 15). This type of monitoring had one unit recording on the peak schedule per site. Our random stratified protocol, described in detail below, was designed to ensure 1) equal monitoring across the different regions while 2) forcing equal monitoring of varying exposure heights within each region and ensuring 3) that there was equal spread across the existing exposure heights over the entire sampling period. To accomplish equal sampling across regions, we allocated equal monitoring effort (number of units) to a region based on the number of spans present within that region. Within each region, we looked at the range of exposure heights present (height of wires relative to local vegetation; see Travers et al. 2013 & 2014 for details) and classified spans into the categories of low, medium, or high exposure height specific for that region (e.g. the range for low exposure in one region may be different than another region). We then assigned random numbers to each span and selected equal numbers from each exposure category. We conducted this sampling without replacement each month. Thus, every month's acoustic monitoring was balanced across regions and the exposure heights were balanced within each region.

[1] Seabird passage rates vary across the season as birds have different burrow visitation rates as they advance through different breeding stages.

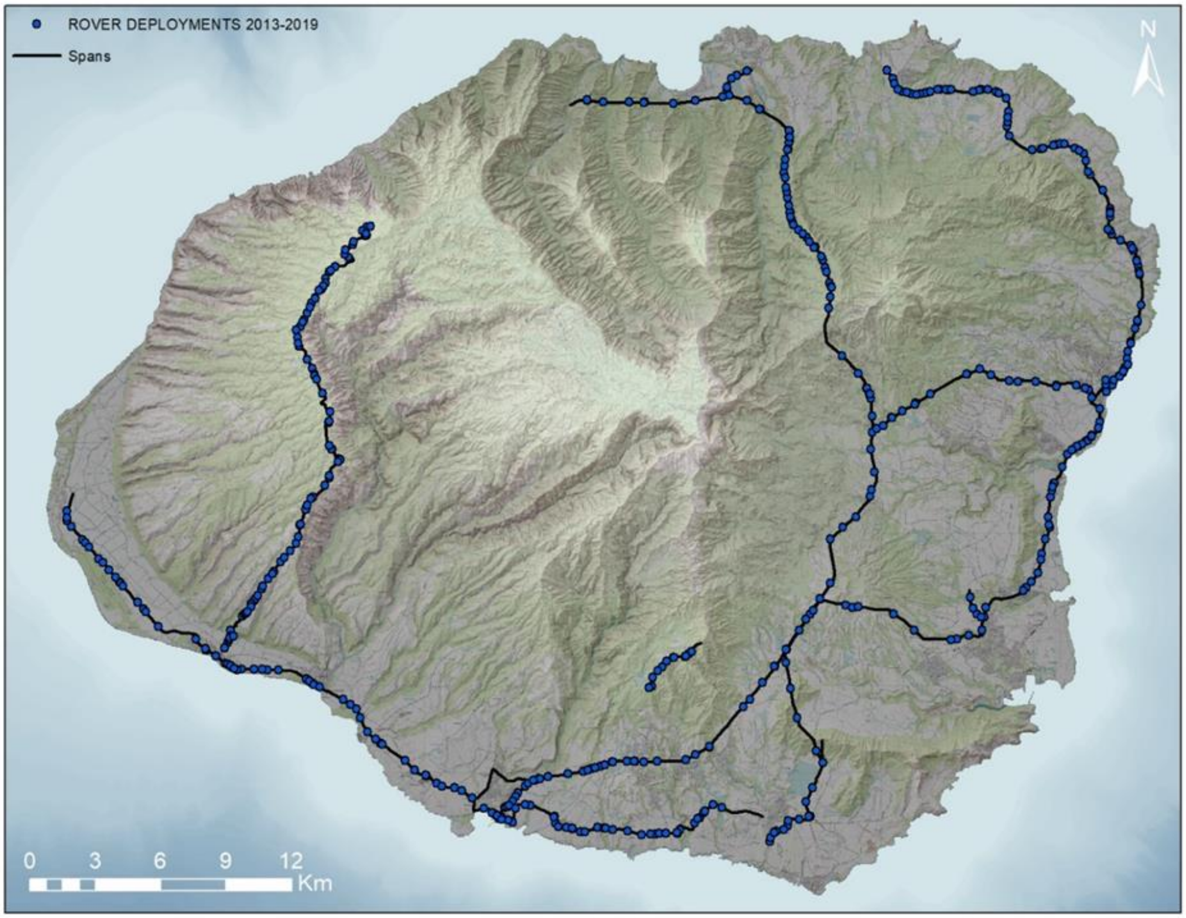

Figure 2. Distribution of rovers monitoring effort 2013-2019 with site selection based on the KESRP simple random stratified sampling design. We have not displayed monitoring effort because rover sites have a uniform effort of one month (20-30 days) on the peak schedule. We have shown that our rover monitoring effort does bias the result towards undercounting strikes. The undercounting of strikes is due the fact that a short window of monitoring effort (20-30 days) has a reduced likely hood of detecting any strikes even if the seasonal strike total is as high as 20 (Travers et al. 2017b). Furthermore, strikes are undercounted when fiberoptic cable is present (because Fiber does not produce a strike sound) and at sites with high ambient noise from vehicle traffic and wind (Travers et al. 2019a).

Conservation Metrics Inc.. Automated detection and classification of acoustic strike sounds

Automated acoustic analysis of all field recordings was carried out with custom detection and classification software developed by Conservation Metrics, Inc. (CMI). We applied a machine learning technique, Deep Neural Networks (DNNs), to detect sounds on field recordings that had spectro-temporal properties similar to those measured from examples of strike sounds. Deep Neural Networks are a powerful tool for detection and classification of events used in many fields such as speech recognition, image recognition, and other pattern recognition tasks (Deng et al. 2013, Schmidhuber 2015, Cichy et al. 2016, Min et al. 2016).

Our workflow splits the stereo acoustic files into two datasets, one for each microphone channel (right and left). Spectro-temporal measurements are extracted from these recordings in discrete time windows (2-seconds long), and discrete frequency bins (256 frequency bins per time step). The Underline Monitoring Project acoustic effort results in the collection of hundreds of millions of discrete 2-second clips every monitoring season, and billions of spectro-temporal measurements.

Feature measurement scores were used to train DNN classification models to detect powerline strikes. Specifically, we developed training and cross-validation datasets with examples of "positive" sound clips containing the sound of interest (i.e. 2-second clips containing powerline strike sounds) and a representative sample of "negative" sound clips (i.e. examples of 2-second clips containing sounds from the soundscapes at all survey sites that are not powerline strikes). The neural networks optimize a combination of spectro-temporal feature values that best differentiates positive sounds from negative sounds in the environment. Trained DNN classification models can then be applied to predict events of interest on acoustic data from future surveys, returning a likelihood that any given 2-second clip contains a sound produced by a powerline strike.

CMI Model performance

There is an inherent trade-off between accuracy (proportion of true positives in the set of possible events identified by the model) and sensitivity (proportion of true positives detected out of total available for detection in the data) in any signal detection problem. An increase in the sensitivity of a detector will usually lead to decrease in accuracy and vice versa. The signal detection challenge for the Underline Monitoring Project is the need to optimize classification model sensitivity for a rare signal, while maintaining accuracy levels that produce a manageable amount of potential events for manual review (*see below*). Collision sounds are rare, in a typical season acoustic surveys collect 60-70,000 hours of acoustic recordings (~7 years in aggregate), and we have typically detected only 1 to 2 hours per season containing collision sounds.

Our current DNN model was developed in 2015. It was trained using example data collected through 2015 and optimized to process large datasets more efficiently than previous detection models. The training data included 1,193 examples of strike sounds and 192,645 randomly selected samples of other background sounds from the soundscape. We evaluated model performance using a standard test dataset developed from KESRP Underline Monitoring Project recordings. Specifically, the test dataset contained recordings from field survey periods when KESRP staff were monitoring for seabird collisions at acoustic monitoring sites in 2013. The test dataset included 216 hours of recordings from 7 sites made on 16 survey nights. Human observers detected a total of 32 strikes during these survey periods. CMI manually reviewed and labeled the test dataset by navigating to each timestamp for a strike observed in the field and finding the strike in the test dataset. There were 9 strikes that could not be located on the sound data, so the test dataset on which we evaluated performance included 23 strike sounds. The DNN model returns a confidence score between 0-1 that a strike is present for each window. Model performance metrics vary based on the confidence threshold selected for an analysis. A receiver operating characteristic (ROC) curve was used to evaluate model performance at different confidence thresholds, and we selected a confidence threshold for our analysis based on a value that balanced the desire for high sensitivity (detection of a high percentage of strike sounds available for detection) and high accuracy (a low number of sounds incorrectly identified as strike sounds). At the chosen threshold of 0.006, the DNN model detected 16 of 23 (sensitivity: 69.6%, accuracy: 0.6%) collisions in the test data. At that threshold, the model classifies 99.29% of the test dataset (over 386,000 2-second clips) as not containing a collision sound, with an accuracy of 99.998%. If the performance of the acoustic method was evaluated as a whole (DNN Detections/Total Observed Strikes) the survey method identifies 16 of 32 strikes (sensitivity: 50%).

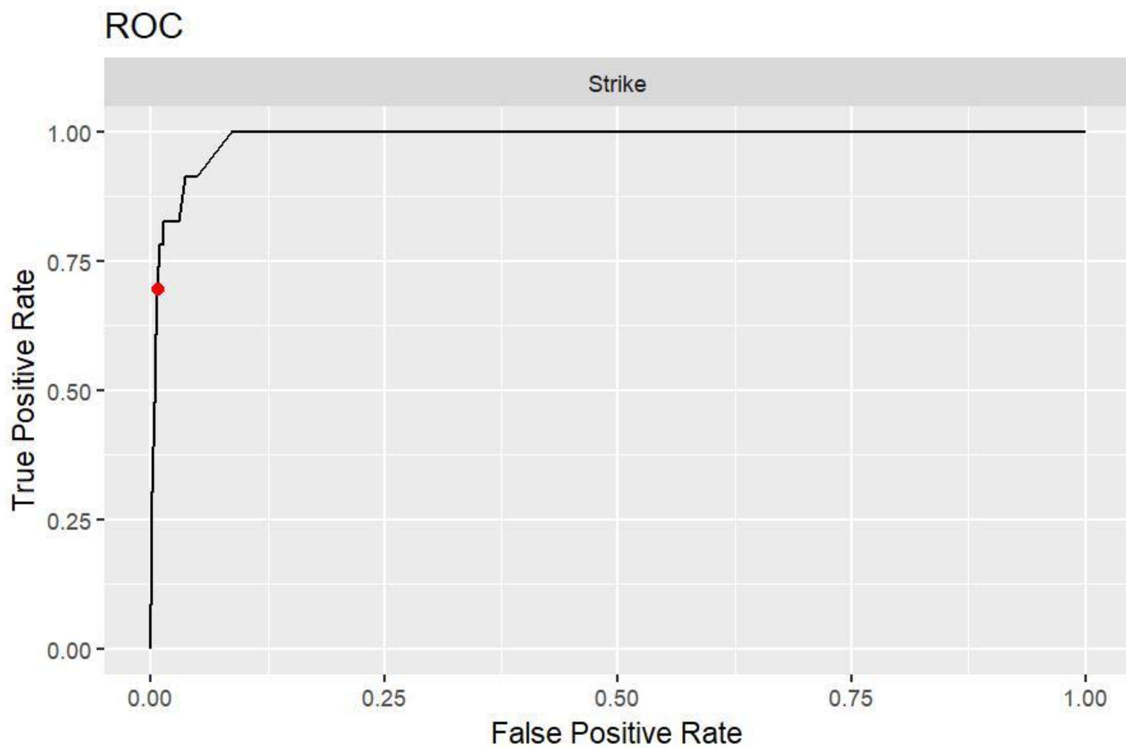

Figure 1:ROC curve for Strike classification model. The red dot represents the DNN confidence threshold selected for our analysis.

CMI Channel selection

Song meter sensors are equipped with two microphones (left and right) that record acoustic data in stereo. During our initial data ingestion process, we split those stereo files into their component channels (*See above*). We then chose only one channel from each recording to analyze for collision sounds. This decision was sometimes based on UMP's guidance (i.e. when UMP utilized two different microphone types for the purposes of a specific equipment test or if there was a clear problem with one microphone). When channel selection wasn't specified by UMP (which was the majority of recordings) we conducted our own assessment of recording quality; using long-form spectrograms and metrics of microphone sensitivity to select the channel with the best quality data.

CMI Auditing - manual review of events of interest

We applied our DNN classification model to all acoustic data received to predict clips containing potential strike sounds, or "events of interest". We then manually reviewed all events that are assigned confidence score above our threshold (0.006). All acoustic "events of interest" occurring in the sensor channel selected for analysis are then reviewed by a human analyst. We call this quality assurance/quality control (QA/QC) review process "auditing". A 16-panel browser screen in CMI's Auditor software enables the analyst to rapidly assess presence/absence of strike sounds in spectrograms of each event of interest – both visually and by listening to the sound (either the 2-second clip, or a longer section of recordings where context is needed). All potential strike sounds were labeled as either strikes or not-strikes by the analyst. As a final QA/QC step, all strike sounds tagged by the analyst were reviewed by a senior CMI staff member to confirm the classification. This two-step process removes all false positive detections predicted as possible events by the DNN. The end result is that all collision sounds positively identified through this process have been manually reviewed by two people to confirm that they meet the criteria of a strike sound - as identified and recorded by UMP field staff.

Data Exclusions

For this analysis, we removed acoustic data from experimental monitoring methods (e.g. SM4, Vibration sensors), and field experiments such as LASER nights, white Light nights, and diverters. We excluded acoustic data collected outside of the night period and for the first half hour after dark and the first half hour before dawn. Removal of the first and last half-hours is a conservative approach, as seabirds do fly with risk in these time windows and the strike patterns detected in these windows match that of seabirds and not other species. However, there is elevated risk that other species could also hit wires during this time period. To reduce the concerns of some reviewers we have removed these collisions. We also removed all acoustic data from areas where we have discerned through years of research that acoustic sensors were not functioning and predicted strikes within these areas using the model parameter estimates. Using BRS data, we determined that there is a 0% chance of detecting a strike sound in the areas KR, KT, WC on the east side, and in area HW on the west side. These areas had ambient noise levels that resulted in a detection rate of zero BRS strike sounds. These are areas we have highlighted in past years as having zero strikes but have dead seabirds under wires (see previous UMP Annual Reports). Removing these data specifically from the Kealia area, also address the issue of the fiber-optic cable. Fiber-opitic cable does not produce a strike sound and thus results in underestimating of strike acoustically. We have not made any adjustment for the fiber-optic cable in the lines running from Ele'ele to Kapaia power plant, which will result in an underestimate for these lines. Lastly, for the current model run, we have elected to be conservative and exclude Waimea Canyon acoustic data because we determined there was a discrepancy with this data when compared to the observational data. In this region, the acoustic data indicated a higher strike rate than did the observation results and to date we have no studies to determine why this would be the case. Since 2017, UMPKESRP has recommended multiple methods to examine the strike rate more closely for this region but due to funding decisions we could not undertake these studies.

Data Analyses Overview

We used a Bayesian hierarchical modeling framework to estimate the annual rate of bird–powerline collisions based on data from acoustic sensors. To accommodate the large volume of data collected from acoustic sensors deployed over many spans and sample periods, we used a tiered analytical approach consisting of 4 steps: 1) We use a sub-sample of data from representative spans for each region to estimate generalized patterns of temporal variation in strike rates. We account for two temporal scales of variation, seasonal (variation across weeks) and diel (variation across 15-minute time steps), and we allow for temporal autocorrelation at both scales; 2) We use a sub-set of data from well-sampled spans to estimate the effect of acoustic signal quality on the likelihood of strike detection; 3) We sequentially step through each sampled site (i.e. an acoustic sensor deployed at the intersection of two adjacent spans) and use all available data to estimate the mean annual number of strikes, accounting for the effects of temporal variation (using the generalized temporal effect estimate from step 1 as a prior for local temporal effects), lunar illumination and fluctuations in acoustic signal quality; and 4) Using the mean annual strike rate estimates for sampled spans as a dependent variable, we use MCMC methods to fit a generalized linear mixed effect model (GLMM) estimating annual strike rate as a function of environmental, geographic and structural covariates, while allowing for random effects (unexplained variation) among regions and spans. We then apply this model to predict annual strike rates for all spans on Kauai, as well as associated estimation uncertainty. We explain each of these analytical steps in the following sections.

Step 1: Generalized Patterns of Temporal Variation

The rate of powerline strikes by seabirds at any given span is not expected to be constant, but rather to vary temporally as a function of changes in the relative abundance and behavior of birds. For example, more birds are likely present at some points of the year and/or times of night, potentially resulting in more strikes, and the strike rate can also change depending on behavioral attributes such as relative flight height with respect to wire spans. Accounting for this temporal variability is necessary to allow for meaningful comparisons of strike rates among spans, or extrapolation of rates across an entire season, while controlling for confounding effects of seasonal and diel variation. We note that it would be less critical to account for temporal variability if all spans were sampled evenly across all days of the year and all times of night, but such uniform sampling is rarely possible.

For analytical tractability we identified two distinct time scales for evaluating temporal variation in strike rates. Specifically, we discretized time into intervals of one week (w = 1, 2… W) for evaluating seasonal effects, and intervals of 15 minutes (q = 1,2… Q) for evaluating diel effects. Exploratory analysis of pilot data suggested that these intervals were appropriate for capturing meaningful patterns of variation at the relevant scales, while still ensuring that time steps were functionally independent. In the case of diel effects, we recognized that biologically meaningful patterns of variation in bird behavior are best described with respect to solar time (sunset and sunrise) rather than a fixed 24-hour clock. In particular, for the first half of the night it is convenient to describe variation in bird activity (and thus strike frequency) with respect to the time elapsed since sunset, while for the second half of the night we can describe variation in bird activity with respect to the number of minutes before sunrise. Assuming that we are interested in describing behavior (and thus powerline strikes) from 30 minutes after sunset to 30 minutes before sunrise, then for nights around summer solstice there are Q = 38 timesteps (9.5 hours) of interest. We can describe q = 1–19 in terms of minutes after sunset (with q = 1 starting at 30 minutes after sunset) and q = 20–38 in terms of minutes before sunrise (with q = 38 ending at 30 minutes before sunrise). However, as one moves backward and forward in the season away from solstice the total night duration increases: we allow for this by having an extendable "middle-of-night" period, and classify all 15-minute intervals in the middle of the night as q = 19 (recognizing that this results in a disproportionally larger number of records for q = 19) This adjustment is reasonable because there tends to be less bird activity (and thus less variability) in the middle of the night. We keep track of the number of additional minutes of q=19 to account for each week and incorporate this adjustment into our calculations of total seasonal strike rates (see below).

In addition to discretization of time at multiple scales, there are several challenges inherent in measuring and describing temporal variation: these include autocorrelation of strike rates between time-steps, non-linear patterns of variation, and interactions between the seasonal and diel time scales (i.e. the functional form of diel effects can vary over the course of the season). Conditional Autoregressive (CAR) models have become a widely used approach for describing complex patterns of variation in a parameter of interest that is autocorrelated across time or space (Besag 1974, Banerjee et al. 2003, Gelfand and Vounatsou 2003). CAR models are an effective means of incorporating temporal correlations into an analysis, particularly in Bayesian models where they require estimation of only a few additional parameters (Lee 2011), and they can be adapted for univariate or multivariate non-linear effects. For our model we wished to describe patterns of variation and autocorrelation in relative strike rates across two temporal dimensions, corresponding to the seasonal and diel timescales. Our specific objective was to estimate a temporal effects matrix, **T**, having dimensions W (number of weeks) and Q (number of quarter-hour timesteps), whose cell values $\gamma_{w,q}$ describe the log ratio of the mean strike rate in week w and timestep q relative to the average rate over all weeks and timesteps. To accomplish this we utilized a CAR model designed to estimate correlated variation in a variable of interest over two dimensions, following the specific formulation described by Liu et al. (2017) based on a generalized multi-dimensional CAR model (Stern and Cressie 1999). We model variation in $\gamma_{w,\mathbf{v}}$, where **v** represents vector [q(1), q(2)… q(Q)], using the following autoregressive structures:

$$\gamma_{1,\mathbf{v}} = \phi_{1,\mathbf{v}} \tag{1}$$

$$\gamma_{w,\mathbf{v}} \mid \gamma_{w-1,\mathbf{v}}, \rho_w = \rho_w\left(\gamma_{w-1,\mathbf{v}}\right) + \phi_{w,\mathbf{v}}, \quad \textit{for } w = 2,3 \ldots W \tag{2}$$

$$\phi_{w,\mathbf{v}} \sim \textit{multivariate normal}\left(0, \Sigma\right) \tag{3}$$

$$\mathbf{\Sigma} = \sigma_\gamma^2 \cdot \textit{inverse}\left(\mathbf{D} - \rho_q \mathbf{G}\right) \tag{4}$$

Equation (2) describes the temporal autocorrelation component for seasonal effects, and follows a standard "AR(1)" autoregressive model formulation (Brockwell and Davis 2016). The value of $\gamma_{w,\mathbf{v}}$ depends (in part) on the value of $\gamma_{w-1,\mathbf{v}}$, with the strength of the correlation determined by fitted parameter ρ_w.

Equation (3) describes the temporal autocorrelation component for diel effects, and follows a conditional autoregressive distribution (Besag 1974): $\phi_{w,\mathbf{v}}$ is a random vector ($\phi_{w,1}$, $\phi_{w,2}$ … $\phi_{w,Q}$), the joint distribution of which is multivariate normal with mean 0 and variance-covariance matrix $\mathbf{\Sigma}$. Equation (4) describes the computation of the variance-covariance matrix, $\mathbf{\Sigma}$: the magnitude (scale) of variation is determined by the fitted parameter σ_γ, while the degree of correlation across timesteps is determined by correlation coefficient ρ_q. The remaining variables in equation (4), **D** and **G**, represent square matrices with dimension Q: the elements of **G** ($g_{q,q'}$) are equal to 1 if timestep q occurs immediately before or after timestep q' (i.e. they are sequential) and 0 otherwise, while the elements of **D** ($d_{q,q'}$) are equal to 0 for all elements except the diagonal and the q^{th} diagonal element gives the number of sequential timesteps for q (1 for q = 1 and q = Q, 2 for all other time steps).

To estimate generalized patterns of temporal variation in strike rate (for use as a prior for temporal effects at individual spans), we selected a sub-set of representative sites for which there were abundant data collected across the entire season over multiple years. To ensure even geographic representation, we selected from each of 7 regions the two sites having the largest sample size of acoustic records from multiple years and for all weeks between Apr 1 - Nov 30 (an acoustic record is defined as a 15 minute time step in which the number of detected strikes has been recorded). For each unique combination of site (i = 1, 2… S), week (w) and timestep (q), we tallied the number of acoustic records available ($R_{i,w,q}$) and the total number strikes detected in those records ($H_{i,w,q}$). The mean expected number of strikes at site i in week w and timestep q is calculated as:

$$\lambda_{i,w,q} = \exp\left(\zeta + \psi_i + \gamma_{w,q}\right)\cdot R_{i,w,q} \quad (5)$$

Where ζ gives the overall mean log strike rate (for these 14 sites), ψ_i is the log proportional deviation from the overall mean associated with site i (estimated as a hierarchical random effect drawn from a normal distribution with mean of 0 and standard deviation σ_i) and $\gamma_{w,q}$ is the average temporal effect for week w and timestep q (estimated using CAR methods as described above). We note that other fixed effects are expected to affect strike rate (including lunar illumination and fluctuations in signal quality), but while these effects are included in site-specific models (see below) we exclude them from this generalized model because, for this data-rich sub-set of sites, the large number of samples over multiple years for each week-timestep combination means that those other effects are effectively "averaged out".
We treat $H_{i,w,q}$, the number of detected strikes, as our observed variable, assumed to be described by a negative binomial distribution that is related probabilistically to the mean expected number of strikes:

$$H_{i,w,q} \sim negative\ binomial\left(mean = \lambda_{i,w,q}, \nu\right) \quad (6)$$

where the inverse scale parameter υ determines the degree of over-dispersion in the recorded number of strikes per sample.

The observed variable $H_{i,w,q}$ constrains the possible values of unknown parameters in equations (1) – (5), allowing us to estimate posterior distributions for these parameters using standard Markov Chain Monte Carlo (MCMC) methods. We used vague prior distributions for all parameters (i.e., weakly informed based on biological feasibility but having no information specific to the analysis): a Cauchy prior (scale = 2.5) for ζ, half-Cauchy priors (scale = 2.5) for 0-bounded parameters σ_γ, σ_i and υ, and flat beta priors for 0-1 bounded parameters ρ_w and ρ_q (Gelman 2006, Gelman et al. 2008). We used R (R.Core.Team 2014) and Stan software (Carpenter et al. 2017) to code and fit the model, saving 20,000 samples after a burn-in of 5,000 samples. We evaluated model convergence by graphical examination of trace plots from 20 independent chains and by ensuring that Gelman-Rubin convergence diagnostic (Rhat) was ≤1.1 for all fitted model parameters. We conducted posterior predictive checking (PPC) to evaluate model goodness of fit, both by graphical comparison of the frequency distributions of empirical data vs. out-of-sample ("new") estimates, and by using the χ^2 statistic (sum of squared Pearson residuals for observed counts vs expected values) to compare fit of observed data and out-of-sample estimates (Gelman et al. 2000). We examined scatter plots of the posterior distribution of χ^2 scores for new vs observed data (in the case of well-fitting models, points in such a plot should be distributed around a line with slope 1) and we computed the associated "Bayesian-P" value (the proportion of new observations more extreme than existing observations; Gelman 2005, Ghosh et al. 2007), which should fall within the range 0.2< Bayesian-P <0.8 for a well-fit model. We summarized results graphically and by reporting the mean and 95% CI of parameter posterior distributions.

Step 2: Effect of Acoustic Signal Quality on Strike Detection

Acoustic recordings, combined with machine learning algorithms for detecting a signal of interest (in this case the sound of a bird-sized object striking a powerline), have been shown to be an effective and scalable method for monitoring the abundance and/or behavior of seabirds (Buxton and Jones 2012, Borker et al. 2014). One challenge inherent with acoustic detection of signals is that the quality of the acoustic recording is sometimes impaired (often as a function of environmental conditions such as wind and rain), such that the probability of signal detection declines as signal quality decreases. This can potentially lead to a bias, with lower levels of detection during times when the signal quality is impaired. Fortunately, there are several metrics of acoustic signal quality that together can be used as an index of relative signal quality, and thereby provide the ability to correct biases associated with poor signal quality. Signal quality metrics show predictable patterns under certain conditions (e.g. microphone failure, rain or water-logged microphones) that are associated with reduced probability of signal detection. The challenge for a given data set is thus to determine the relationship between signal quality metrics and detection probability.

To estimate the effect of acoustic signal quality on the likelihood of powerline strike detection, we first sub-sampled data from those sites that were recorded during the peak period of strike activity ($3<w<19$ and $26<q<32$, as determined from the generalized temporal matrix **T** described in the previous section) and for which at least one strike was detected. We then developed a conditional logistic regression model to estimate the effects of signal quality variables on the probability of strike detection. Specifically, for each detected strike we randomly selected 4 "matching" non-strike records from the same site during the same peak period (and having the same lunar illumination and set of environmental conditions): for H detected strikes, this resulted in a data set of $N = 5H$ records, with a mean expected strike probability of 0.2. These data were analyzed as a series of Bernoulli trials, in which the outcome of each record (Y = 1 for a strike, Y = 0 for no strike) was estimated as:

$$y_n \sim bernoulli(\theta_n) \quad (7)$$

where θ_n is the probability of that a strike occurs and is detected in record *n*, calculated as:

$$logit(\theta_n) = \kappa + \sum \alpha_j \cdot X_{n,j} \tag{8}$$

where κ determines the baseline strike probability for the sample and α_j is a vector of parameters associated with predictor variables X_j that potentially affect the likelihood that a strike is detected.

We next added a second observed data set to the model: for a sub-set of acoustic records that overlapped with visual surveys it was possible to compare observed strikes with their corresponding acoustic records to evaluate a) the average probability that visually-confirmed strikes were detected by the acoustic algorithm and b) the effect of signal quality metrics on this probability. For each of *c* = 1, 2… *C* visually confirmed strikes, we define z_c as a binary variable with value of 1 if the strike was detected by the acoustic recording and a value of 0 otherwise. These data were analyzed as a series of Bernoulli trials, in which the outcome of each record was estimated as:

$$z_c \sim bernoulli(\varphi_c) \tag{9}$$

and φ_n is the probability that a visually confirmed strike is detected in acoustic record *c*, calculated as:

$$logit(\varphi_c) = \alpha_0 + \sum \alpha_j \cdot X_{c,j} \tag{10}$$

where α_0 is a parameter specifying the baseline strike detection probability, α_j is the same vector of parameters defined for equation (8) and X_j are predictor variables that potentially affect the likelihood that a strike is detected.

There were 6 signal attribute metrics that we expected *a priori* to potentially provide information on the likelihood of a strike being successfully detected by an acoustic record: flux, flux sensitive, level, level absolute, click and burst. Unfortunately, the raw metrics were colinear to a certain degree and thus not fully independent. Moreover, the relationship between metrics and detection probability was not necessarily linear and there were potential interactions between metrics. To address the problem of collinearity we used principal components analysis (PVA) to collapse variation and obtain a smaller number of orthogonal variables (factors) that were linear transformations of the original signal attribute metrics. We used function "prcomp" in the stats library of R (R.Core.Team 2014), which utilizes singular value decomposition of the centered and re-scaled data matrix to produce orthogonal factors that were rotated functions of the original variables, centered on zero and with unit variance. The first 4 factors explained 96% of the variation in the raw signal attribute metrics, so we used these as predictor variables for equation (8). We also evaluated quadratic terms for each of the PCA factors as well as first-order interactions.

We used standard MCMC techniques to fit equations (7) - (10) to the observed data, with model fitting and evaluation methods identical to those described for the temporal effects model (see step 1, above). We evaluated alternative combinations of predictor variables, retaining those terms where the 90% credible intervals of the posterior distributions did not overlap 0, and we used the "Leave-out-one Information Criterion" (LooIC) to compare models with different combinations of predictor variables and select the best-supported model (Vehtari et al. 2017). With the best-supported model we drew from posterior predictive distributions of model parameters and calculated the predicted signal detection probability (SDP) associated with each 15-minute acoustic record (*a*) in the full data set:

$$SDP_a = logit^{-1}\left(\alpha_0 + \sum \alpha_j \cdot X_{a,j}\right) \quad (11)$$

We summarize graphically the distribution of SDP values and report the mean, standard error, and upper and lower 95% quantiles.

Step 3: Estimating Site-specific Strike Rates

The generalized temporal matrix (**T**) and the SDP estimates generated from step 1 and step 2 models were used as inputs for a site-specific model to estimate annual strike rates. The structure of the site-specific model is similar to the generalized temporal model of step 1, with the mean expected number of detected strikes at site *i* in week *w* and timestep *q* ($\Lambda_{i,w,q}$) calculated as:

$$\Lambda_{i,w,q} = \exp\left(\zeta + \psi_i + \overline{\gamma}_{w,q} + \gamma^*_{w,q}\right) \cdot R_{i,w,t} \cdot \overline{SDC}_{i,w,q} \cdot \Omega_{i,w,q} \quad (12)$$

where ζ is the overall mean log strike rate (as estimated in model step 1) and ψ_i is the log proportional deviation from the overall mean associated with site *i* (estimated as a hierarchical random effect drawn from a normal distribution with mean of 0 and standard deviation σ_i). Unlike equation (5), the temporal effect in equation (12) is divided into two components: $\overline{\gamma}_{w,q}$, which represents the generalized temporal effect common to all sites (as estimated in model step 1), and $\gamma^*_{w,q}$, which represents deviations from the generalized temporal effect that are specific to site *i* and is estimated using the CAR methods described in equations (1) - (4). By using this split formulation, we effectively treat the generalized temporal effect matrix as a prior, providing a reasonable baseline for those sites having low sample sizes or missing data from portions of the season. For sites having larger sample sizes and complete seasonal coverage, the sum of $\overline{\gamma}_{w,q}$ and $\gamma^*_{w,q}$ produces a locally-specific temporal effects matrix. The last 3 terms in equation (12) represent sample-specific adjustment factors: $R_{i,w,q}$ is a multiplier that adjusts the per-capita strike rate for the number of observed records, $\overline{SDC}_{i,w,q}$ is the signal detection probability statistic (as estimated in model step 2) averaged over the sample of acoustic records for site *i* in week *w* and timestep *q*, and $\Omega_{i,w,q}$ adjusts for the effects of lunar illumination in week *w* and timestep *q*. This last term was included based on *a priori* knowledge that moon illumination can affect bird behavior and thus the frequency of wire strikes. To account for the effects of lunar illumination, the relative degree of moon illumination for each record was specified as the proportion of moon face illuminated (and forced to 0 when the moon was below the horizon). We then re-centered this variable such that the mean value across all timesteps within a single season was 0, and we define *MI* as the re-scaled moon illumination associated with a single acoustic record. We then computed the mean and standard deviation of *MI* for all records recorded at site *i* in week *w* and timestep *q* (designated as $\overline{MI}_{i,w,q}$ and $sMI_{i,w,q}$, respectively). Finally, we calculate the moon illumination adjustment factor as:

$$\Omega_{i,w,q} = \exp\left(\overline{MI}_{i,w,q} \cdot \omega + 0.5 \cdot (sMI_{i,w,q} \cdot \omega)^2\right) \quad (13)$$

Where ω is a fitted parameter that accounts for the effects of moon illumination on strike rate.

For each site, *i*, and for each unique value of week and timestep, we tallied the number of acoustic records available ($R_{i,w,q}$) and the total number strikes detected in those records ($H_{i,w,q}$). For some sites a modification of the wire array (e.g. removal of the top wire) occurred part way through the sampling period: in these cases we partitioned the data into before and after the modification event (treatment), and consider each of these data sets as separate "sites" for the purpose of estimating strike rates before vs. after the treatment. We treat $H_{i,w,q}$, the number of detected strikes, as our observed variable, and we assumed it was described by a negative binomial distribution related probabilistically to the mean expected number of strikes:

$$H_{i,w,q} \sim negative\ binomial\left(mean = \Lambda_{i,w,q}, \nu\right) \tag{14}$$

where the inverse scale parameter υ determines the degree of over-dispersion in the recorded number of strikes per sample. The observed variable $H_{i,w,q}$ constrains the possible values of unknown parameters in equations (12) - (13), allowing us to estimate posterior distributions for these parameters using standard Markov Chain Monte Carlo (MCMC) methods. Model fitting and evaluation methods were identical to those described for the generalized temporal effects model (see step 1, above).

The posterior predictive distributions of fitted parameters were then used to estimate annual strike rates for each site, Y_i. We first created an index vector *t* representing all combinations of *w* and *q*, iterated so as to create a complete and ordered temporal sequence for all days over all weeks of a season from Apr 1 - Nov 30 (and accounting for variation in night duration via the extendable "middle-of-night" period, as described in step 1). We used this index vector to estimate the expected sum of strikes over an entire season:

$$Y_i = \exp\left(\zeta + \psi_i\right) \cdot \sum_t^T \exp(\overline{\gamma}_t + \gamma_t^*) \tag{15}$$

In comparing equation (15) to equation (12), we note that the terms adjusting for signal quality and number of records have dropped out, as we are now interested in "true" number of strikes rather than detectable strikes, and we assume just one record per unique value of *t*. Similarly, the term for moon illumination effect is dropped from equation (15) because the re-centered moon illumination variable *MI* results in an average seasonal moon effect value of 0. The posterior distribution for Y_i therefore represents our expectations (and associated uncertainty) about the average annual number of strikes at a given site and wire-array configuration. We use this posterior distribution as the "observed data" input for the final model step.

Step 4: Predictors of Strike Rate and Island-wide Estimate

We can express the expected annual number of strikes at a given span as a generalized linear mixed-effects model (GLMM), whereby the log of the mean expected value is an additive linear function of several fixed effects (corresponding to geographic, environmental and/or structural covariates) as well as a random effects that account for unexplained variation among regions and spans-within-regions. Specifically, if we define $Yexp_s$ as the expected mean annual number of strikes at span *i*, then:

$$\log(Yexp_s) = \xi + \sum_k X_{k,s} \cdot \beta_k + \log(Lng_s) + \eta_{region|s} + \varepsilon_s \quad (16)$$

where the intercept parameter ξ represents the log mean value, X_k is a matrix whose columns consist of *k* predictor variables (normalized and re-centered to have mean of 0 and standard deviation of 1) and β_k is a vector of *k* fitted parameters that describe the effect of the predictor variables, Lng_s is the total length of span *s* (in units of 100m), η represents unexplained variance (random effects) associated with region (estimated as a hierarchical random effect drawn from a normal distribution with mean of 0 and standard deviation σ_r) and ε represents unexplained variance (random effects) associated with a given span (estimated as a hierarchical random effect drawn from a normal distribution with mean of 0 and standard deviation σ_s). We evaluated a variety of potential predictor variables, using an information theoretic approach to determine which fixed effects to include in the final model. Potential geographic predictor variables included distance from ocean (*dstoc*), distance to nearest known nesting colony (*dstcol*), mean angle or slope of the landscape between adjacent poles (*slp*), mean gradient of the landscape in the area surrounding the span (*grad*), and topographical position index (*tpi*, a neighborhood-based measure of local variability in elevation). Potential environmental variables included mean annual wind shear (*wshr*), mean annual windspeed (m/sec.) within 100m of the span (wnd^{100}) and mean annual windspeed within 30m of the span (wnd^{30}). Potential structural predictor variables included the number of wire layers (*wlyr*) mean height (m) above ground (*abgh*) for the top wire level within the array, mean exposure (*exmn*, where exposure is defined as the height difference between the top wire level in the array and the top of the tallest obstacle to flight), standard deviation in exposure (*exsd*), maximum exposure (*exmx*), the percent of the wire layer exposed (*pcex*), and the total height of the array (i.e. the height between the top and bottom wire layer) divided by the number of layers, which provides a measure of the space between wire layers (*sbwl*).

To estimate the parameters in equation (16) we summed the values of $Yexp_s$ for the two spans comprising each site to obtain a site-specific value ($Yexp_i$), which we could then compare to “observed” values represented by the posterior predictive estimates of annual strike rate by site (Y_i) based on acoustic monitoring data (model step 3). Because the posterior distributions of Y_i were well-fit by gamma distributions, we were able to use a limited vector of quantiles to capture the distribution of uncertainty in the estimated value of Y_i for a given span. Specifically, for each span we computed 11 evenly spaced quantiles between 0.05 and 0.95 from the posterior distribution of Y_i. We confirmed that the original posterior distribution could be well-approximated by fitting a gamma distribution to the vector of quantiles. The combined array of quantile values for all spans (designated as $y_{i(u)}$) was then treated as an observed data variable, assumed to be described by a gamma distribution that was related probabilistically to the expected strike rate

$$y_{i(u)} \sim gamma\left(shape_i = \left(Yexp_i \cdot \tau_i\right), \tau_i\right) \quad (17)$$

where the inverse scale parameter τ_i was estimated separately for each site to account for differing degrees of precision in estimates of Y_i. In this way, sites having greater sample sizes (and thus more precise estimates of Y_i) contributed more to the estimation of fixed effect parameters in equation (16).

We used standard MCMC techniques to fit equations (16) - (17) to the observed data, with model fitting and evaluation methods identical to those described for the temporal effects model (see step 1, above). We set vague priors for all parameters, including Cauchy priors for ξ and β parameters and half-Cauchy priors for σ parameters (scale parameter = 2.5 in both cases). The prior distribution for τ_i was a half-Cauchy distribution with scale parameter ι itself a fitted parameter with a vague normal prior. We evaluated all combinations of predictor variables, retaining those effects where the 90% credible intervals of the posterior distributions did not overlap 0, and we used the "Leave-out-one Information Criterion" (LooIC) to compare models with different combinations of predictor variables and select the best-supported model (Vehtari et al. 2017). We present goodness of fit statistics and credible intervals for parameters included in the final model.

Finally, drawing from the posterior predictive distributions of fixed effect parameters and random effects, we generated predictive distributions of $Yexp_s$ (mean expected annual strike rate) for all spans around the island. We noted that the site-specific estimates for sampled spans in Waimea Canyon appeared anonymously high relative to visual surveys. Accordingly, we relied on posterior predictive estimates of strike rates for all spans in the Waimea Canyon region, which resulted in lower, more conservative estimates for sampled spans.

Results

Acoustic data on powerline strikes were collected over 7 years, from 2013 – 2019, with sample sizes of 500 or more 15-minute recordings analyzed from each of 441 sites (882 spans) for a total of 902,520 data records. There were 7,339 bird strikes positively identified from these records, for an average strike rate across the entire power grid of 0.008 per 15-minute recording.

Step 1: Generalized Patterns of Temporal Variation

The model to estimate generalized patterns of temporal variation in strike rate converged well, with Rhat <1.1 for all parameters (Table 1). Posterior predictive distribution plots indicated excellent goodness of fit (Figure 3), with a Bayesian-P value of 0.42. While there was considerable variation in mean log strike rate among sites (see ψ random effect values, Table 1), seasonal and diel trends in the relative frequency of strikes exhibited clear patterns when averaged across sites (Figure 4). The average period where strike rates were generally highest was 30-90 minutes before sunrise between April 20 and September 20, although it should be noted that the highest strike rate period is very site specific and can vary dramatically across different portions of the power line grid.

Step 2: Effect of Acoustic Signal Quality on Strike Detection

Results from a principal component analysis (PCA) indicated that 4 orthogonal PCA factors captured 96% of the combined variation in 6 signal quality metrics (Figure 5a). Loadings plots indicated that level, level absolute and burst loaded heaviest on PC1, flux and flux sensitive loaded heaviest on PC2, click loaded heaviest on PC3, and burst loaded heaviest on PC4 (Figure 5b-d). These 4 PCA factors were included as predictor variables in a model estimating the probability of signal detection. This model converged well, with Rhat <1.1 for all parameters (Table 2). Posterior predictive distribution plots indicated excellent goodness of fit (Figure 6), with a Bayesian-P value of 0.48. The best-supported model included 6 predictor variables that had significant effects on signal detection (Figure 7): PC1 and PC2 were positively related to the likelihood of signal detection, PC3 and PC4 had negative effects on signal detection, and significant quadratic effects included $PC2^2$ and $PC3^2$ (which had negative and positive effects, respectively, on the probability of signal detection). Applying the fitted model to all data records produced an estimated average strike detection rate of ~60%, although the distribution of signal detection probabilities was highly skewed (Figure 8). The most common detection probability rate was in the range of 60-85%, but there was a long "left tail" of records having detection probabilities of 0-60%, reflecting poorer signal quality.

Step 3: Site-specific Strike Rates

We fit separate models estimating annual strike rates to data from 441 sites, representing 882 spans. Models converged well, with Rhat values <1.1 for all parameters estimated for all spans, and provided excellent goodness of fit: sample posterior predictive plots from representative spans (Figure 9) show a close match between observed and out-of-sample predictive distributions, with Bayesian-P values from posterior predictive checks close to 0.5 (Figure 10). The temporal matrices for individual sites were broadly similar, although there were some site-specific differences in the seasonal and diel timing of peaks in strike activity (Figure 11). Sites also varied in terms of the effect of moon illumination on strike rates (Figure 12), although most sites exhibited a negative relationship between moon illumination and strike rates. PL Trail was an exception, with more sites in this region exhibiting a positive relationship between moon illumination and strike rates (Figure 12).

The estimated annual strike rates differed considerably among sites, and the precision of estimates was generally greater for sites having more robust sample sizes (Figure 13). The overall distribution of estimated annual strike rates was skewed, with most sites having low estimated numbers (<10) but a few sites having relatively high numbers of strikes (100 or more; Figure 14). The estimated mean annual number of strikes per site (corresponding to current wire configurations) was 31.6, with a standard deviation of 76.5, a median value of 4.9 and a 95% CI of 1.96 – 247.5.

Step 4: Predictors of Strike Rate and Island-wide Estimate

The model analyzing predictors of annual strike rate converged well, with Rhat <1.1 for all parameters (Table 3). Posterior predictive distribution plots indicated excellent goodness of fit (Figure 15), with a Bayesian-P value of 0.496. The best-supported model included 6 fixed-effect predictor variables (Figure

16): strike rates tended to increase with distance to ocean (*dstoc*) and decrease with increasing gradient of the landscape (*grad*); there were more strikes for arrays having more wire layers (*wlyr*) although arrays having greater space between wire layers (*sbwl*) had fewer strikes; and strike rate was higher for arrays having a greater percent of the wire span exposed (*pcex*) and lower for spans having more variance in exposure height (*exsd*).

In addition to the above-described fixed effects, there was a substantial degree of variance in strike rate attributable to unexplained differences (random effects) among regions and among sites within regions, with site differences accounting for a larger component of variation (Figure 17). The region having the highest strike rates was the PL Trail. Applying a posterior predictive approach, we estimated annual strike rates for all spans: the cumulative mean annual number of strikes across all spans prior to wire modification was estimated as **18,956 (95% CI = 4,417– 56,903**)[2]. A map of the strike rate estimates shows that most areas have less than 20 strikes per year, with a few clear hot spots of strike activity occurring in PL TRAIL and CENTRAL regions (Figure 18).

Step 5- Estimating immediately grounded seabirds and species ratios

When seabirds collide with power lines the minimum immediate grounding rate has been calculated as 13.0%, while the upper bound is 22.8% (Travers et al. 2020). When these immediate grounding rates are applied to the 18,956 acoustic strikes the minimum and upper bound of immediately grounded birds is **2,464-4,321 per year**.

The seabird passage rate was used in the past to identify the species-specific ratio of collisions and mortalities. If we apply the 70/30 Newell's Shearwaters to Hawaiian Petrel passage rate ratio used in the past, the immediate grounding rate by species is **1,725-3,025 immediately grounded Newell's Shearwaters and 739-1,296 immediately grounded Hawaiian Petrels**. However, separate to the Bayesian model it should be noted that we are actively working on updating the species specific collision rate and will present those updated results when the updated analysis is complete.

Step 6- Minimizing seabird power line collisions

Given the very large numbers of seabird power line collisions illustrated by this model update, which is in line with previous KESRP take models (see previous Briefing Documents), mitigation alone is clearly not practicable for offsetting this level of take. This is true for the current minimum grounding estimate of 2,462 seabirds annually but was also true for all previous model estimates. The previous estimates

[2] Note this number was created using all data prior to any minimization. The number presented does not include reductions for Kahili Undergrounding and the static wire removal in the coffee fields. Furthermore, in the 2020 seabird breeding season, KIUC has started implementing larger scale minimization efforts than prior to 2020, by removing the static wire across multiple larger sections of wires.– see discussion below. With new measures in place, take estimates for 2020 will be lower.

(UMPKESRP 3 model amalgamation and the 3 versions of the FWS acoustic strike models from 2014, 2015, and 2016) considered fewer power line sections and had lower totals collisions, but each estimate also exceeded the available practicable mitigation options. As has been outlined in previous UMP Annual Reports and Briefing Documents, to mitigate for seabird power line collisions, power line minimization needs to be implemented in a manner that dramatically lowers the current level of collisions.

We have previously recommended several minimization actions that will help reduce seabird power line collisions to a level that can be mitigated. Before examining those options, we should first consider ideal minimization efficacy levels and the remaining mortalities for mitigation. If power line minimization targets of 80 or 90% reductions are achieved the required mitigation offset would be reduced to 492 or 246 seabirds annually, respectively. Certainly, the target goal of 90% minimization would reduce mitigation requirements (246 seabirds) to a level that is both practicable and financially feasible for KIUC. Minimization can be achieved through the following actions.

Static wire removal- We have previously reported estimates for several minimization actions. Static wire removal resulted in an estimated reduction of 36-72% depending on the terrain. Recent unreported observation work indicates that static wire removal could reduce strikes by as much as 78% on steel towers in flat terrain. Static wires are present in nearly all high strike locations and are geographically widespread and are therefore an ideal starting point for large scale geographic minimization[3].

LED Diverters- In discussion with researchers tackling powerline collisions in South Africa in early 2016, we were provided with unpublished information that LED diverters used in their work reduced avian collision rates at their study sites by more than 90%. If diverters were studied thoroughly on Kauai, diverters could also be implemented at a large geographic scale.

Power line reconfiguration- We have previously reported that wire modification plans put forward by KIUC in their first draft HCP produced in 2016, would lower collisions by 72-96% depending on the plan and the terrain. In the most challenging terrain, we have recommended that combining reconfiguration with the addition of static wire removal and or diverters would achieve significantly better reductions. Lastly, KIUC's new seabird team has put forth a wire design called spacer cable. This construction uses insulated wires, which increases the diameter of the wires, and allows wires to be closer together and much lower on the poles. We have not yet been asked to estimate the benefit of this method, but our opinion is that any method that maximizes the lowering of wires will greatly reduce collisions. If the spacer cable is lowered to the level currently being discussed, we believe that spacer cable could also achieve greater the 90% collision reductions.

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[3] In 2020 the new KIUC seabird team began large scale static wire removals at multiple high collision areas. At the time of writing, static wires have been removed in Kilauea, CP central region (previously in Ele'ele). Preparations are completed and static wire removal is about to begin in LC Central region. Once the third minimization action is complete KIUC will have partially minimization of 29.3 Kilometers of power lines in the beginning half of 2020. Prior to 2020, 8.4 Kilometers of power lines had been minimized. Lastly, the new KIUC team is developing plans for removing the static wire on the northern section of power line trail.

Maintenance of existing trees or promoting tree growth in a wire safe manner- In most areas trees that are taller than wires force bird to fly over wires, which would thus achieve 100% reduction when fully shielding wires.

Conclusion- As discussed above, achieving a 90% or greater seabird collision reduction should be achievable at power line sections on Kauai that are modified. High collision areas need to be modified immediately to minimize powerline collisions and bring the strike rate down to a level that can then be offset through mitigation actions such as predator control in colonies and the creation of fully protected areas surrounded by predator proof fences. Minimization needs to be implemented at a geographic scale that will reduce island-wide take to levels where mitigation will realistically offset take. While the modeled strike rates produced in this briefing document (and through previous models) are high, we believe that it is entirely possible and financially feasible to do this.

Tables

Table 1. Parameter estimates from model step 1. Hierarchical random effect values of ψ are shown for 14 representative sites (2 from each of 7 regions) selected for analysis of generalized temporal trends.

Parameter	***mean***	***sd***	***2.5%***	***50%***	***97.5%***	***Rhat***
ζ	0.193	0.606	-1.083	0.212	1.339	1.013
σ_γ	0.180	0.050	0.083	0.181	0.275	0.999
σ_i	2.162	0.565	1.336	2.072	3.516	1.002
υ	3.150	0.705	2.094	3.045	4.828	1.001
ρ_w	0.649	0.051	0.543	0.652	0.742	1.012
ρ_q	0.853	0.038	0.765	0.857	0.914	1.014
ψ*[1]*	1.972	0.593	0.854	1.951	3.233	1.012
ψ *[2]*	1.373	0.603	0.244	1.352	2.657	1.012
ψ *[3]*	1.323	0.600	0.185	1.296	2.594	1.012
ψ *[4]*	-0.018	0.653	-1.245	-0.034	1.345	1.010
ψ *[5]*	-1.950	1.005	-4.163	-1.881	-0.147	1.003
ψ *[6]*	-2.916	1.447	-6.268	-2.726	-0.673	1.003
ψ *[7]*	2.113	0.591	1.008	2.089	3.387	1.012
ψ *[8]*	2.449	0.591	1.334	2.426	3.716	1.013
ψ *[9]*	-2.546	0.983	-4.680	-2.488	-0.781	1.004
ψ *[10]*	-2.461	1.486	-5.946	-2.267	-0.145	1.001
ψ *[11]*	2.010	0.609	0.858	1.986	3.304	1.011
ψ *[12]*	0.520	0.637	-0.706	0.503	1.849	1.011
ψ *[13]*	-1.521	0.739	-3.001	-1.513	-0.063	1.008
ψ *[14]*	0.005	0.632	-1.194	-0.013	1.329	1.011

Table 2. Parameter estimates from model step 2. The fixed effect parameters affecting signal detection probability (α_j for J = 1:6) correspond to linear and quadratic effects of 4 PCA factors: PC1, PC2, PC3, PC4, $PC2^2$, $PC3^2$.

Parameter	*mean*	*sd*	*2.5%*	*50%*	*97.5%*	*Rhat*
κ	-1.969	0.087	-2.140	-1.970	-1.801	1.001
α_0	-0.632	0.190	-1.008	-0.632	-0.261	1.000
α_1	0.426	0.053	0.323	0.426	0.532	1.002
α_2	0.669	0.070	0.534	0.668	0.809	1.002
α_3	-0.392	0.126	-0.647	-0.389	-0.146	1.000
α_4	-0.722	0.107	-0.932	-0.722	-0.512	1.001
α_5	-0.042	0.027	-0.096	-0.041	0.009	1.001
α_6	0.057	0.024	0.009	0.058	0.101	1.000

Table 3. Parameter estimates from model step 4. The fixed effect parameters affecting signal detection probability (β_j for J = 1:6) correspond to predictor variables *dstoc*, *grad*, *wlyr*, *sbwl*, *pcex*, and *exsd*

Parameter	*mean*	*sd*	*2.5%*	*50%*	*97.5%*	*Rhat*
ξ	-0.341	0.476	-1.302	-0.337	0.524	1.005
σ_r	0.897	0.337	0.461	0.829	1.723	1.001
σ_s	1.169	0.044	1.087	1.169	1.256	1
ι	0.089	0.006	0.079	0.089	0.1	1
β_1	0.643	0.132	0.389	0.641	0.904	1.006
β_2	-0.096	0.094	-0.276	-0.094	0.09	1.009
β_3	0.179	0.06	0.06	0.179	0.296	1.01
β_4	-0.396	0.141	-0.675	-0.395	-0.12	1.009
β_5	1.205	0.342	0.533	1.207	1.878	1.013
β_6	-0.125	0.083	-0.288	-0.124	0.037	1.01

Figures

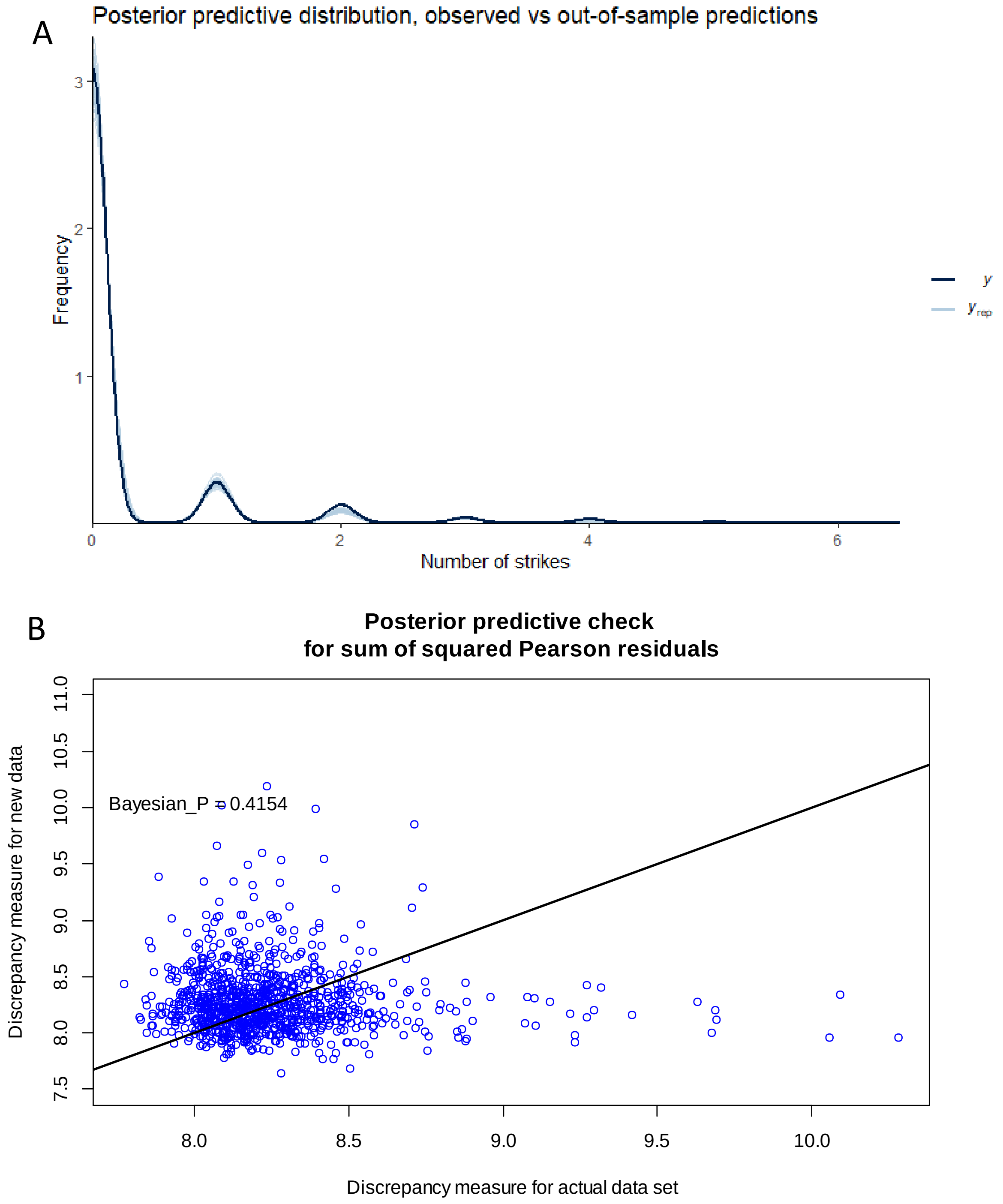

Figure 3. Posterior predictive plots for Bayesian model of temporal variation in strike rate. A) frequency distribution of observed number of strikes per sample (y = black line) and out-of-sample predictions (y_{rep} = grey lines), with the degree of concordance between distributions indicating goodness of fit ; and B) scatter plot of a discrepancy measure (squared Pearson residuals) for observed data vs "new data" (out-of-sample predictions) generated by model: clustering of values around a 1:1 relationship (solid black line) indicates a well-fit model, as quantified by a Bayesian-P value near 0.5.

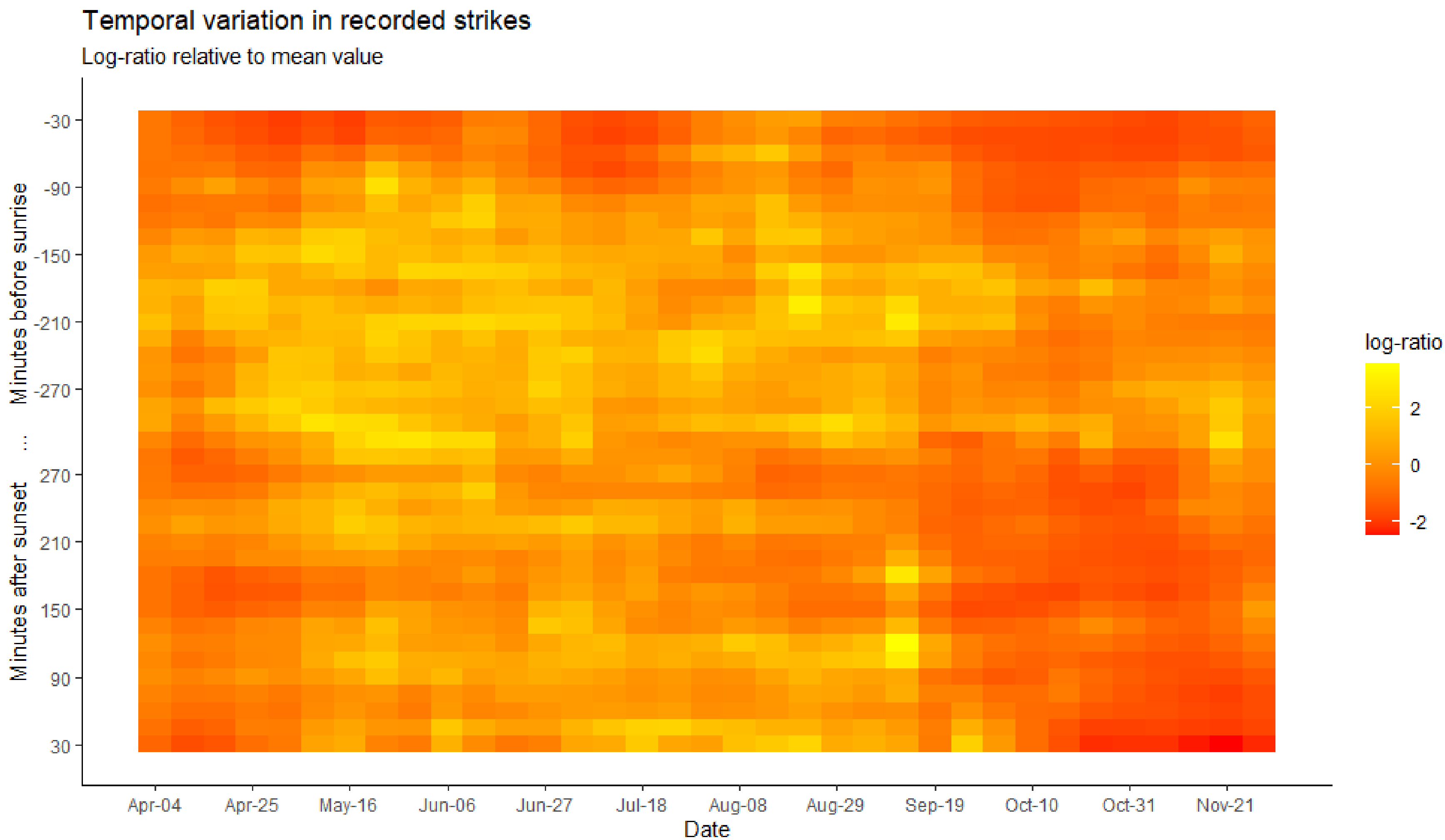

Figure 4. Heatmap plot of a temporal matrix (**T**) of the relative rate of bird strikes as a function of date of the season (x-axis) and time of night (y-axis). Colors show variaiton in the log-ratio relative to the overall mean, such that a value of 0 corresponds to the mean.

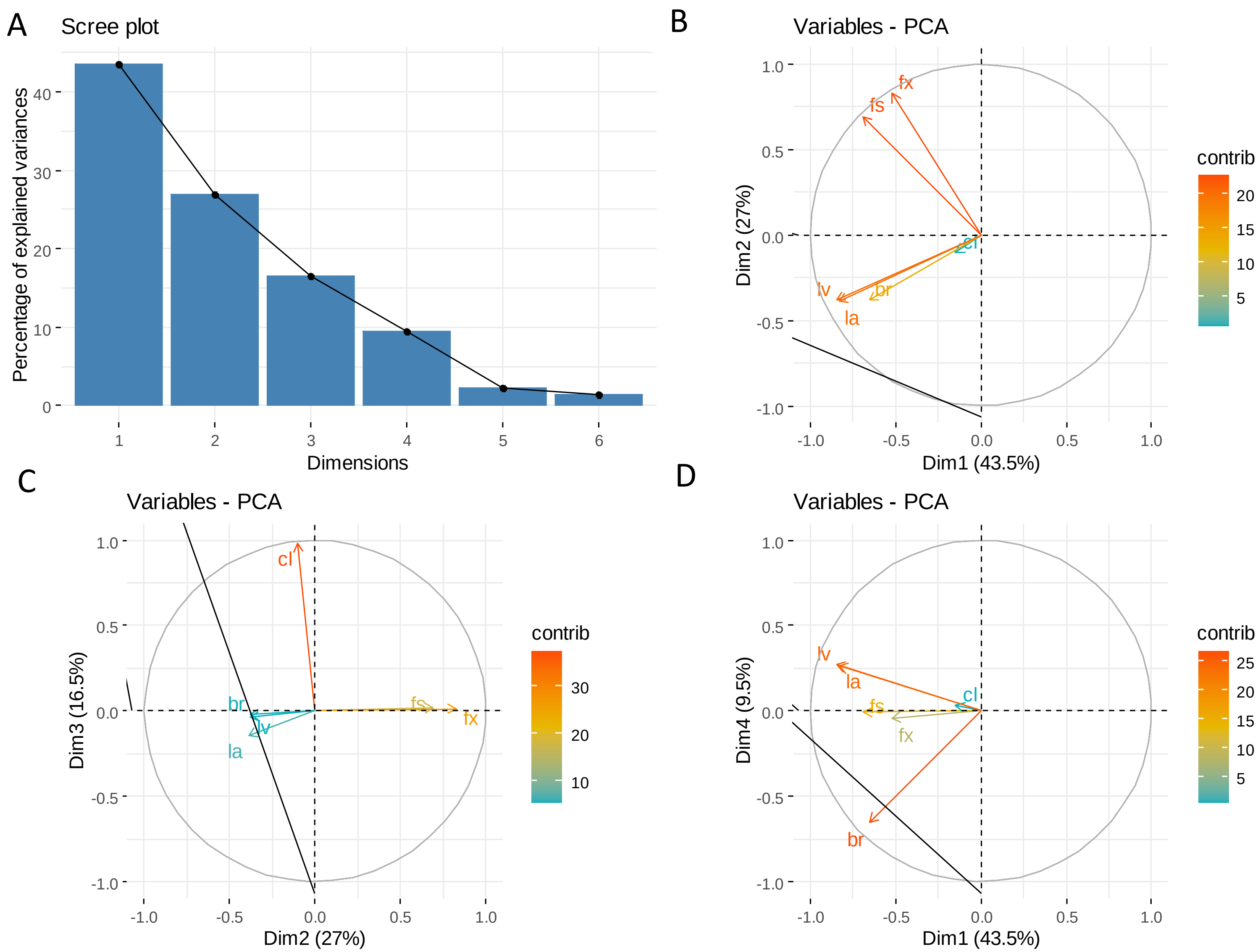

Figure 5. Graphical results from a principal components analysis (PCA) of 6 signal quality metrics: flux (fx), flux sensitive (fs), level (lv), level absolute (la), burst (br) and click (cl) . A) Scree plot showing the reletive amount of variation in the original 6 variables explained by each of the PCA factors (ordered). B) radial loadings plot showing the relationship betweeen the original variables (loadings vectors) and PCA factors 1 (x-axis) and 2 (y-axis); C) radial loadings plot showing the relationship betweeen the original variables and PCA factors 2 (x-axis) and 3 (y-axis); D) radial loadings plot showing the relationship betweeen the original variables and PCA factors 1 (x-axis) and 4 (y-axis). In plots B-D, the color of loadings vectors indicates their relative contribution to the PCA factors in the respective ordination.

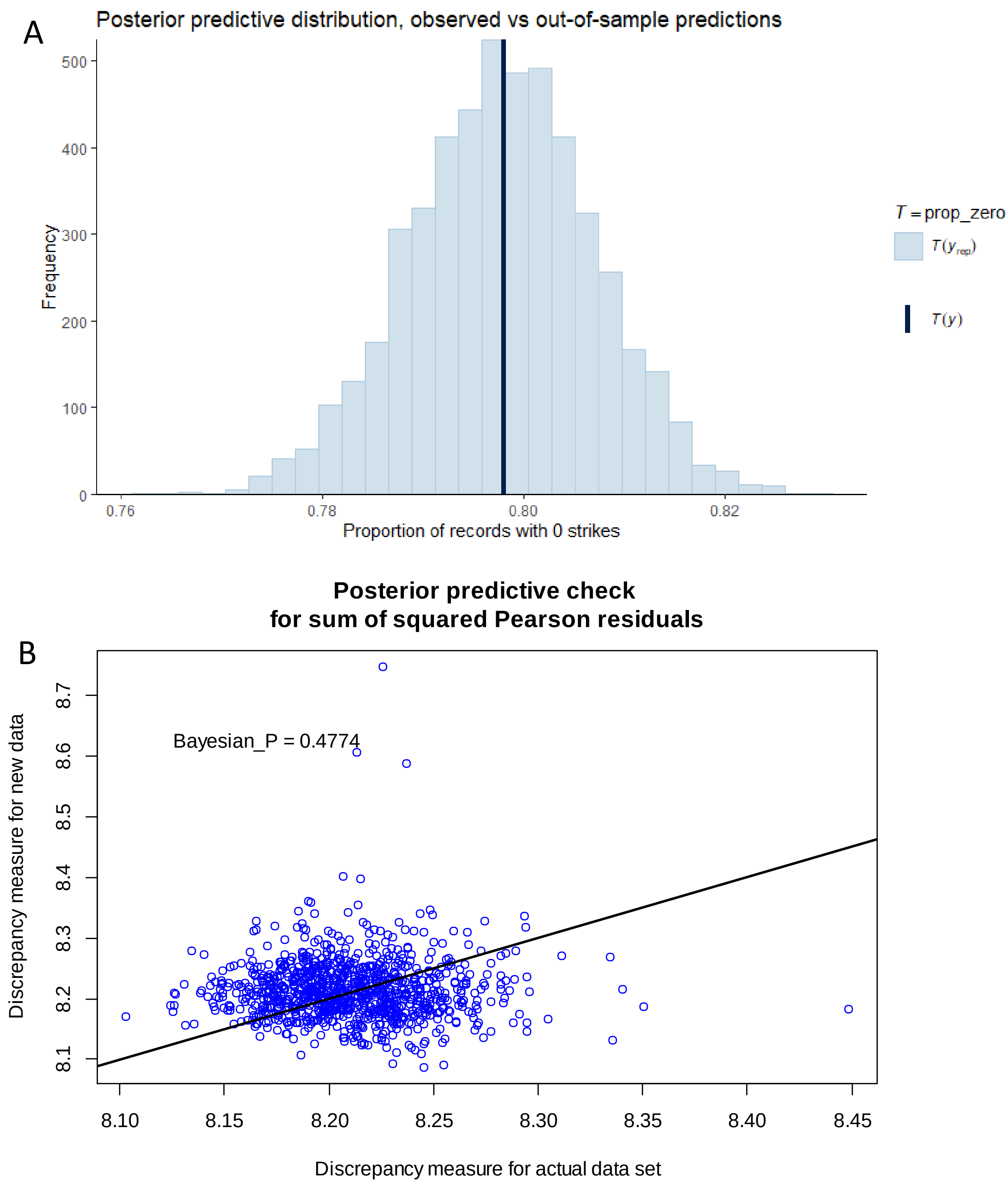

Figure 6. Posterior predictive plots for Bayesian model of signal quality effects on strike detection probability. A) frequency distribution of the proportion of out-of-sample model predictions where 0 strikes were detected (grey bars) as compared to the actual proportion of 0-detections in the observed data set (y = black line); and B) scatter plot of a discrepancy measure (squared Pearson residuals) for observed data vs "new data" (out-of-sample predictions) generated by the model: clustering of values around a 1:1 relationship (solid black line) indicates a well-fit model, as quantified by a Bayesian-P value near 0.5.

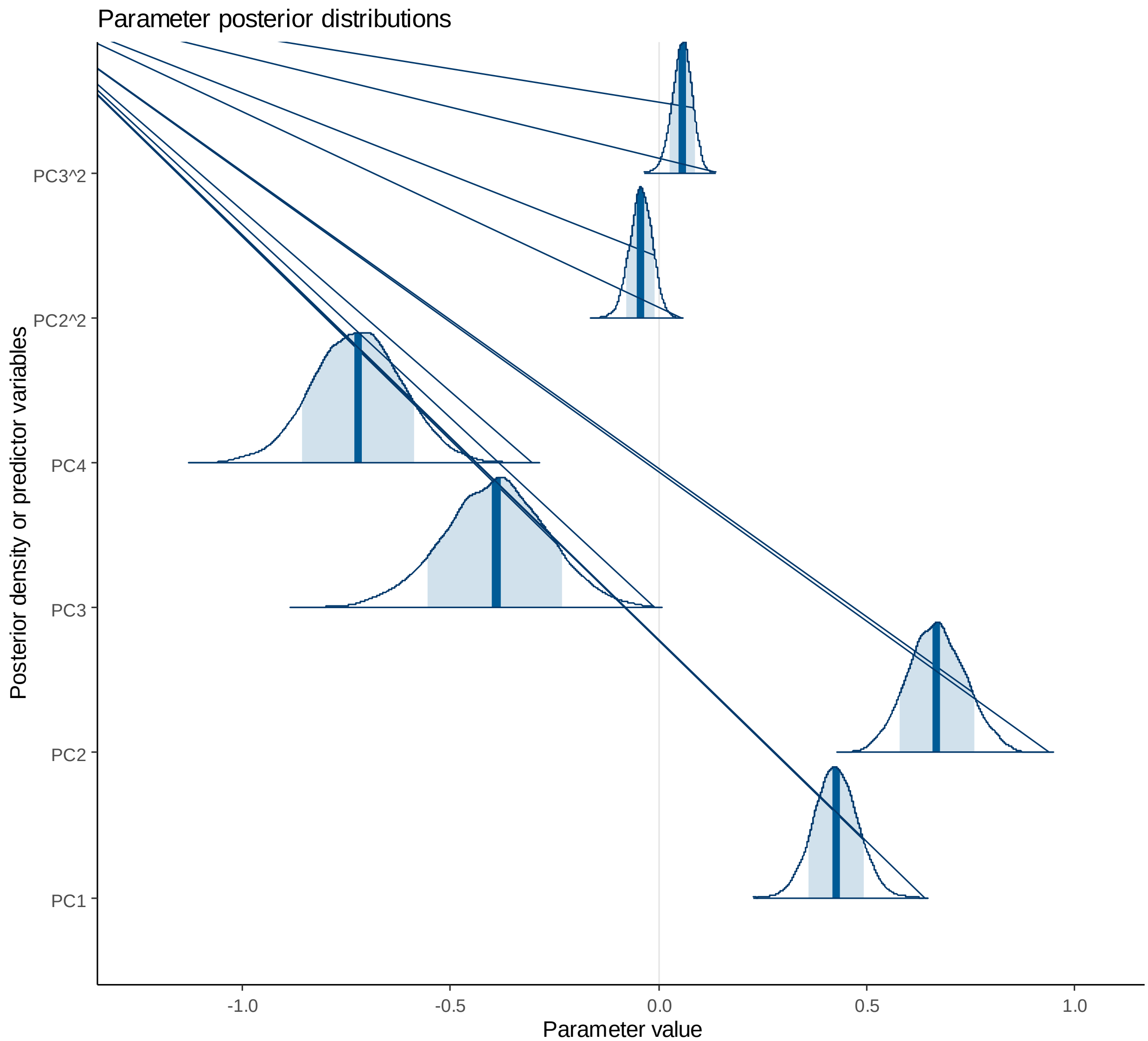

Figure 7. Posterior distribution plots for the parameters in a model predicting strike detection probability as a funciton of signal quality metrics. A PCA was used to collapse variaiton of raw signal quality metrics into 4 orthogonal PCA factors, and the parameters of the model correspond to linear and/or quadratic effects of these factors. Shaded area of each density distribution indicates the 90% CI, and the solid vertical line indicates the mean parameter estimate.

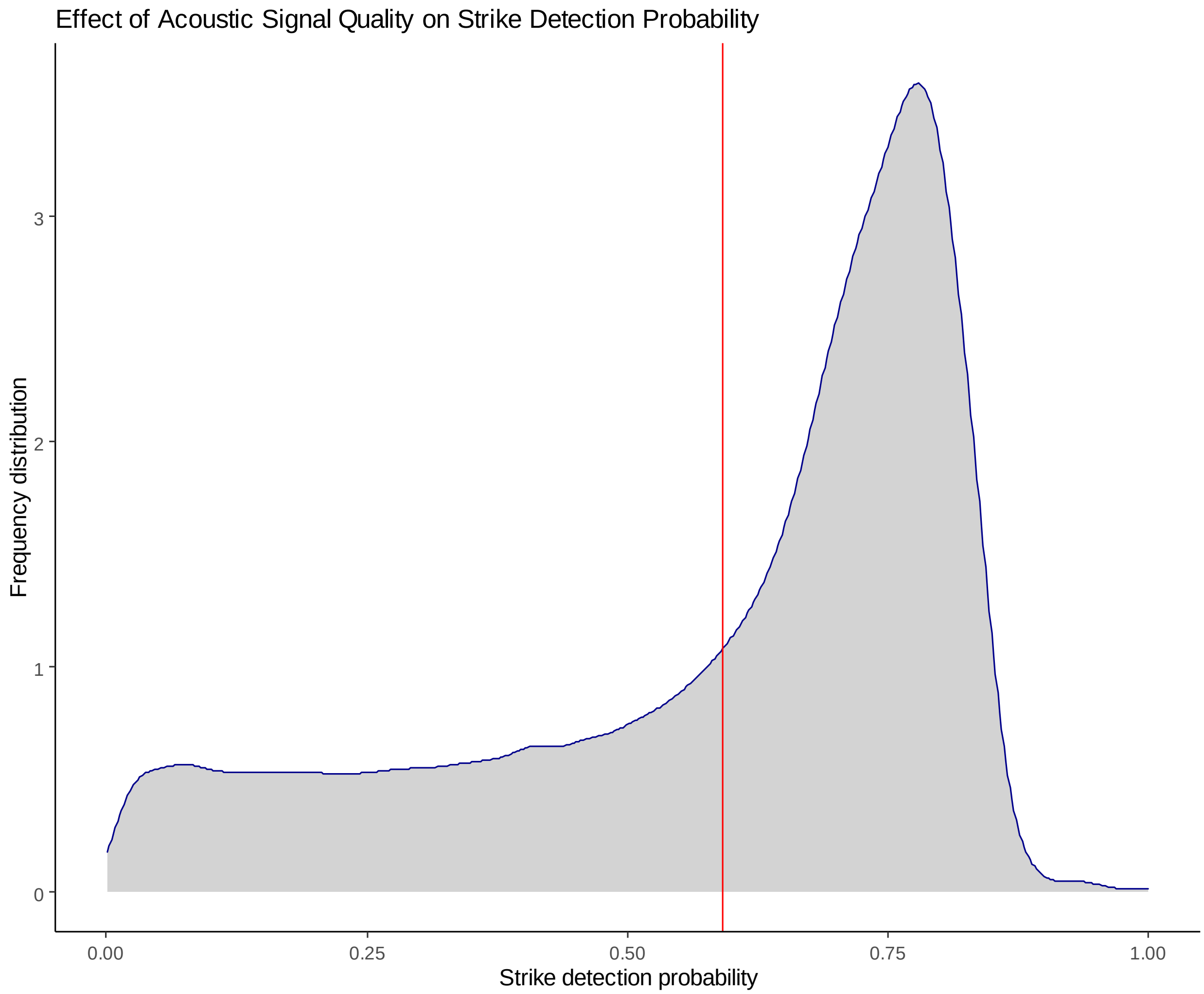

Figure 8. Density-distribution of the estimated strike detection probability for all acoustic records included in the analyses (N=902,520).

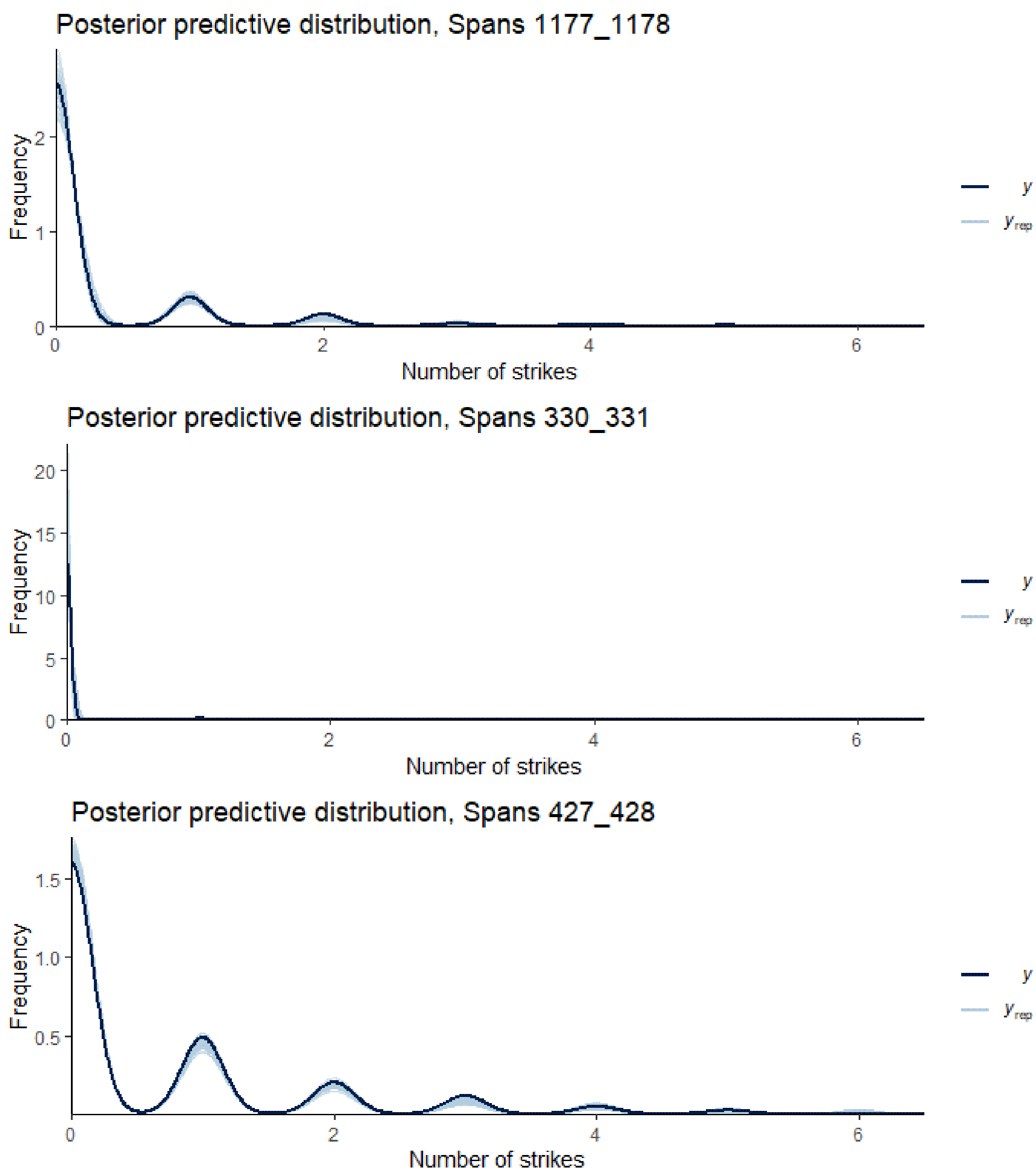

Figure 9. Posterior predictive plots for Bayesian model of site-specific annual strike rates, with each panel representing the results from an analysis of one site (2 spans) selected haphazardly. Plots show the frequency distribution of observed number of strikes per sample (y = black line) and out-of-sample predictions (y_{rep} = grey lines), with the degree of concordance between distributions indicating goodness of fit.

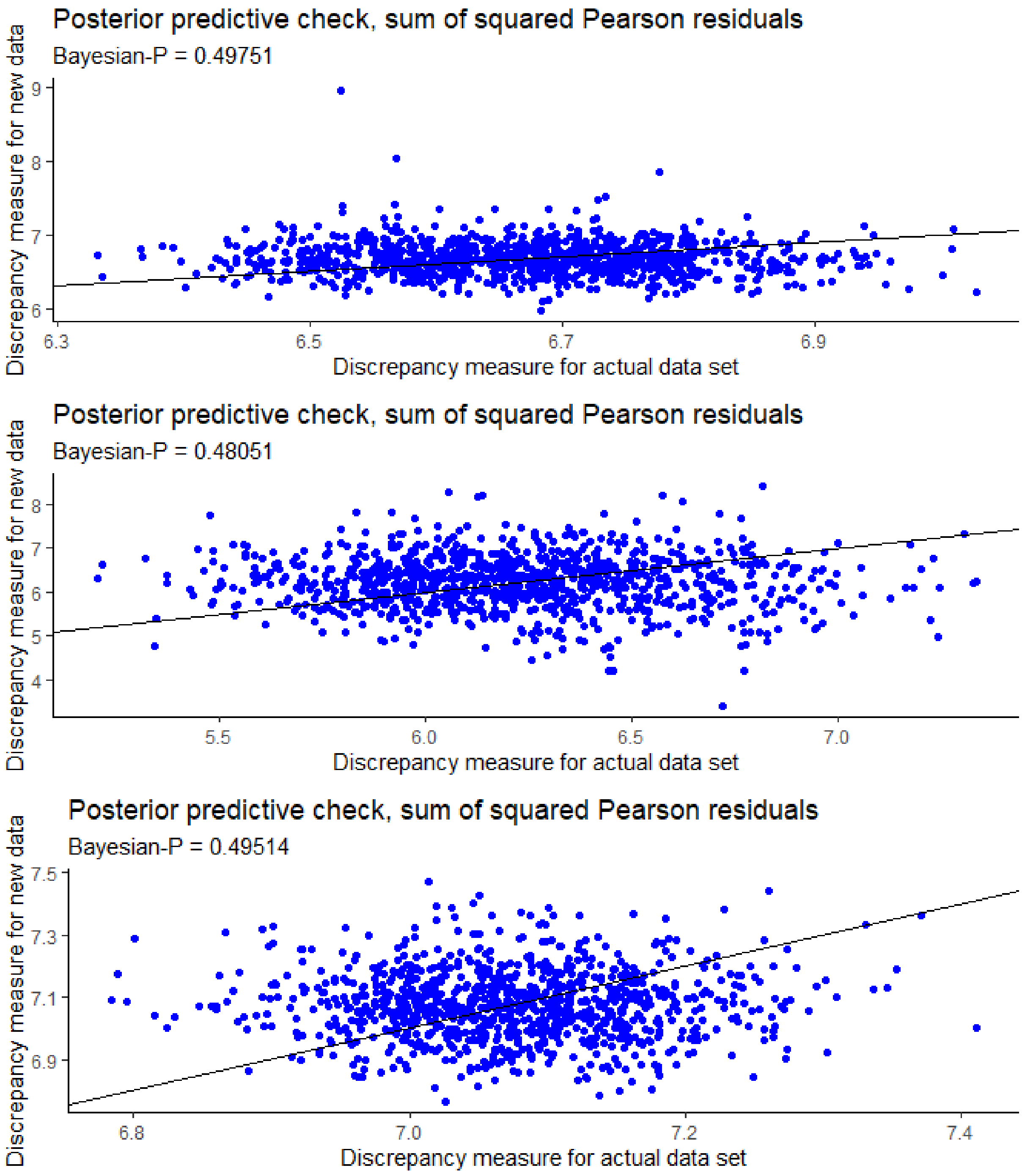

Figure 10. Posterior predictive plots for Bayesian model of site-specific annual strike rates, with each panel representing the results from an analysis of one site (2 spans) selected haphazardly. Scatter plots represent an ordination of a discrepancy measure (squared Pearson residuals) for observed data vs "new data" (out-of-sample predictions) generated by model: clustering of values around a 1:1 relationship (solid black line) indicates a well-fit model, as quantified by a Bayesian-P value near 0.5.

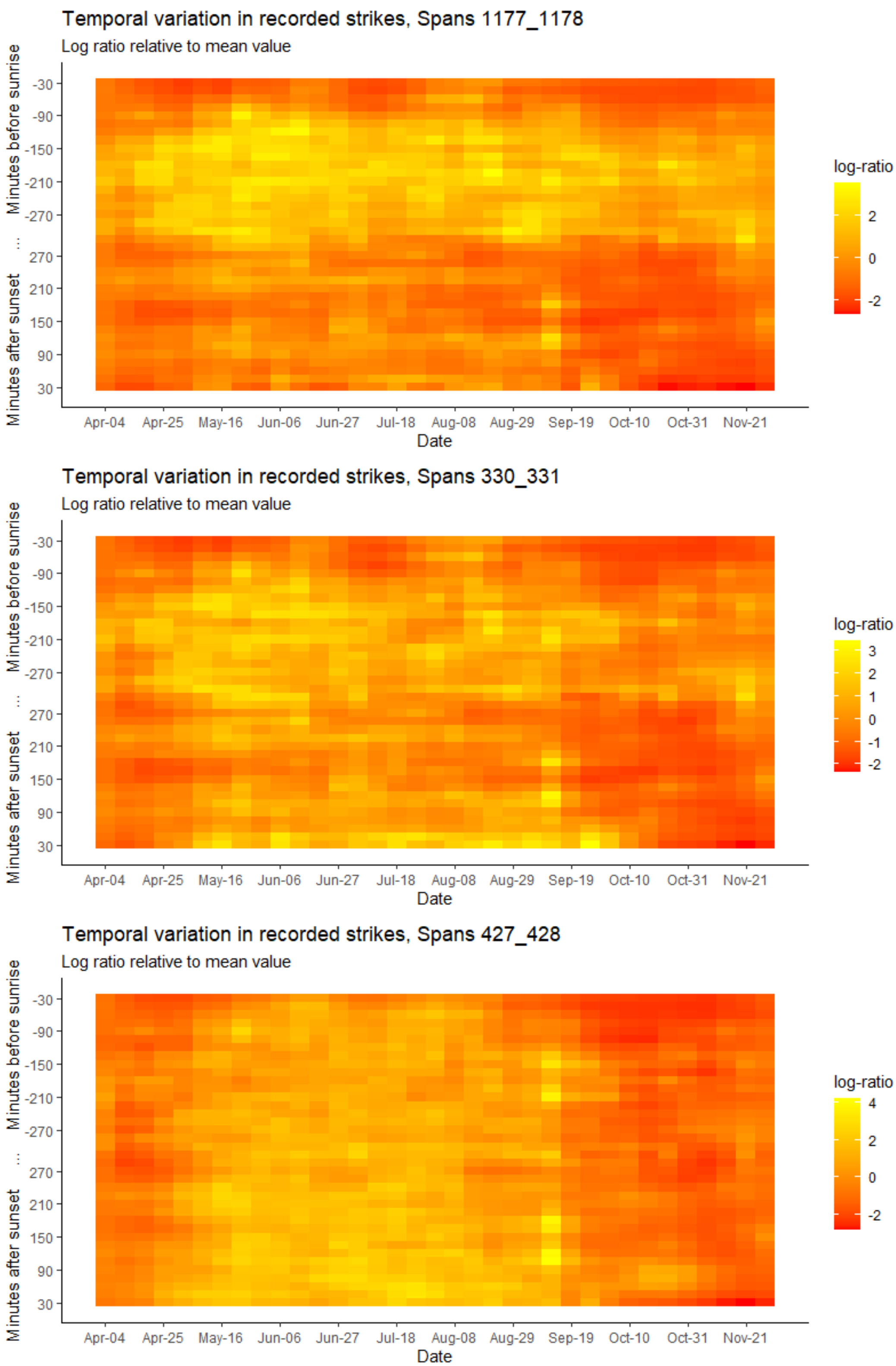

Figure 11. *Representative heatmap plots for 3 arbitrarily selected sites, showing variability among sites in the temporal matrix (***T***) of relative rate of bird strikes as a function of date of the season (x-axis) and time of night (y-axis). Colors show variaiton in the log-ratio relative to the overall mean, such that a value of 0 corresponds to the mean.*

Figure 12. Plot of the estimated values of parameter ω, the effect of moon illumination of strike rate, for each of the 441 sites analyzed, color-coded by region. Points represent the mean estimate of ω for each site (values <0 correspond to a negative relationship between moon illumination and strike rate) and dotted error bar lines show parameter uncertainty (± 1 standard deviation of posterior samples).

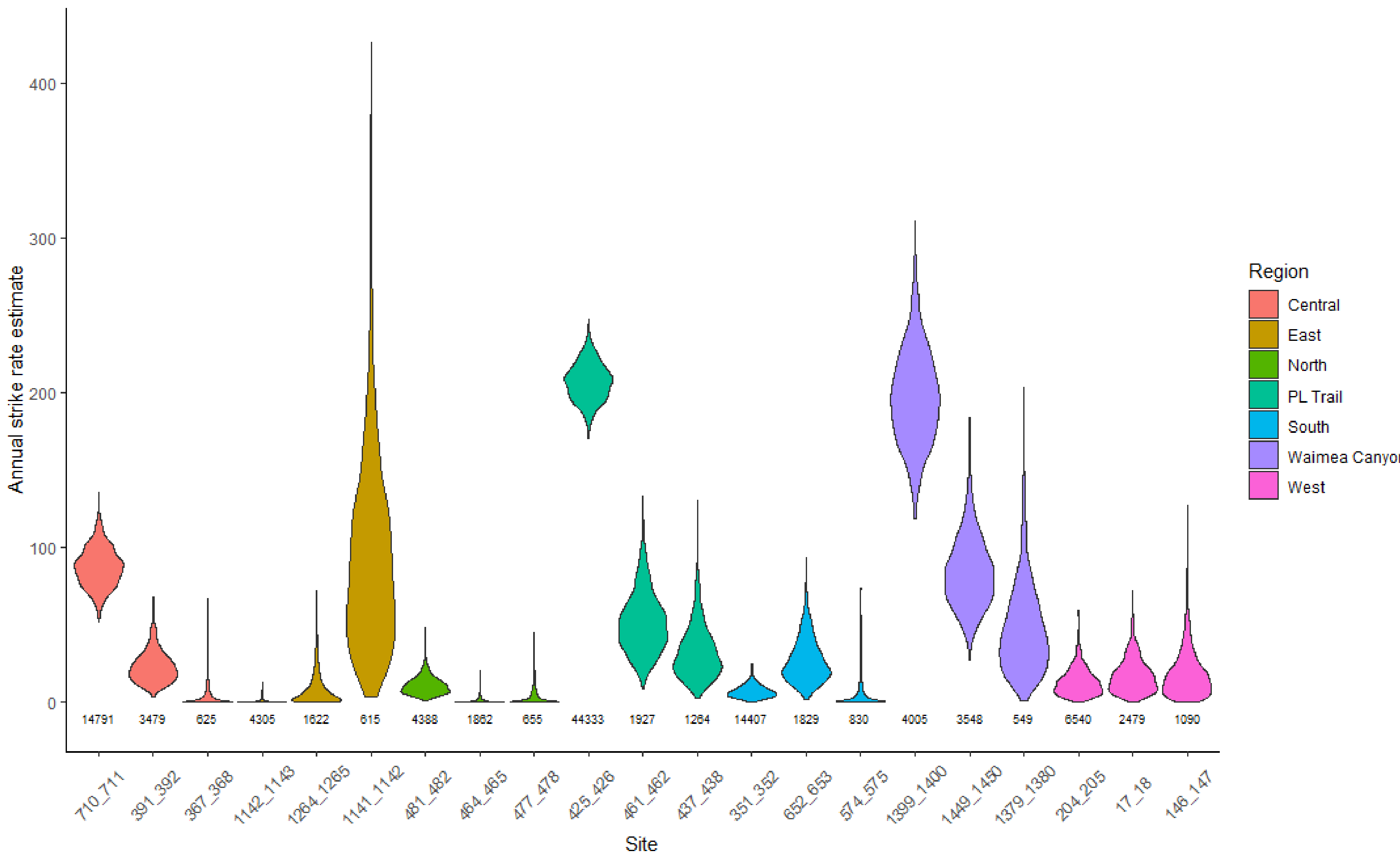

Figure 13. Violin plot of the posterior distributions of estimated annual strike rates for 21 randomly selected sites (3 from each of 7 regions). Site labels show the ID numbers of the two spans at each site, and the numbers below each violin are the sample sizes (number of 15-minute acoustic records) for each site.

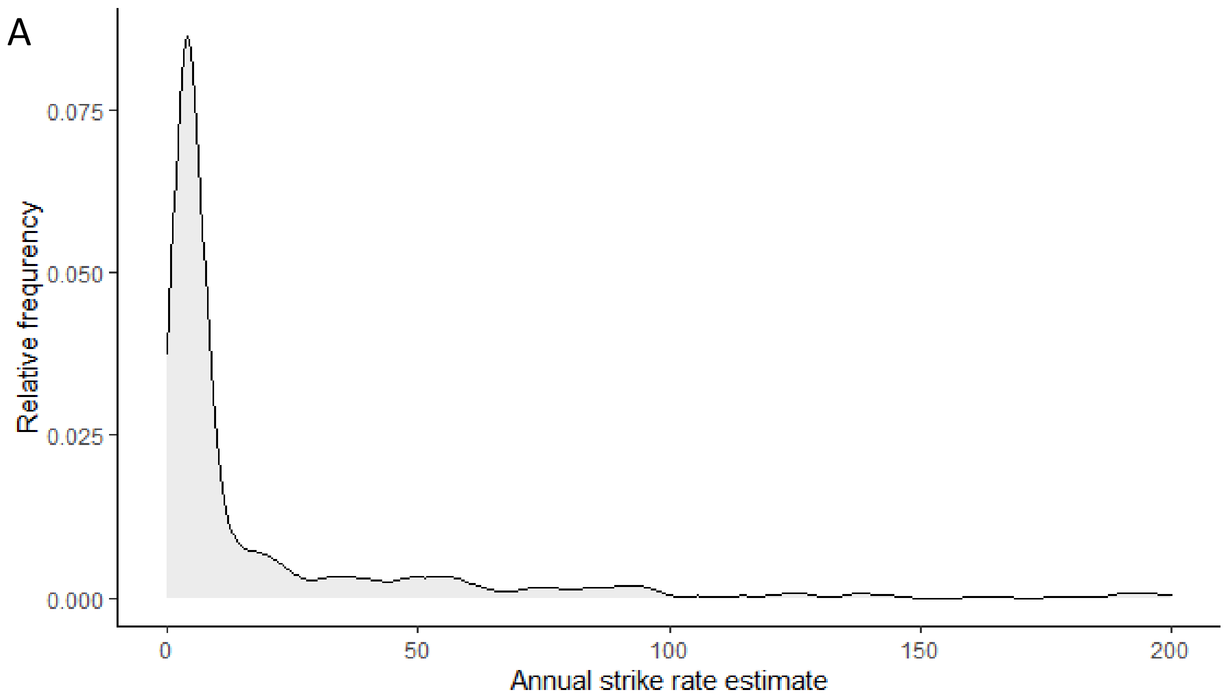

Figure 14. Results from site-specific analyses of annual strike rate. Density distribution of annual strike rate estimates across all 441 sampled sites.

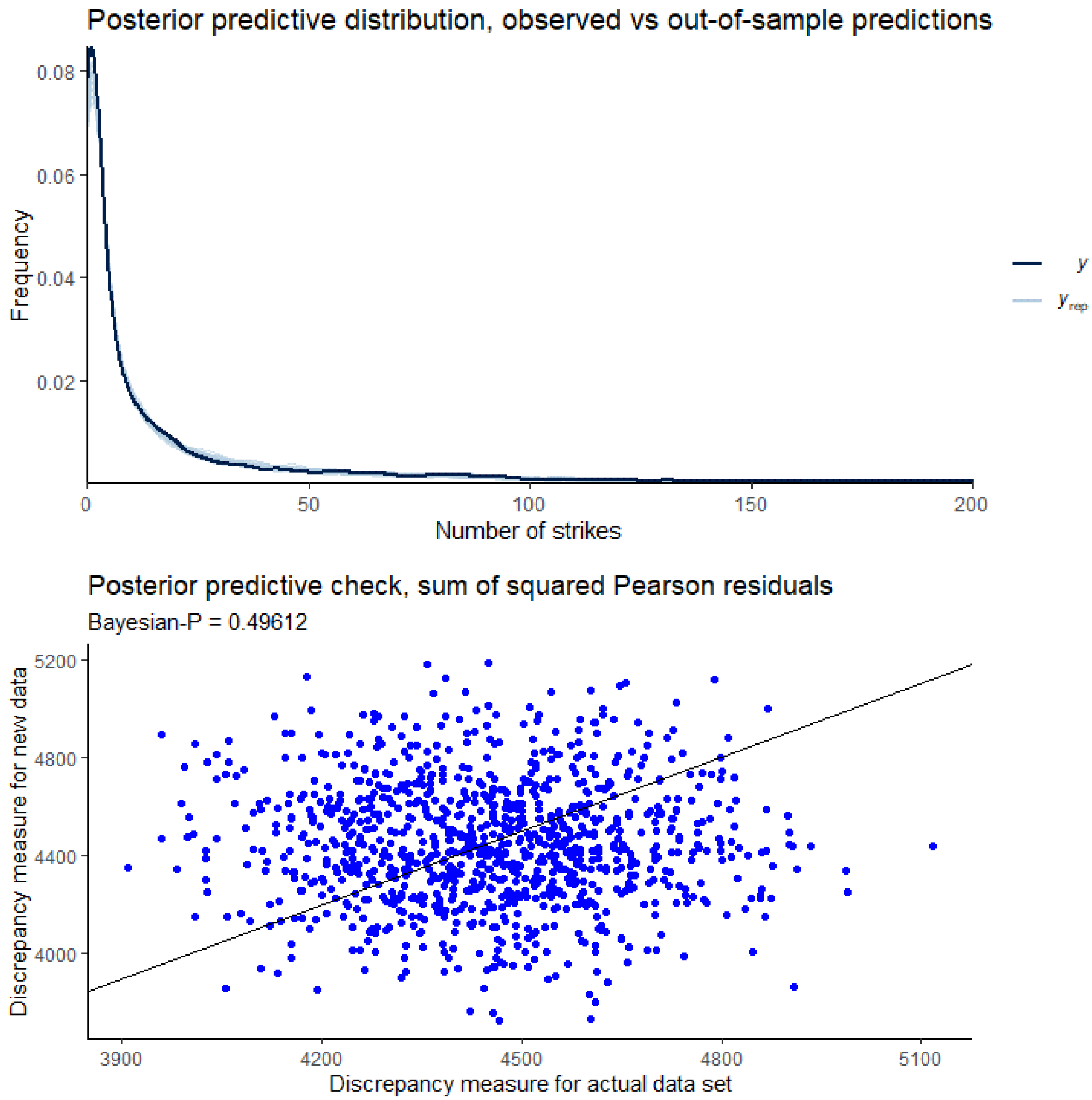

Figure 15. Posterior predictive plots for Bayesian model of the factors explaining variation in annual strike rate. A) frequency distribution of observed number of strikes per sample (y = black line) and out-of-sample predictions (y_{rep} = grey lines), with the degree of concordance between distributions indicating goodness of fit ; and B) scatter plot of a discrepancy measure (squared Pearson residuals) for observed data vs "new data" (out-of-sample predictions) generated by model: clustering of values around a 1:1 relationship (solid black line) indicates a well-fit model, as quantified by a Bayesian-P value near 0.5.

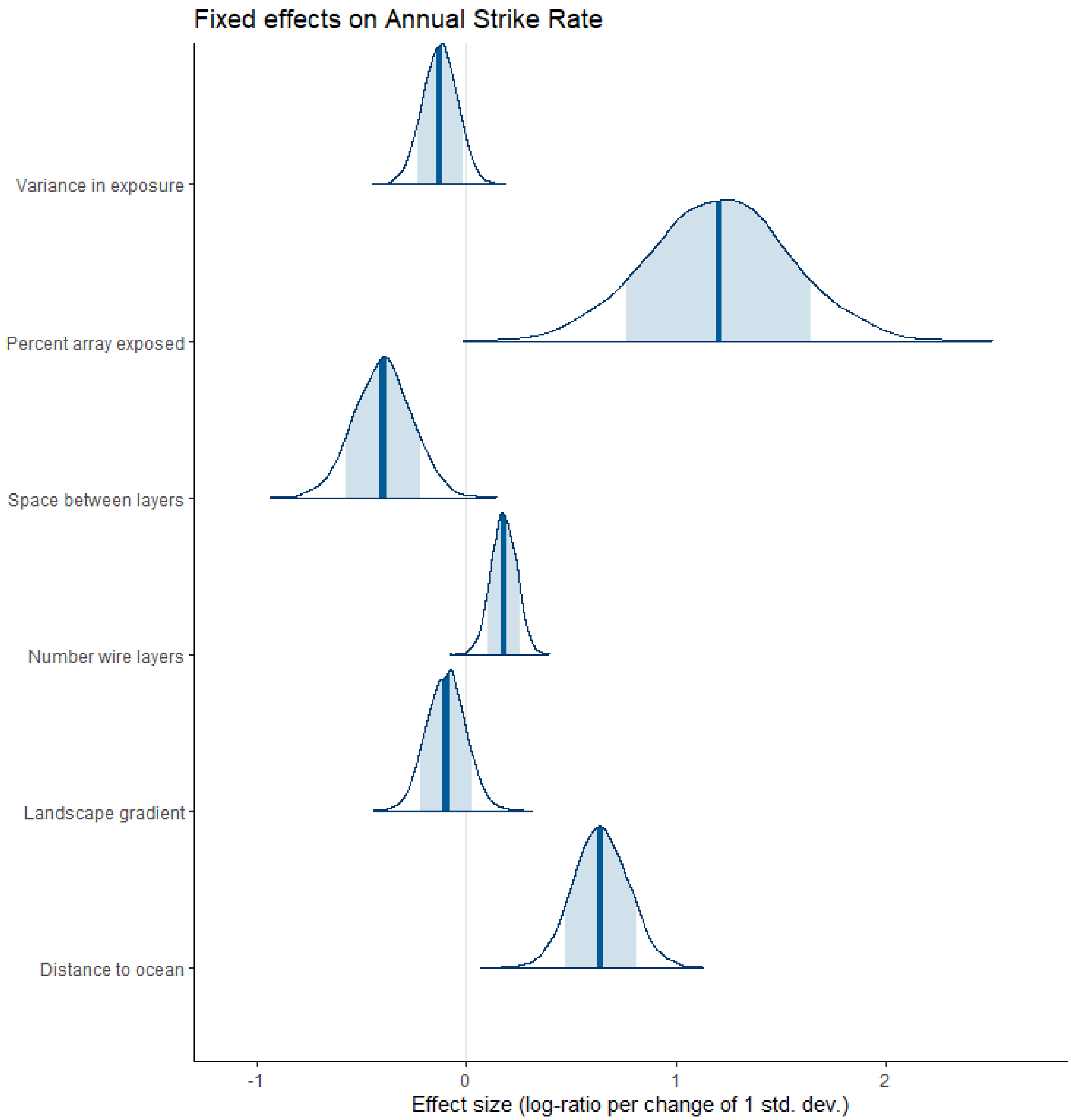

Figure 16. Posterior distributions for fixed-effect parameter estimates (β) from a Bayesian model examining the predictors of annual strike rate. The shaded area of each density distribution indicates the 90% CI, and the solid vertical line indicates the mean parameter estimate. An effect value of 0 indicates no effect of the predictor variable on annual strike rate, while values >0 indicate a positive relationship between the variable and strike rate.

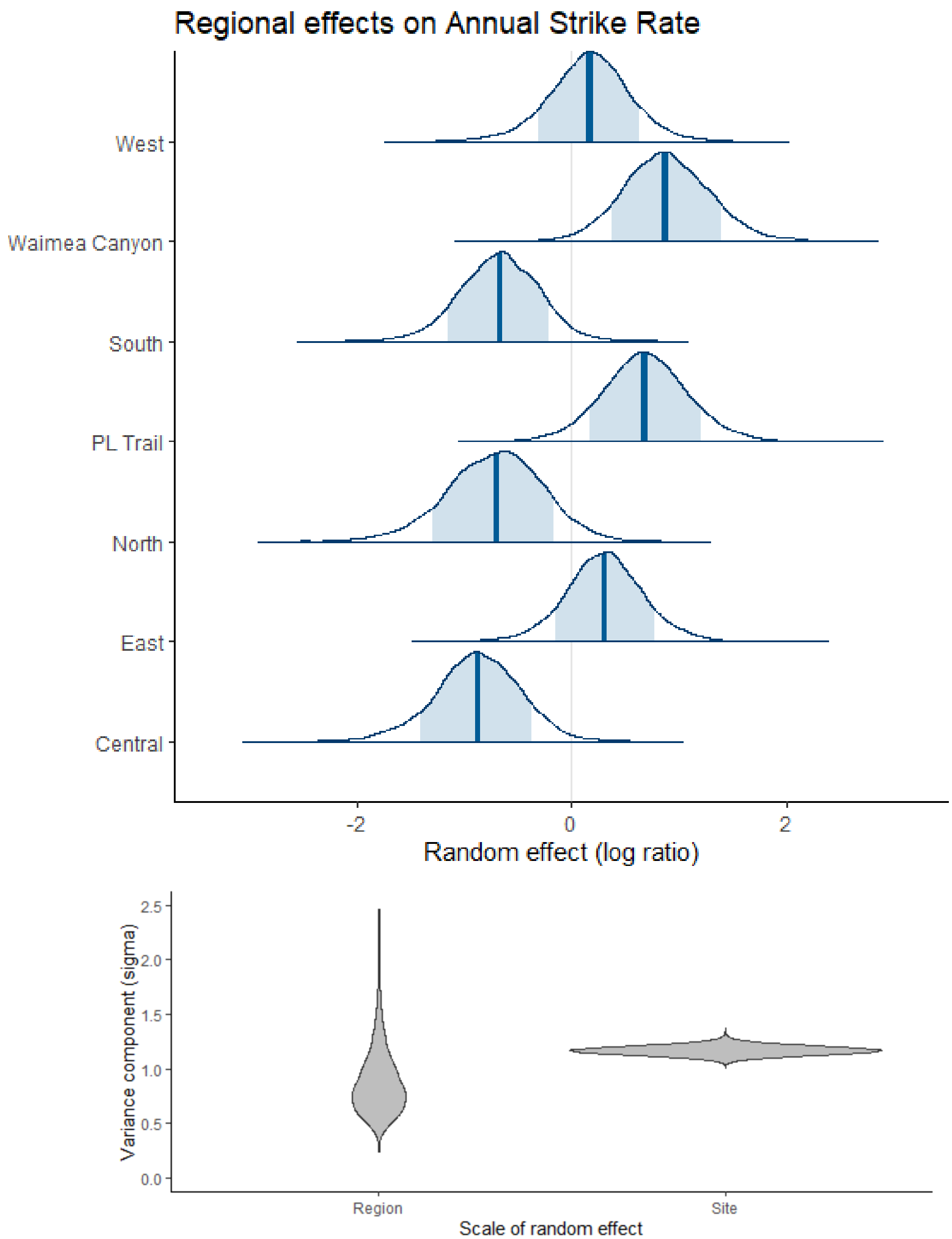

Figure 17. A) Posterior distributions of regional effects from a Bayesian model examining the predictors of annual strike rate. The shaded area of each density distribution indicates the 90% CI, and the solid vertical line indicates the mean parameter estimate. The vertical line (0) represents the average across all regions, while values >0 indicate a higher-than-average strike rate values for the indicated region. B) Violin plots showing the posterior distribution of estimated variance components (σ parameters) associated with unexplained differences among regions and unexplained differences among sites within regions.

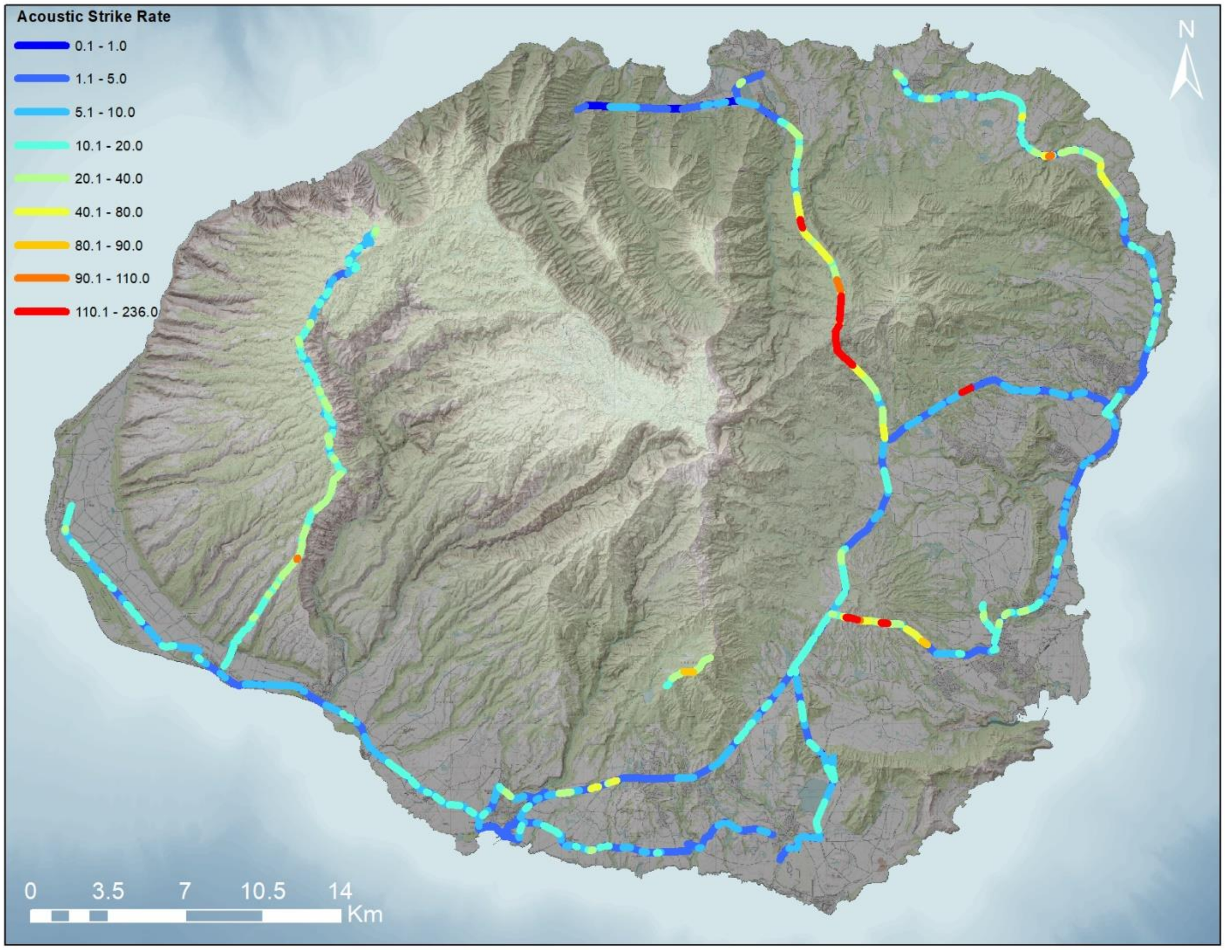

Figure 18. Map of Kauai showing the locations of all wire spans, color-coded to indicate the estimated annual number of bird strikes for each span.

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Appendix 5E

Population Dynamics Model for Newell’s Shearwater (‘a‘o) on Kaua‘i

The purpose of this appendix is to describe the population dynamics models developed by KIUC for Newell's shearwater (ʻaʻo). The population dynamics model for Hawaiian petrel (ʻuaʻu) is presented in Appendix 5F, *Population Dynamics Model for Hawaiian Petrel (ʻuaʻu) on Kauaʻi*.

A population dynamics model was not developed for band-rumped storm-petrel (ʻakēʻakē) because of the lack of data on this species.

The population dynamics models for Newell's shearwater (ʻaʻo) was developed for the following specific uses in the HCP:

1. To evaluate the effects of the requested take authorization of the species from KIUC's covered activities (described in Chapter 5, *Effects*) in the absence of any mitigation.
2. To quantify the benefits of the conservation measures proposed in Chapter 4, *Conservation Strategy*, to the Kauaʻi metapopulations of these species.
3. To determine the net effects of the HCP covered activities and conservation measures on the Kauaʻi metapopulation of this species and to quantify the net benefit provided by the HCP.
4. To track population trends during HCP implementation over the 50-year permit term.

This appendix is divided into four sections: (1) Overview of the model, including methods, initial conditions, technical specifications, and tables with model input values, (2) Model results, (3) A discussion of model limitations, uncertainties, and assumptions, and (4) References cited.

The appendix and population dynamics models were developed by John R. Brandon, PhD, Senior Biometrician at ICF with extensive review by David Zippin, PhD, Senior Conservation Biologist. Dr. Brandon designed the mathematics and code for the modeling framework. Model inputs were developed in close collaboration with André F. Raine, PhD, Science Director for Archipelago Research and Conservation (ARC) and Marc Travers, MS, Senior Scientist at ARC, both of whom are experts on seabird biology and lead scientists on multiple studies of endangered seabirds on Kauaʻi. Dr. Raine and Mr. Travers provided input and data for many of the model parameters as cited throughout the appendix.

5E.1 Overview of the Population Dynamics Models

The model for Newell's shearwater (ʻaʻo) is composed of 14 distinct subpopulations.[1] Each subpopulation corresponds to one of the 10 conservation sites proposed in the HCP, including four social attraction sites that are located within the HCP conservation sites at Honopū, Pōhākea, Upper Limahuli Preserve, and Site 10.[2] The 14 subpopulations are listed in Table 5E-1 and their locations illustrated in Figure 5E-1 (see Chapter 4, *Conservation Strategy*, and Appendix 4A, *Conservation Site Selection*, for a map and details of the 10 conservation sites).

[1] The term *subpopulation* is used here to distinguish between groups of individuals associated with breeding colonies located in different geographic areas of the island. Together, these subpopulations make up the Kauaʻi metapopulation.

[2] KIUC will select a tenth conservation site ("Site 10") but the final location of this site is still under evaluation. See Figure 4-6 for the general location of the site. The conservation benefits of Site 10 are based on the previously selected site that proved infeasible (Upper Mānoa Valley). KIUC will ensure that Site 10 will provide equal or greater benefits than the Upper Mānoa Valley site it is replacing.

Outside of the 10 conservation sites, the rest of Kauaʻi was subdivided into four regions that correspond to the known metapopulation distribution of the species (see Figure 1 in Appendix 3A, *Species Accounts*). Each area in the model encompasses a geographic portion of the island which has similar conservation threats and management efforts for the species, as well as similar available data sources for estimating the abundance and trend of breeding pairs which nest there (Table 5E-2).

The modeling framework allows each subpopulation to have its own set of vital rate values and therefore different trends in abundance through time. This reflects the fact that pressures such as powerline collisions and predation vary depending on region and topography. For example, the remote areas in the northwestern region of the island do not have powerlines (see Figure 5E-1). Available tagging data is consistent with the flyways of breeding colonies in those areas resulting in little to no vulnerability to powerline collisions (e.g., Raine et al. 2017a). For breeding colonies in northwestern Kauaʻi (including the conservation sites), where powerline collision vulnerability is low and predator control efforts have been effective, acoustic monitoring data has demonstrated increases in abundance since 2014–2015 (Raine et al. 2022a). The opposite is true in other areas of the island where breeding colonies are particularly vulnerable to powerline collisions and light attraction. Examples include those sites that have flyways crossing the Powerline Trail in the middle of the island, where collisions are known to be highest (Travers et al. 2020; also see Chapter 5, Figure 5-1 estimated relative rates of bird strikes per wire span).

Furthermore, available monitoring data also differs by each area. For example, radar survey data, which is the longest running systematic monitoring study for trends in relative abundance for this species, are only available from areas with road access (the radar system is mounted on a vehicle).

The spatially explicit model developed here serves to account for these differences and complexities in the overall metapopulation dynamics and allows for monitoring data (e.g., trends) from different areas to be incorporated in the model. The vital rates for each subpopulation are also modeled to change through time as future management efforts are implemented, corresponding to the timeline of these measures described in Chapter 4, *Conservation Strategy*. For example, increases in estimated powerline strike minimization efficacy are modeled through time to reduce powerline strike mortality rates. Similarly, the timing of installation of predator exclusion fencing around particular management sites are modeled to reduce predation mortality rates for the corresponding subpopulations at those sites in future years.

Island-based estimates of abundance for each subpopulation are used to initialize population trajectories, which are then projected forward in time through the 50-year permit term. For simplicity, the model does not assume any dispersal among the Kauaʻi subpopulations, except for immigration into the four social attraction sites (see Section 1.3, *Social Attraction Site Dynamics and Dispersal*, for details), which is reasonable because shearwaters and petrels exhibit strong natal philopatry[3] (e.g., Harris 1966; Perrins et al. 1973; Warham 1980) and established breeding pairs typically return to the same nesting burrow year after year. The model also does not assume any dispersal between Kauaʻi and other islands in Hawaiʻi.

[3] *Natal philopatry* is the tendency of an animal to return to breed in the place of its birth.

Table 5E-1. Modeled Subpopulations, HCP Status, and Associated HCP Management Actions.

Modeled Subpopulation	HCP Status	HCP Management Actions (see Chapter 4 for details)
Pihea[a]	Conservation site	Predator control[b] and partial pig fence
North Bog[a]	Conservation site	Predator control and partial pig fence
Pōhākea[a]	Conservation site	Predator control and partial pig fence (site excludes Pōhākea PF)
Pōhākea PF[c]	Conservation site with social attraction	Predator control, predator exclusion fence completed in 2022, encircling this subarea of the Pōhākea conservation site; social attraction
Hanakāpi‘ai	Conservation site	Predator control
Hanakoa	Conservation site	Predator control
Upper Limahuli Preserve[a]	Conservation site	Predator control and ungulate exclusion fencing, predator exclusion fence to be completed for a portion of the site in 2025; social attraction introduced in the same year
Conservation Site 10	Conservation site	Predator control, predator exclusion fence to be completed for a portion of the site in 2025; social attraction introduced in the same year
Honopū[a]	Conservation site	Predator control and ungulate fencing (site excludes Honopū PF)
Honopū PF	Conservation site with social attraction	Predator control, predator exclusion fenced completed in 2022, encircling this subarea of the Honopū conservation site, social attraction
Hanalei to Kekaha	N/A	None
Wainiha and Lumaha‘i Valleys	N/A	None
Kalalau east to Upper Mānoa (excluding conservation sites)	N/A	None
Nā Pali Coast	N/A	None
Waimea Canyon	N/A	None

[a] Ungulate (deer, pig and goat) exclusion or partial pig exclusion fence is already in place. Partial pig exclusion fences block pigs from accessible portions of a site’s perimeter.
[b] Predator control involves species specific efforts for ungulates, cats, rodents and barn owls.
[c] PF stands for predator exclusion fence. Construction of the predator exclusion fence at Honopū was completed in 2022.

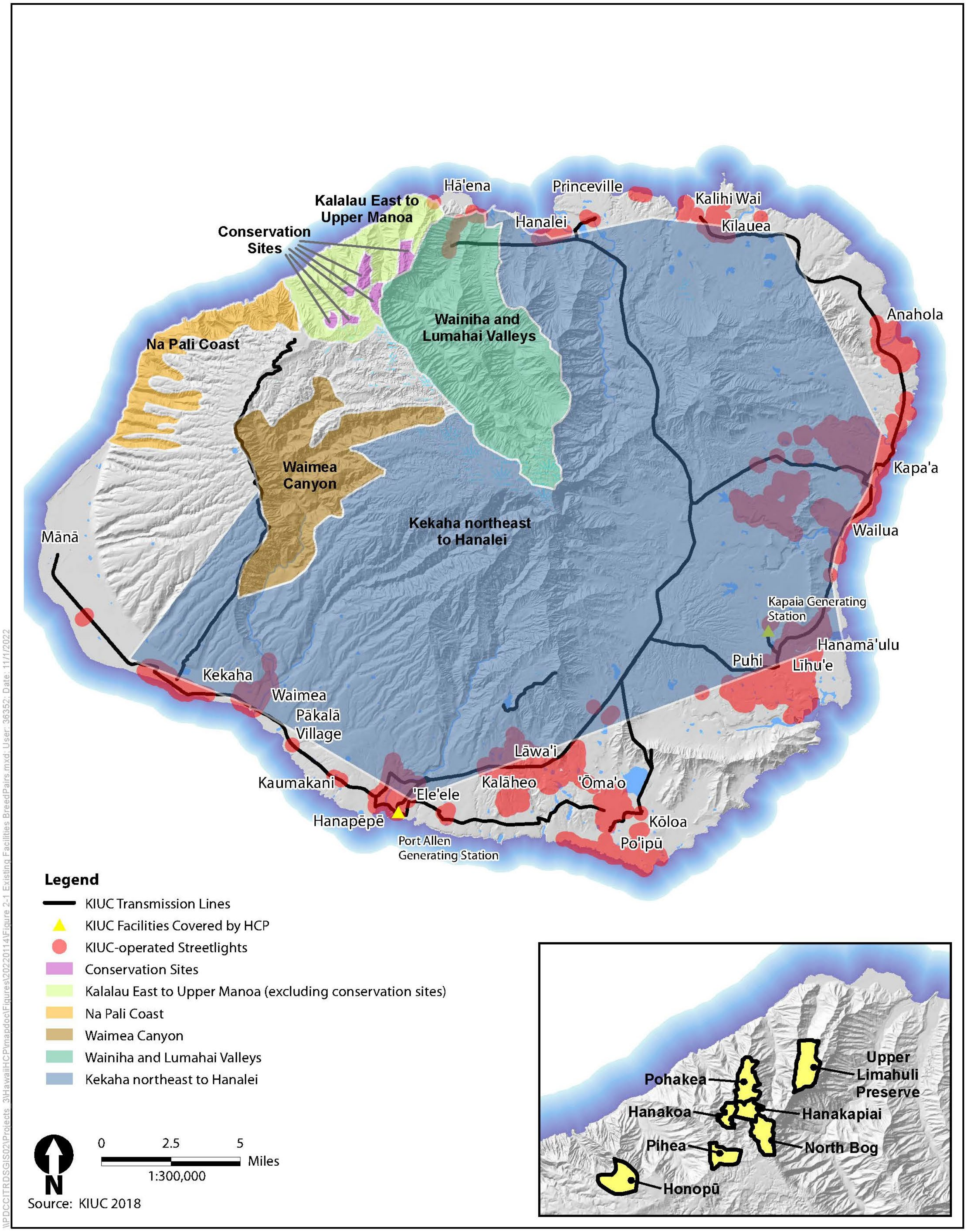

Figure 5E-1. Locations of Regional Subpopulations in Population Dynamics Models for Newell's Shearwater ('a'o) and Location of KIUC's Covered Facilities

5E.1.1 Initial Conditions

The initial conditions for the model were set in 2019, before projections forward in time from that year were carried out. Modeled reductions in powerline line mortality rates due to minimization efforts that are accounted for in the model start in 2020. Population trajectories for Newell's shearwater (ʻaʻo) were based on the following parameter categories, each of which is described below:

1. Estimates of **abundance** on Kauaʻi.
2. **Vital rates** by age class under optimal conditions (i.e., natural mortality and fertility rates in the absence of introduced predators and powerlines).
3. Estimates of **powerline injury and mortality**, prior to 2020 minimization efforts.
4. Estimates of **predation rates** with and without predator control measures.

5E.1.1.1 Estimates of Abundance on Kauaʻi

All population dynamics models must begin with an estimate of initial population size to forecast future abundance levels. The only published estimates of abundance of Newell's shearwater (ʻaʻo) come from transect surveys conducted on ships at sea. Because of the use of these estimates in previous studies, these at-sea population estimates and their limitations are summarized in the following subsection. This summary is followed by an explanation of the methods used for this HCP to develop a spatially explicit population estimate of Newell's shearwater (ʻaʻo) on Kauaʻi.

At-Sea Abundance Estimates

Seabird populations are often estimated using counts of birds observed at sea and calculations of what proportion of the total population may have been sampled. This technique is used because (1) a substantial fraction of seabirds remains at sea prior to reaching breeding age, and (2) at-sea surveys can enumerate populations which may have breeding colonies spread over different islands or geographic locations, and which can otherwise be difficult to locate and count on land during the breeding season. This is the case for Newell's shearwater (ʻaʻo), where nesting adults are nocturnal, and nests are located underground in densely vegetated and rugged, remote montane environments.

Neither of the available at-sea estimates were adopted for the HCP population dynamics models because they include serious spatial deficiencies in geographical survey coverage, leading to uncorrected sources of statistical bias. Further, at-sea estimates alone, even if they could be corrected for these biases, provide only a single population estimate for the entire island of Kauaʻi. An important innovation of the HCP population dynamics model is that it considers important spatial differences in mortality risk in different areas of Kauaʻi, as discussed below. The at-sea abundance estimates are briefly described here for context, however, because they have been used in previous population modeling studies.

The modeling studies of Ainley et al. (2001) and Griesemer and Holmes (2011) incorporated the at-sea abundance estimate of Newell's shearwater (ʻaʻo) from Spear et al. (1995) to form the basis for estimating mortality rates from light fallout. These earlier modeling studies did not project trajectories of absolute abundance based on the at-sea survey estimates. Rather, the modeled trajectories were based on a hypothetical relative abundance level of 1,000 Newell's shearwater

(ʻaʻo) in the first year of the population trajectories (e.g., Ainley et al. 2001:120; Griesemer and Holmes 2011:30).

Spear et al. (1995) estimated a total population size of 84,000 Newell's shearwater (ʻaʻo) based on shipboard observations between 1984 and 1993. Subsequently, Joyce (2016) analyzed shipboard observations from more recent surveys during 1998–2011 and calculated an at-sea total abundance estimate of 27,011. Vorsino (2016) adopted the Joyce (2016) at-sea estimate of abundance to forecast model trajectories of absolute abundance for Newell's shearwater (ʻaʻo) on Kauaʻi. In all three modeling studies that incorporated available at-sea abundance estimates (Ainley et al. 2001; Griesemer and Holmes 2011; Vorsino 2016), 90 percent of the total population of Newell's shearwaters (ʻaʻo) was assumed to be from Kauaʻi.

The authors of the at-sea estimates of abundance explicitly acknowledge that the resulting estimates of abundance are not comprehensive because available survey data does not encompass the entire at-sea range of either species (e.g., Joyce 2016:183). As Griesemer and Holmes (2011:16) note, "Repeating at-sea surveys or determining another method of population estimation is critical to recovery planning." Available estimates from at-sea surveys have limitations for several reasons.

- The at-sea range of Newell's shearwater (ʻaʻo) is incredibly large, and dedicated survey coverage of their at-sea range has not been undertaken in any systematic way. For example, the available at-sea data analyzed by Joyce (2016) comes from surveys with spatial coverage designed to estimate the abundance and distribution of cetaceans (whales and dolphins), and which did not survey areas north of the United States Exclusive Economic Zone around Hawaiʻi (an area from the shoreline to 200 nautical miles [370.4 kilometers] outside the islands), where chick provisioning (breeding adult) Newell's shearwater (ʻaʻo) have been observed through tagging (Joyce 2016:230). Likewise, more recent tagging data for this species are also consistent with the available at-sea survey effort covering only a fraction of the at-sea range of this species (Raine et al. 2020; ARC unpublished tagging data). Therefore, the at-sea estimates of abundance represent a fraction of total abundance.
- In order to take into account the spatial complexities of different pressures and conservation benefits in different areas of Kauaʻi, the at-sea abundance estimates would need to be partioned such that a proportion of the at-sea estimates (which represent the total at-sea population) could be assigned to each area of the island. In other words, what proportion of the at-sea estimates of abundance represents those birds associated with the conservation sites? Such assumptions would have a high degree of uncertainty, so it is preferable to use available survey data from the conservation sites themselves. Survey data at the conservation sites provide a more current and defensible estimate of covered seabird abundance than older at-sea estimates.
- At-sea estimates are compiled from survey data collected during different times of year, which further complicates interpretation because the at-sea range of Newell's shearwater (ʻaʻo) changes according to life stage and season (see Joyce 2016:230, which shows tag locations of chick provisioning adults generally north of Kauaʻi during the summer nesting season, and Raine et al. 2020:45, which shows at-sea locations of fledglings south of Kauaʻi, including south of the equator, during the late fall and early winter).
- There are no available correction factors to scale the at-sea abundance estimates to total abundance on Kauaʻi, which is necessary to incorporate estimates of powerline strike numbers, and the effects of powerline strike minimization on total abundance for the HCP population dynamics model. This is important because using an abundance estimate that only represents a

fraction of total population size would lead to negatively biased results in terms of forecasting future abundance levels given estimated strike numbers or trends from radar data.

- For example, if the abundance estimate from Joyce (2016) is assumed to pertain to the year 2004 (the approximate mid-year of the corresponding 1998–2011 at-sea survey period), where the number of Newell's shearwater (ʻaʻo) on Kauaʻi represent 90 percent of the estimated at-sea abundance, and a -13 percent annual rate of population decline is assumed (e.g., from Raine et al. 2017b), the forecasted abundance would be 4,571 total Newell's shearwater (ʻaʻo) on Kauaʻi in the year 2016. Given the assumptions made here about the mortality level associated with estimated powerline collisions (e.g., the proportion of powerline collisions resulting in mortality is 28.8%; Travers et al. 2021), the annual average number of Newell's shearwater (ʻaʻo) mortalities resulting from powerline collisions during 2013 to 2019 was 3,196. Applying this level of mortality to the projected 2016 abundance level based on the uncorrected at-sea survey estimate would result in an approximate -70% annual decline, which is inconsistent with long-term monitoring data.
- If a -6.9 percent rate of decline were assumed instead, from an updated analysis of trends including more recent years of radar survey data (Raine and Rossiter 2020), the model forecasted total population size on Kauaʻi from this at-sea abundance estimate would be 7,744 Newell's shearwater (ʻaʻo) in the year 2020. In either case, recent population sizes this low are not consistent with concurrent observational data from multiple sources, including: (1) Estimates of breeding pairs in the conservation sites (Raine et al. 2022a); (2) Estimated collisions and resulting mortality levels (Travers et al. 2020, 2021); and (3) Trends in relative abundance from the radar surveys, which would be expected to exhibit much more drastic rates of decline if the at-sea abundance estimates were not biased low due to incomplete survey coverage of the species at-sea range, and instead represented an accurate measure of true abundance, rather than an estimate of minimum abundance.

For all of these reasons we chose not to utilize at-sea population estimates. Instead, the population estimates used to initialize the model are based on different Kauaʻi-specific data sets, as described below.

Breeding Pair Population Estimates on Kauaʻi

Given the serious limitations of the at-sea abundance estimates, which miss a significant (but as of yet unquantified) proportion of the island's breeding population—and breeding colonies in different areas of Kauaʻi are not uniformly vulnerable to threats such as introduced predators, light fallout, or powerline strike mortalities—staff at ARC developed spatially explicit estimates of Newell's shearwater (ʻaʻo) breeding pair abundance on Kauaʻi for this HCP.

These estimates were adopted as the basis for calculating the initial model population size in the HCP population dynamics model. They also allow for a modeling approach that can help to address the fundamental question of whether localized conservation efforts (e.g., predator control, predator-proof fencing, or social attraction sites) in targeted breeding areas on Kauaʻi can result in a sufficient net benefit to offset future minimized powerline strike mortalities for the island-wide population (metapopulation) on Kauaʻi.

Breeding pair abundance in 2021 was estimated for each of the modeled subpopulations (Table 5E-2, Figure 5E-1). The approach used to estimate the number of breeding pairs differed between areas, dictated in part by the extent to which various data sources are available (or lacking) for each area.

In general, however, the breeding pair estimates developed by ARC are informed by acoustic call rate and nesting burrow monitoring studies, which have demonstrated a significant relationship between call rates and estimated densities of active nesting burrows (e.g., Raine et al. 2019). These acoustic call rates are used in combination with published habitat suitability models (Troy et al. 2014, 2017). To the extent possible, the most recently analyzed study data from 2021 have been used to inform the resulting breeding pair estimates.

For the two modeled areas of Kauaʻi that have the highest level of collisions (Hanalei to Kekaha and Waimea Canyon), preliminary model results indicated that ARC's estimates of breeding pairs for these areas were, in combination with the biological assumptions in the model, incompatible with the observed trends from the radar survey and the level of mortality from the average annual unminimized strike estimate during 2013–2019. In other words, preliminary model results for these two areas, when based on ARC's breeding pair estimates and the low modeled maximum population growth rate (i.e., resiliency) produced modeled subpopulation trends from unminimized powerline strike mortality rates that were much more negative (i.e., much greater projected declines) than any trends estimated from the radar survey since that systematic survey began collecting data in 1993.

Therefore, an alternative approach was used to calculate the breeding pair abundance necessary to sustain the rate of decline observed in the radar data (Raine et al. 2017b; Raine and Rossiter 2020), given the estimated average annual number of unminimized powerline collisions during 2013–2019 for these two areas (Travers et al. 2020). This approach to initialize the breeding pair abundance in the model for the Hanalei to Kekaha and Waimea Canyon areas is described in more detail under the area-specific descriptions of breeding pair abundance estimation process and background considerations for each modeled subpopulation below. Using estimated trends from radar data to initialize the model also integrates the effects of powerline collisions and light fallout prior to the HCP, to the extent available data allow, because the trend estimate is based on radar survey data starting in 1993.

Table 5E-2 provides a summary of the approach used for each modeled subpopulation as well as a relative comparison of mortality sources (the differences in mortality help explain why each subpopulation was modeled) and uncertainty in the estimate of abundance. Where certainty in abundance was moderate and habitat suitability modeling was used (i.e., Kalalau east to Upper Mānoa), nesting densities were extrapolated from other areas with available data, and expert opinion was used to derive density correction factors to account for lower expected nest densities in areas with higher levels of mortality (i.e., due to unmanaged predation outside the conservation sites).

Table 5E-2. Summary of Approach to Initial Population Estimate, Relative Mortality Levels by Source, and Data Availability by Modeled Subpopulation of Newell's Shearwater (ʻaʻo)

Modeled Subpopulation	Data Sources Used for Initial Population Estimate	Relative Population-Level Mortality by Source			Certainty in Abundance Estimate
		Powerlines	Light Attraction	Predation	
Conservation Sites (7)[a]	Habitat Suitability Model and auditory survey polygons (based on annual surveys)	Low	Low	Low	High

Modeled Subpopulation	Data Sources Used for Initial Population Estimate	Relative Population-Level Mortality by Source			Certainty in Abundance Estimate
		Powerlines	Light Attraction	Predation	
Nā Pali Coast	Song meters/regression analysis	Low	Low	Low	Moderate
Wainiha and Lumaha‘i Valleys	Habitat suitability model and auditory survey polygons	Low	Low	Moderate	Moderate
Kalalau east to Upper Mānoa	Habitat suitability model and cover ratios[b] calculated from auditory survey polygons in Wainiha and Lumaha‘i Valleys	Low	Low	Moderate	Moderate
Hanalei to Kekaha	Radar trend and strike estimate	**High**	Moderate	**High**	Low
Waimea Canyon	Radar trend and strike estimate	**High**	Moderate	Low	Low

[a] There are six existing conservation sites: (1) Upper Limahuli Preserve; (2) Pihea; (3) North Bog; (4) Pōhākea; (5) Hanakāpī‘ai; and (6) Hanakoa. Conservation Site 10 is discussed in Section 1 above.
[b] Cover ratios were used to extrapolate the fraction of suitable habitat used by nesting seabirds detected through acoustic surveys to areas without available acoustic survey data, before applying density correction factors to account for lower nesting densities in areas that have been more greatly affected by powerline strike, light attraction, and predation mortalities (Raine et al. 2019; Raine et al. 2022a.).

Hanalei to Kekaha

This area is most affected by powerline collisions, light attraction, and predation (e.g., Troy et al. 2014 and see Figure 5E-1). It is also the area of the island for which trends in relative abundance have been estimated through the long-term systematic radar survey since 1993 (e.g., Day and Cooper 1995; Raine et al. 2017b). Thirteen radar sites have been surveyed since 1993 in the Hanalei to Kekaha area. Two additional radar sites have also been surveyed in Wainiha and Lumaha‘i Valleys starting in 2006, where trends have been stable (Raine and Rossiter 2020; see below for details).

The radar survey on Kaua‘i represents the longest systematic monitoring study of trends in abundance for this species anywhere. Raine et al. (2017b) estimated the average rate of decline in Newell's shearwater (‘a‘o) abundance, between 1993 and 2013, across all radar sites in the Hanalei to Kekaha area at approximately -13 percent per year. Since that study, Raine and Rossiter (2020) present the most recent estimates for the long-term subpopulation trend for this area. When averaged across all radar sites in this area, the more recent estimate of the average annual rate of decline is -6.9 percent per year during 1993–2020. During those three decades, the most extreme rate of decline for any of the 13 individual radar sites in this area has been estimated at the Hanalei radar site. The trend in relative abundance from that radar site is -10.7 percent per year during 1993–2020.

As noted above, the total breeding pair estimates developed by ARC for Hanalei to Kekaha were found through preliminary modeling results to be incompatible with the estimated number of powerline collisions, associated mortalities, and the most negative trend estimated from radar survey data. Given the biological assumptions in the model, this combination of factors, as initially explored (i.e., relatively small abundance relative to the magnitude of powerline collision mortalities for a species with low maximum rates of modeled population growth) led to resulting modeled rates of decline that were much greater than any trends that have been observed through the radar surveys in this area, or elsewhere on Kaua'i.

To correct this inconsistency, an alternative approach to initializing abundance for the Hanalei to Kekaha area was developed so that the model would match both the magnitude of powerline collisions estimated from acoustic monitoring and trends in abundance estimated from the long-term systematic radar surveys. This approach was also applied to the Waimea Canyon area, which ran into similar compatibility issues between estimates, given the relatively large number of unminimized collisions in that area.

The initialization approach for Hanalei to Kekaha and for Waimea Canyon involved solving for the combination of (1) abundance at age, and (2) the subadult and adult powerline mortality rates that result in the estimated number of collision mortalities, while matching the -10.7 percent rate of decline estimated from the radar survey at the Hanalei radar site (a worst-case recent trend). The solutions for abundance and powerline mortality rates at age were found using non-linear numerical optimization (a penalized maximum likelihood approach) as implemented in the Stan programming language using the *cmdstanr* package (Stan Development Team 2022; Gabry and Češnovar 2022). The specific penalties used to fit the model were as follows.

1. The Bayes acoustic estimate of powerline strikes was assumed to follow a log-normal distribution with a mean in log-space corresponding to the strike allocation for this area (described below), and a coefficient of variation assumed to be 0.001, which ensures the resulting modeled number of strikes matches the mean of the reported estimate.
2. The trend from the radar data was modeled as a normally distributed random variable with a coefficient of variation of 0.01, which again ensured the resulting modeled trend matched the point estimate for the rate of decline.
3. The proportion of powerline collision mortalities that were subadult was assumed to follow a *Beta*(11, 3) probability distribution, which corresponds to the sample of 14 downed Newell's shearwater ('a'o) examined and categorized as 11 subadults and 3 adults by Cooper and Day (1998), i.e., the expected proportional age-class split for powerline collision mortalities was 79 percent subadult and 21 percent adult.

The estimate of powerline collisions is an annual average during 2013–2019. It was assumed that this estimate pertained to 2016, the midpoint year of the acoustic monitoring data analyzed by Travers et al. (2020). In an analogous example, this approach to estimating abundance is the same as solving a problem where one wants to calculate the amount of money in a stock market account 1 year earlier. If one knows the rate of decline in the market from one year to the next was -10 percent, and the account lost $10 last year, there must have been $100 in the account before the loss.

The resulting abundance at age from this approach was then projected forward from 2016, under the assumption of a stable age distribution at the -10.7 percent rate of decline, through 2019, after which time the initial unminimized powerline mortality rates at age were reduced each year according to the modeled minimization schedule under the HCP.

Estimates for the number of annual powerline collisions are not available prior to 2013. However, incorporating estimated trends from radar data to initialize the model integrates the effects of powerline collisions and other sources of mortality prior to 2013, to the extent available data allow, because the radar trend is based on observations starting in 1993.

Upper Limahuli Preserve, Conservation Site 10, Pihea, North Bog, Pōhākea, Honopū, Hanakāpi'ai, and Hanakoa)

This conservation sites have the highest level of management (mainly predator control) and are in northwest Kaua'i away from most powerlines and light sources (Figure 5E-1). The Upper Limahuli Preserve, Conservation Site 10, and North Bog conservation sites are close to the towns of Hā'ena and Wainiha and thus closer to powerlines and light sources. There is one streetlight at Hā'ena Beach Park that is approximately 0.4 mile north of the Upper Limahuli Preserve; however, all lights and powerlines are located over 1 mile to the east. The remaining four conservation sites in the Hono O Nā Pali Natural Area Reserve are west of the Upper Limahuli Preserve, Conservation Site 10, and North Bog conservation sites, over 3 miles from the nearest powerlines or light sources to the east.

The covered seabirds in this area are expected to be affected the least of any area by all stressors (Table 5E-2). This area also has the best available data (e.g., annual auditory surveys, extensive burrow searches) for abundance estimates based on annual surveys (e.g., Raine et al. 2019, 2022a). Breeding pair estimates have been conducted on an individual basis for the conservation sites and have been presented previously in annual seabird monitoring reports (e.g., Archipelago Research and Conservation 2021; Raine et al. 2022b).

In 2017, the first estimates of breeding pair abundance were produced at all monitored management areas using two independent methods: (1) a habitat suitability model, which utilized the peer-reviewed models presented in Troy et al. (2014, 2017) where suitable habitat ranked 7+ and an average nearest neighbor distance was used from known burrows at monitored colonies to model nesting density; and (2) a regression analysis of acoustic monitoring data, which provides an estimate of active burrows (i.e., breeding pairs) as a function of call detections, given previous studies comparing paired visual and acoustic data in the same nesting areas. Based on the outputs of the two models, it was decided that the habitat suitability model was the most appropriate way of providing population estimates and that the acoustic method would need to be further refined before it could be used for this metric (e.g., Raine et al. 2019). For these sites, habitat suitability modeling (Troy et al. 2014, 2017) is also employed for portions of the conservation sites outside the acoustic arrays, using the estimated nearest neighbor distances between active burrows (i.e., burrow densities) to predict breeding pair numbers outside the acoustic array footprint.

The habitat suitability model was updated in 2021 by including new polygons from auditory surveys undertaken in 2021 and total surface area to take into account vertical space such as drainages and cliff walls. Two population estimates were then created for each site: (i) a low population estimate using only polygons related to "hot spot heavy" or "ground calling activity," and (ii) a high population estimate using *all polygons* collected during auditory surveys. In areas where suitable nesting habitat overlapped between Newell's shearwater ('a'o) and Hawaiian petrel ('ua'u) (i.e., where the habitat is suitable for nesting for either species), the habitat was partitioned between species to prevent double counting of available nesting habitat.

The breeding pair abundance in 2021 in the population dynamics model is equal to the lower of the two estimated values for all areas except for Hanalei to Kekaha and Waimea Canyon, where the approach to estimating initial abundance is described in the respective area descriptions.

Kalalau East to Upper Mānoa

This area is in the northwest of Kauaʻi away from most powerlines and light attraction issues. However, this area is unmanaged and thus more heavily affected by predators than adjacent conservation sites. Like Hanalei to Kekaha, the Troy et al. (2014, 2017) habitat suitability model was used to estimate breeding pairs in this area, but only included suitable habitat ranked at 8+ (i.e., suitable habitat ranked lower than 8 was assumed to contain zero breeding pairs). The modeled suitable habitat was also further reduced by an elevation cut-off, such that suitable habitat below 1,922 feet (585.9 meters) above sea level for Newell's shearwater (ʻaʻo) was assumed to contain zero breeding pairs. As this area is largely unsurveyed, a cover ratio was applied. The cover ratio used was the same ratio calculated for Lumahaʻi (see *Wainiha and Lumahaʻi Valleys*). To calculate estimated densities of active nests, the average nearest neighbor distance from burrows in Upper Limahuli Preserve was multiplied by 1.5, to account for active nests being more dispersed in unmanaged areas.

Nā Pali Coast

This area is in northwest Kauaʻi far from powerlines and light attraction sources. The entire subpopulation is within steep, north-trending valleys. As a result, foraging breeding adults and fledglings are expected to exit and enter the region almost entirely towards the ocean. While this area is largely unmanaged, the seabirds breeding here nest on nearly vertical cliffs several thousand feet high and are thus assumed to be much less affected by predators than other unmanaged sites. The current breeding pair estimate for the Nā Pali Coast is based on call rate data collected from 15 song meters deployed in this area in 2020, and a regression fit between call rates and active nests, to predict the number of breeding pairs (Raine et al. 2019). There is a strong statistically significant relationship between call rate and the number of active burrows located around acoustic sensors (Raine et al. 2019).

Waimea Canyon

This area is in the center of Kauaʻi, but it is affected by powerline collisions and light attraction. While this area is largely unmanaged, like the Nā Pali Coast area the birds breeding here nest on near-vertical cliff walls and are thus assumed to be less affected by predators than other unmanaged sites. Initial modeled abundance for this area was calculated using the same approach described above for the Hanalei to Kekaha area, except that the modeled rate of decline was assumed equal to the average estimated across all radar sites in the Hanalei to Kekaha area (-6.9 percent per year).

Wainiha and Lumahaʻi Valleys

This area encompasses two of the largest valleys on Kauaʻi with breeding Newell's shearwater (ʻaʻo). While affected to some degree by powerlines and light attraction, radar data has shown no trend since monitoring began in 2006 (e.g., Raine and Rossiter 2020) and tracking data shows that birds transiting over this area are predominantly higher than powerlines (Raine et al. 2017a). There is no predator management in this area, but in order to match the stable radar trend since 2006, it was assumed that predation rates were equal to those modeled in the Waimea Canyon and Nā Pali Coast areas (i.e., that birds in these valleys have been confined to very steep and less accessible habitat and have reduced predation rates).

Auditory surveys were conducted in portions of Lumahaʻi Valley in 2020, and the corresponding call rate data was combined with survey data in both valleys in 2012–2014 and used after filtering out any call rates that did not meet the "heavy" and "ground calling" criteria (e.g., Raine et al. 2020). This approach excluded any breeding pairs associated with low-density nesting areas. Like other areas, habitat suitability modeling was also incorporated, and the breeding pair estimate for Wainiha and Lumahaʻi Valleys only included suitable habitat ranked at 8+ (i.e., suitable habitat ranked lower than 8 was assumed to contain zero breeding pairs). For areas within each valley that were not surveyed a cover ratio was applied. This was created by considering all areas within each site where auditory surveys were undertaken, drawing an 0.6-mile (1-kilometer) radius around each survey point, and creating a cover ratio within that survey radius of seabird activity polygons (heavy and ground calling) to suitable habitat. The cover ratio was then extrapolated to unsurveyed areas. The modeled suitable habitat was also further reduced by an elevation cut-off, such that suitable habitat below 1,922 feet (585.9 meters) above sea level for Newell's shearwater (ʻaʻo) was assumed to contain zero breeding pairs. The estimated densities of active nests were multiplied by 1.5, which reduced the breeding pair estimate, to account for active nests being more dispersed in unmanaged areas.

Social Attraction Sites

Several social attraction sites are also included in the population dynamics model, including at: Pōhākea, Conservation Site 10, Upper Limahuli, Honopū, and Kahuamaʻa. These sites are assumed to start from zero birds in the first year of operation and are mentioned here for completeness in terms of listing modeled subpopulations. The modeling assumptions for social attraction sites are described in detail under Section 1.3, *Social Attraction Site Dynamics and Dispersal*.

Table 5E-3. Abundance Estimates (males and females combined) of Newell's Shearwater (ʻaʻo) on Kauaʻi in 2021 by Subpopulation and Age Class

Subpopulation (see Figure 5E-1 for locations)	2021 Breeding Adults (ages 6+)[a]	2021 Subadults (ages 1–5)[b]	2021 Total Abundance (ages 1+)	Fraction of Total Powerline Strikes[c]	2016 Powerline Mortalities (all ages) per 100 breeding adults in 2020
Pihead	< 2	< 1	< 2	2×10^{-6}	0.5
North Bog	133	76	209	0.0013	2.5
Pōhākea[e]	579	330	909	0.0015	1.0
Hanakāpiʻai	152	87	239	0.0007	1.0
Hanakoa	89	51	140	0.0001	0.5
Upper Limahuli Preserve[e]	996	568	1,564	0.0077	2.5
Conservation Site 10[e]	397	226	623	0.0024	2.5
Honopū[e]	180	103	283	0.0003	0.5
Wainiha and Lumahaʻi Valleys	4,698	2,677	7,375	0.0221	1.5
Hanalei to Kekaha	13,538	8,368	21,906	0.8604	20.3
Kalalau east to Upper Mānoa[f]	1,642	936	2,578	0.0077	1.5
Nā Pali Coast	818	466	1,284	0.0013	0.5
Waimea Canyon	1,971	1,426	3,343	0.0945	15.3
Total Kauaʻi abundance	**25,140**	**15,314**	**40,454**		

[a] Values for breeding adults correspond with the minimum theoretical estimate of abundance based on several alternative data sources, methods for estimation, including a partioning of suitable nesting habitat between Newell's

shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu), and expert opinion (e.g. Raine et al. 2019; Raine et al. 2022a). Estimates for all conservation sites with established subpopulations (first 8 rows) were derived in 2021. Estimates of unmanaged subpopulations (last 4 rows) are derived from the habitat suitability analysis of Troy et al. (2014) restricted to 1,922 feet (585.6 meters) above sea level and above (the lowest elevation in managed colonies with a known burrow) correcting for the more dispersed nature of unmanaged colonies as compared to managed colonies.

[b] Except for the Hanalei to Kekaha and Waimea areas, the initial number of subadults was derived under the assumption that subadults comprise 36.3 percent of the age 1+ (non-chick) component of the population (Ainley et al. 2001). This assumption is quite close to the numerical solution for the proportion in a stable age distribution for the first two areas, which is a function of the high fledgling natural mortality rate assumed, as well as the high proportion of powerline mortalities that are assumed to be subadults in the model.

[c] Spatial patterns in the acoustic collision detection data from powerline collision monitoring and rationale for the modeled strike allocation is described in more detail below.

[d] The Pihea conservation site is aimed at protecting Hawaiian petrel (ʻuaʻu). The amount of suitable nesting habitat for Newell's shearwater (ʻaʻo) is more limited there than at other sites. Due to the limited amount of suitable nesting habitat, the estimated number of existing breeding pairs is between zero and one.

[e] The social attraction sites at Pōhākea, Upper Limahuli Preserve, Conservation Site 10, and Honopū have initial starting populations of zero so are not listed (see Table 5E-7).

[f] The area from Kalalau east to Upper Mānoa Valley excluding conservation sites.

5E.1.1.2 Vital Rates under Optimal Conditions

A critical set of assumptions used in the KIUC HCP population dynamics model relate to the vital rates of the target species. *Vital rates* for any population dynamics model dictate population trajectories in the absence of any external factors, also referred to here as *optimal conditions*. Estimated reductions in vital rates relative to optimal conditions allow the modeling of expected impacts on population dynamics from combined threats (e.g., mortalities due to introduced predators and powerline collisions). Likewise, the estimated effects of conservation measures on vital rates allow the modeling of expected benefits of mitigation and minimization measures. Vital rates for this model include the following.

- Survival from one age class to the next age class
- The age at first reproduction (also termed the "adult" age)
- The annual breeding probability for adults (expressed as a fraction of adult birds that breed each year)
- The reproductive success rate (i.e., the fraction of eggs laid by adults that survive to emerge from the nest as fledglings)

During the last decade, burrow monitoring and other studies have led to a substantial increase in available species-specific estimates of endangered seabird vital rates on Kauaʻi (e.g., Raine et al. 2020, 2022a; Archipelago Research and Conservation 2021). Likewise, advances in powerline monitoring methods have resulted in estimates of powerline strike numbers, resulting mortalities, and locations (e.g., Travers et al. 2020, 2021). In addition to recent estimates of vital rates related to reproduction and recruitment from burrow monitoring studies, acoustic monitoring of call rates and satellite tagging studies also provide information on trends in abundance and relative vulnerability to powerline collisions for breeding colonies in conservation sites in northwestern Kauaʻi. These newly available estimates serve to inform the biological assumptions of the KIUC HCP population dynamics model.

However, even with the improved estimates of vital rates and additional information on trends in abundance that recent monitoring efforts provide, there remains a high level of uncertainty for many of the biological assumptions that are input parameters for the population dynamics model. For example, the most recently reported estimate of the number of seabird powerline strikes from the Bayesian analysis of acoustic strike monitoring data collected between 2013 and 2019 has a 95 percent posterior predictive probability interval of 4,417–56,903 strikes per year (Travers et al. 2020). Moreover, in some instances, the parameter values adopted for this set of biological assumptions may be based wholly, or in part, upon expert opinion, and therefore confidence intervals cannot be calculated. Despite these limitations, the biological assumptions described in this appendix represent the best available scientific data, which is the regulatory standard for HCPs under the federal Endangered Species Act and Hawai’i Endangered Species Act.

The optimal rate of population growth is related to (but might be less than) the intrinsic rate of growth of the population, which is the maximum expected exponential growth rate that populations can achieve in the absence of density dependent competition for resources, and decreases in vital rates through anthropogenic effects and invasive predators (e.g., Caughley 1977). The optimal rate of population growth is a key parameter in conservation risk assessments and management strategy evaluations (e.g., Niel and Leberton 2005). However, the optimal population growth rate is also a difficult parameter to estimate, especially for species without long-term surveys of abundance to monitor the rate of recovery from low population levels. At present, no empirical estimate exists for the optimal rate of population growth for Newell’s shearwater (‘a‘o).

Given the biological assumptions for the vital rates of this model, the resulting optimal rate of modeled population growth (i.e., in the absence of introduced predators, powerline strike or light fallout mortality) is 2.36 percent per year. This is similar to the optimal rate of population growth modeled by Griesemer and Holmes (2011:30), which was 2.3 percent per year.

In practice, however, the optimal rate of population growth is never achieved in the KIUC model, because even for those sites with predator-proof fences, birds are still assumed to be vulnerable to powerline strike mortalities (E-15at relatively low levels, given these sites are in northwestern Kaua‘i) as well as aerial predation by introduced barn owls. The highest rate of modeled population growth in the KIUC model is achieved at the Honopū PF site. This site has a relatively low powerline strike mortality rate in the model (0.5 unminimized powerline mortalities per 100 breeding adults), due to its remote geographic location on the Nā Pali Coast, and predation rates other than barn owls are assumed to be zero. Ignoring immigration of existing birds from other areas due to social attraction at this site, the underlying modeled population growth rate is 2.03 percent per year at Honopū PF.

The optimal rate of population growth in a population dynamics model is a function of the optimal input values for the vital rates. All else being equal, higher optimal input values for survival or reproductive rates (or lower age at reproduction) result in higher values of optimal population growth rates and vice versa (e.g., Caswell 2001). The biological assumptions for the individual component life history values in the model are as follows.

Fledgling Survival Rates

Fledgling (age 1) survival rates and subsequent survival rates to breeding age were derived from the satellite tagging study reported by Raine et al. (2020). In that study, 12 Newell’s shearwater (‘a‘o) fledglings were tracked at sea. From the tag signals it was possible to estimate if a fledgling died at sea (i.e., the tag stopped reporting movements in a manner that indicated it had not simply fallen off). Based on the observations of tagged fledglings, only 25 percent of tagged fledglings survived their first month at sea, suggesting that this percentage or lower would reach breeding age (Raine et al. 2020). Therefore, the fledgling survival rate assumed in the model was set such that, in combination with the assumed subadult survival rate, 25 percent of fledglings in the model (under near optimal conditions) would reach breeding age. Combined with the subadult survival rates at age described below, this assumption yields a fledgling survival rate of 0.371 (i.e., survival from age 1 to age 2). Accounting for fallout from light attraction further reduces the fledgling survival rate in the Hanalei to Kekaha area of the model (Section 3.1, *Conservative Assumptions*). The estimated level of fallout includes correction factors for the proportion of grounded seabirds that go undetected, e.g., for KIUC streetlights, 89.6% of grounded Newell's shearwater ('a'o) are assumed to go undetected (Appendix 5C: *Light Attraction Modeling*). Fallout, whether detected or not, is assumed to result in 100% mortality in the model.

Subadult and Adult Survival Rates

There are no available empirical estimates of adult survival rates for Newell's shearwater ('a'o). Instead, adult survival rates were based on multiple studies undertaken on the similar Manx shearwater (Harris 1966; Perrins et al. 1973; Brooke 1977) and were set to 0.924. Subadult survival rates (ages 2–5 years) were set equal to the adult survival rate, which is consistent with a life history punctuated by very high first year at-sea mortality rates for fledglings, followed by relatively low natural mortality rates for subadults and adults. The exact values for subadult survival rates at age are uncertain, in part because subadults may spend several years at sea, making conventional approaches for estimating survival rates, like mark-recapture, impracticable. The values for subadult survival rates at age assumed in the model are consistent with the Raine et al. (2020) satellite tagging study on Kaua'i described above in *Fledgling Survival Rates* and result in 25 percent of modeled fledglings reaching breeding age (age 6) under near optimal conditions.

Age at First Breeding

Like previous modeling studies, the age at first breeding was assumed to occur at 6 years (Ainley et al. 2001; Griesemer and Holmes 2011; Vorsino 2016).

Reproductive Success Rate

The reproductive success rate (RS) in the model measures the fraction of eggs that develop into a chick that survives to fledge. This is consistent with how reproductive success rates have been defined in the burrow monitoring study data. Reproductive success rates have been estimated from burrow monitoring studies at the conservation sites, both before (RS = 0.558) and after (RS = 0.872) dedicated predator mitigation measures. The RS rate at the conservation sites is taken from 3-year average value estimated across sites during 2019–2021 (e.g., Archipelago Research and Conservation 2021; Raine et al. 2022a). As a conservative assumption, this observed value was further reduced to account for observations of seabird bycatch in predator traps (n = 34 since 2016; Hallux unpublished data). Dividing the number caught in predator traps by estimated breeding age abundance at the conservation sites, the observed RS was reduced to 0.867. For areas in the model without predator mitigation, the reproductive success rate is assumed to be equal to that estimated at the conservation sites prior to dedicated mitigation measures. An adjustment was made for the Nā Pali Coast and Waimea areas, given that nests in these areas are confined to very steep and inaccessible cliff sides. Following the assumption that predation mortality rates in these two areas are 25 percent of those in unmanaged areas, due to the nests in these areas being confined to vertical high cliffsides largely inaccessible to mammalian predators (see also *Predation Rates*), it was also assumed that the reproductive success rate in these two areas is 25 percent greater than in unmanaged areas (RS = 0.698).

The RS rates in areas with predator-proof fences were based on the estimated RS rates at the conservation sites following dedicated predator mitigation, with an upward percentage adjustment corresponding to observed predation rates on nests without predator proof fences, which were 0.0023 for adults and 0.02 for chicks (Raine et al. 2022a; Raine unpublished data). This resulted in a modeled RS rate inside predator-proof fences of 0.891, or a 2.2 percent increase compared to the estimated RS rate from burrow monitoring studies at the conservation sites.

An additional area-specific adjustment was made to the RS values to account for powerline collisions that result in injury but not mortality and might cause breeding individuals to be unable to fledge a chick successfully (e.g., due to an inability to forage effectively that season). Following the observations of Travers et al. (2021), 24.5 percent of powerline collisions were assumed to result in non-lethal injury. These were individuals with post-collision elevation loss that were not assigned to immediate grounding mortality or short-term grounding mortality (within 3,609 feet [1,100 meters] of wires). The observed elevation loss of these birds not assigned as grounded/mortality, was used as a proxy for injury. The elevation loss indicates the collision was more severe or affected the bird more than those that flew off without elevation loss.

Future powerline collision levels, and their non-lethal effects, were derived from the powerline mortality rate calculations described below, under the assumption that mortalities were 28.8 percent of all collisions. The derived number of collisions was then multiplied by 24.5 percent to calculate the associated number of collisions resulting in non-lethal injuries. This number was multiplied by 21.4 percent to account for the proportion of collisions that are expected to be breeding adults (Cooper and Day 1998). And the resulting number of collisions resulting in non-lethal injuries of breeding age birds was divided by the number of breeding birds in an area each year, and used as a percentage reduction in reproductive success rate in that area that year.

Breeding Probability

Breeding probability is the percentage of adults (age 6 or older) that breed each year. This probability has been estimated through long-term studies of active breeders at the conservation sites and is 0.993 for Newell's shearwater (ʻaʻo) (Raine et al. 2022b). The breeding probability value is assumed to be constant across all geographic areas and through time in the model.

5E.1.1.3 Powerline Mortality

The powerline mortality rate for each area i with no minimization was calculated for subadults and adults by dividing the proportion of unminimized powerline mortalities for each age class by the corresponding estimates of abundance for that area.

$$\psi_{a,i}^{sa} = \frac{p_i \Omega \rho \nu \pi_{sa}}{\sum_{a=3}^{5} \hat{N}_{a,i}^{sa}}$$

(Equation 1)

$$\psi_{6+,i} = \frac{p_i \Omega \rho \nu (1 - \pi_{sa})}{\widehat{N}_{6+,i}}$$

Where:

- $\psi_{a,i}^{sa}$ and $\psi_{6+,i}$ are the annual powerline mortality rates for subadults, ages 3–5 years, and adults (ages 6 years and older; Figure 5E-2) in area *i* prior to any minimization (i.e., unminimized). In the context of powerline strikes, subadults refer to ages 3–5 years because ages 1 and 2 are assumed to be at sea and are not vulnerable to powerline strikes in the model (Equation 3). The powerline mortality rates are assumed to be equal for subadults of each vulnerable age.
- p_i is the modelled fraction of total powerline strikes for each species that are associated with birds from area *i* in 2016 (see Table 5E-2 for list of areas).
- Ω is the estimated number of seabird powerline strikes in 2016 (Hawaiian petrels [‘ua‘u] and Newell’s shearwater [‘a‘o] combined).
- ρ is the proportion of total strikes that are Newell’s shearwater (‘a‘o) (Travers et al. 2021).
- ν is the total grounding rate (i.e., the proportion of strikes that result in mortality; Travers et al. 2021).
- π_{sa} is the proportion of powerline strikes that are subadults (Cooper and Day 1998).
- $\widehat{N}_{a,i}^{sa}$ is the number of subadults at age (ages 3–5 years) and $\widehat{N}_{6+,i}$ is the number of adults in 2016, which when projected forward through time in the model, equal the island-based estimates from 2021 (see Table 5E-3). The initial age structure in the model, for those areas outside Hanalei to Kekaha and Waimea, assumes that 63.7 percent of the population is composed of breeding adults (the remaining 36.3 percent are assumed to be ages 1–5 subadults), following Ainley et al. (2001).

Table 5E-4 shows the assumed values for most of the variables above. The text below the table explains the rationale for these variables.

Table 5E-4. Powerline Strike Assumptions for the Population Dynamics Model

Powerline Strike Variable	Model Variable	Assumed Value
2016 annual powerline strikes of Newell’s shearwater (‘a‘o) and Hawaiian petrel (‘ua‘u) combined, before minimization (i.e., average annual unminimized strike estimate during 2013–2019)	Ω	15,853[a]
Total grounding rate	ν	0.288[b]
Proportion of strikes that are Newell’s shearwater (‘a‘o)	ρ	0.70[c]
2016 annual estimated mortalities of Newell’s shearwater (‘a‘o)	calculation	3,196[d]
Proportion of powerline strikes that are subadults	π_{sa}	0.79[e]

[a] Total number of estimated seabird powerline strikes of Newell’s shearwater (‘a‘o) and Hawaiian petrels (‘ua‘u) combined. Estimate excludes waterbird strikes and strikes minimized during the Short-Term HCP. Based on 2013–2019 acoustic data and the Bayesian estimate model described in Travers et al. (2020).

[b] The total grounding rate includes 13 percent "immediately grounded," 10.2 percent "unknown outcome", and 5.6 percent of birds that strike powerlines having been observed with the most severe of post-flight behaviors and that are hence assumed to have eventually died (Travers et al. 2021).
[c] Travers et al. (2021)
[d] Mortalities are calculated as the proportion of unminimized seabird strikes for each species, multiplied by the total grounding rate.
[e] See text for additional explanation (Cooper and Day 1998).

Powerline Strike Allocation by Subpopulation

The powerline strike allocation by subpopulation is based on the percentage of acoustically detected strikes that have been analyzed to estimate strike totals across the island (Travers et al. 2020). The assumed empirical strike allocations are: 89.1 percent of strikes in the Hanalei to Kekaha area, 10.8 percent of strikes in the Waimea Canyon area, and 0.1 percent of strikes from the Wainiha and Lumahaʻi Valleys area (Travers et al. 2020; Travers unpublished data). Some variance from the empirical acoustic detections was incorporated in the modeled allocation so that 3.1 percent of strikes from the Hanalei to Kekaha area were assumed to result from collisions by individuals from breeding colonies in the remote northwestern areas. This allowed the model to incorporate a low level of powerline collision vulnerability for individuals associated with the conservation sites and surrounding areas, which is consistent with observations from tagging studies (Raine et al. 2017a). In general, the spatial differences that have been observed through acoustic powerline collision monitoring data served as a key motivating factor for developing a spatially explicit population dynamics modeling framework.

Powerline Strike Allocation by Species

As described in Chapter 5, *Effects*, estimates of powerline strikes of the covered seabirds are derived from acoustic data on strikes for all seabirds combined. Acoustic data cannot be separated by species. Instead, we must make an assumption of the proportion of strikes allocated to either Newell's shearwater (ʻaʻo) or Hawaiian petrel (ʻuaʻu). Travers et al. (2021) has reported that powerline collisions directly observed in the field occur in a proportion of 70.5 percent Newell's shearwater (ʻaʻo) to 29.5 percent Hawaiian petrel (ʻuaʻu). The modeling assumption corresponds to these proportions, with 70 percent of all estimated strikes assumed to be Newell's shearwater (ʻaʻo) and 30 percent assumed to be Hawaiian petrel (ʻuaʻu) (Table 5E-4).

Powerline Strike Allocation by Age Class

Birds detected colliding with powerlines through acoustic monitoring, which is used to estimate strike numbers, cannot be identified to age class. However, the proportions of strikes that are subadults and adults are important for the population dynamics model. Limited evidence suggests that subadults are more susceptible to powerline strikes than adults. For the purposes of this model, powerline strikes of Newell's shearwater (ʻaʻo) are assumed to be composed of 79 percent subadults (ages 3–5 years) and 21 percent adults (ages 6 years and older) (Table 5E-4).

This assumption corresponds to the proportions estimated by Cooper and Day (1998), who analyzed brood patch vascularization and wear of rectrices for 14 downed Newell's shearwater (ʻaʻo) collected on powerline mortality searches during 1993–1994. Three of those downed Newell's shearwater (ʻaʻo) had highly vascularized brood patches and worn rectrices, which suggests those birds were incubating eggs in burrows, and hence they were classified as breeding adults (age 6+). The remaining 11 birds either had no brood patch (n=10) or a downy brood patch (n=1); all but the latter had unworn rectrices. Those 11 birds (78.6 percent) were classified as subadults, and the three others (21.4 percent) were classified as breeding adults.

Mortality from Future Powerlines

Mortality due to construction of future powerlines was assumed to apply only to the Hanalei to Kekaha area (Figure 5E-1). The vast majority (> 99 percent) of new powerlines are expected to be constructed in this area, which is where human population growth is forecast to occur on Kauaʻi (see Chapter 2, *Covered Activities*, for details). As described in Chapter 5, *Effects*, at the end of the 50-year permit term, powerline strikes would be increased by an estimated 6.8 percent. The species-specific increase in future strikes was calculated by applying the species split to this percentage, and then applying a linear increase in the strike mortality rate each year, such that by the end of the HCP term, the strike mortality rate was equal to the estimated percent increase in strikes.

Mortality from Fallout from Existing and Future Streetlights and Covered Facility Lights

Appendix 5C, *Light Attraction Modeling*, describes the process for quantifying take of the covered seabirds from attraction to lights owned and operated by KIUC. Mortality due to fallout from light attraction was assumed to affect fledglings (age 1 year) only in the Hanalei to Kekaha area. Fallout is assumed to result in 100% mortality in the model, so as a conservative approach the benefits of Save Our Shearwaters (SOS) rehabilitation efforts are not counted (given that there is little data on survival once the birds are released). Based on this assumption, and the light attraction modeling (Appendix 5C), the number of mortalities from fallout each year for Newell's shearwater (ʻaʻo) was set to 92.6 in the model. This estimate represents expected mortalities resulting from existing and future light sources anticipated by the end of the 50-year permit term. However, this value was applied at the start of the population trajectories as a conservative approach for modeling fallout mortality levels through time, so annual fallout mortalities from attraction to lights owned and operated by KIUC is likely overestimated at the start of the metapopulation projections.

5E.1.1.4 Predation Rates

Predation mortality rates have been estimated at the conservation sites, both with and without trapping and fencing (i.e., mitigation). Prior to dedicated predator control, predation mortality rates for all predators combined were estimated to be 0.18 for chicks in the nest, and 0.0272 for breeding adults[4] at the nest (Raine et al. 2022a; Raine unpublished data). For areas outside the conservation sites (with no active management), predation rates at the nest were assumed to be equal to the estimates for the conservation sites prior to dedicated predator control, with three exceptions. The exceptions were the Nā Pali Coast, Wainiha and Lumahaʻi Valleys, and Waimea Canyon areas, where predation mortality rates are assumed to be 25 percent of the unmitigated rates. These values were assumed for the Wainiha and Lumahaʻi Valleys in order to match the stable trend in abundance estimated from radar surveys in this area during 2006–2020 (Raine and Rossiter 2020). In the Nā

[4] In other words, 18 percent of all chicks at all conservation sites are assumed to be lost to predators in the absence of dedicated predator control structures or actions. Similarly, 2.7 percent of all adults at the conservation sites are assumed to be lost to predators annually in the absence of any predator control structures or actions. Chicks are not tracked explicitly in the model, but chick survival (and mortality from predation) is measured in the estimated reproductive success rates of adults from burrow monitoring studies, and those reproductive success rate estimates (and hence chick mortality) from monitoring studies are explicitly included in the model.

Pali Coast and Waimea Canyon areas predation rates are expected to be substantially less than other areas due to the steep and inaccessible cliff locations to which breeding pairs are largely confined. As discussed in Chapter 4, *Conservation Strategy*, breeding colonies likely persist in these locations because of their inaccessibility to mammalian predators (as well as being far away from the majority of threats from powerline collision and light attraction).

With predator control measures at the conservation sites, predation mortality rates were estimated to decrease to 0.02 for chicks and 0.0023 for adults (Raine et al. 2022a; Raine unpublished data). The effect of these reductions in predation rates at the nests is also evident in the reproductive success rates estimated before (55.8 percent reproductive success rate) and after dedicated predator control measures (86.7 percent reproductive success rate) at the conservation sites (e.g., Raine et al. 2022a). Although predation mortality rates for chicks are not explicitly included as a variable in the model and are therefore not considered further, they are subsumed in the reproductive success rate estimates used in the model, as discussed above under *Reproductive Success Rate*.

Barn owl predation rates on the wing for adults were assumed to be equal to the adult predation rate at the nest (0.0023; Raine et al. 2022a; Raine unpublished data), and the same barn owl predation rate on the wing was assumed for ages 3–6+ in the absence of additional information. The assumed barn owl predation rate on the wing was added to the terrestrial predation rates at the nest for all areas. For example, in the Kalalau east to Upper Mānoa area, the adult predation rates at the nest were assumed to be equal to those estimated at the conservation sites prior to dedicated predator control measures (0.0272) plus the assumed barn owl predation rate on the wing (0.0023), or a total adult predation rate of 0.0295 (Table 5E-5). For areas with predator-proof fences, the terrestrial predation rate was assumed to be zero, and the assumed predation rate was limited to that assumed for barn owls on the wing. In other words, the adult predation rate was modeled as the sum of the applied nest predation rate (which differed between areas in the model) and the assumed barn owl predation rate on the wing (which was constant between areas in the model). Predation rates at the nests were assumed to vary between different areas according to different management measures (Table 5E-5).

The predation rate for ages 3–5 was set to 0.0023, under the assumption that those ages are not vulnerable to terrestrial predators because they are not nesting, but they are vulnerable as prospectors to being killed by barn owls on the wing (Table 5E-5).

Table 5E-5. Assumptions for Annual Predation Rates, with and without Predator Control

Site	Without Predator Control[a]		With Predator Control[b]	
	Adults	Subadults (3–5 yrs)	Adults	Subadults (3–5 yrs)
Conservation Sites	--	--	0.0046	0.0023
Conservation Sites with Predator-Proof Fences	--	--	0.0023	0.0023
Kalalau east to Upper Mānoa	0.0295	0.0023	--	--
Hanalei to Kekaha	0.0295	0.0023	--	--
Wainiha and Lumaha'i Valleys[c]	0.0074	0.0006	--	--
Nā Pali Coast[c]	0.0074	0.0006	--	--
Waimea Canyon[c]	0.0074	0.0006	--	--

[a] Without predator control is defined as no fencing, no predator trapping, and no predator removal efforts. With predator control includes trapping and ungulate fences for the conservation sites, or sites with predator-proof fences (second row).
[b] See Table 5E-6 for differences in predation mortality rates assumed for different age classes.
[c] Due to the inaccessibility of these sites (Nā Pali Coast and Waimea Canyon), predation rates for adults and subadults are set at 25 percent of the rates of other sites without predator control. The same assumption is made in terms of reduced predation rates for Wainiha and Lumaha'i Valleys in order for the initial modeled trend to match the stable trend in radar survey data at the two monitoring sites for these valleys during 2006–2020 (Raine and Rossiter 2020).

5E.1.2 Population Dynamics Model and Projections of Abundance

This section describes the model structure, each of the model parameters, and the rationale for each model input.

The population dynamics model is described below in terms of the numbers of females-at-age for each species, under the assumption of a 50:50 sex-ratio:

$$N_{1,t,i} = 0.5\gamma_{t-1,i}\beta N_{6+,t-1,i}S^*_{6+,t-1,i} - F_{t,i} \quad \text{(Equation 2)}$$

$$N_{2,t,i} = N_{1,t-1,i}S^*_{1,t-1,i}$$
$$N_{3,t,i} = N_{2,t-1,i}S^*_{2,t-1,i}$$
$$N_{4,t,i} = N_{3,t-1,i}S^*_{3,t-1,i}$$
$$N_{5,t,i} = N_{4,t-1,i}S^*_{4,t-1,i}$$
$$N_{6+,t,i} = N_{5,t-1,i}S^*_{5,t-1,i} + N_{6+,t-1,i}S^*_{6+,t-1,i}$$

Where:

- $N_{a,t,i}$ is the number of female birds at age a during year t in area i. Birds aged 6 years and older (denoted as age 6+) are modeled as a plus-group, *aka* a self-loop group (Figure 5E-2). Fledglings are denoted as age 1 in the model.
- $\gamma_{t,i}$ is the reproductive success rate during year t in area i. Reproductive success rates in the model vary between conservation sites and unmanaged areas, and can change with time for areas with future predator control measures (e.g., predator-proof fences).
- β is the breeding probability for sexually mature birds (assumed constant across areas).

- "Fertility" is defined here as the product: $0.5\gamma_{t-1,i}\beta S^{*}_{6+,t-1,i}$
- Hence, fertility, or the number of female fledglings produced per breeding female per year, is a function of the adult survival rate. Chick mortality rates, which are subsumed in the reproductive success rate variable, are therefore directly related to parental mortality rates in the model vis-à-vis reductions in the numbers of fledglings produced.
- $F_{t,i}$ is the number of age 1 birds that die from fallout due to KIUC lights during year *t* in area *i*. This term is included with a time and area component for generality, but in practice, fallout is assumed to be limited to the Hanalei to Kekaha subpopulation with 46.3 age 1 female mortalities per year (i.e., 92.6 fallout mortalities per year for age 1 males and females combined).
- $S^{*}_{a,t,i}$ is the survival rate of birds at age *a* during year *t* in area *i*, which for ages 3 years and older is a function of the estimated predation and powerline mortality rates-at-age, as well as the powerline minimization level in year *t*:

$$
\begin{aligned}
S^{*}_{1,t,i} &= S_1 \\
S^{*}_{2,t,i} &= S_2 \\
S^{*}_{3,t,i} &= S_3(1-\phi_{3,t,i})\left[1-\psi_{3,i}(1-\delta_t)\right] \\
S^{*}_{4,t,i} &= S_4(1-\phi_{4,t,i})\left[1-\psi_{4,i}(1-\delta_t)\right] \\
S^{*}_{5,t,i} &= S_5(1-\phi_{5,t,i})\left[1-\psi_{5,i}(1-\delta_t)\right] \\
S^{*}_{6+,t,i} &= S_{6+}(1-\phi_{6+,t,i})\left[1-\psi_{6+,i}(1-\delta_t)\right]
\end{aligned}
\qquad \text{(Equation 3)}
$$

Where:

- S_a is the natural survival rate at age *a* prior to any mortalities from predators or powerlines (Table 5E-5).
- $\phi_{a,t,i}$ is the predation mortality rate at age *a* during year *t* in area *i* (Tables 5E-5 and 5E-6). Predation rates vary through time in the model in the areas where future predator control measures will occur or where predator-proof fences are installed.
- $\psi_{a,i}$ is the unminimized powerline mortality rate at age *a* in area *i.* The unminimized powerline mortality rates vary by area due to unequal per-capita vulnerability to powerline strikes (Equation 1; Table 5E-3).
- δ_t is the minimization efficacy in terms of reducing powerline strikes during year *t*. The minimization rate varies between years according to the strike minimization schedule under the HCP (Table 5E-8).

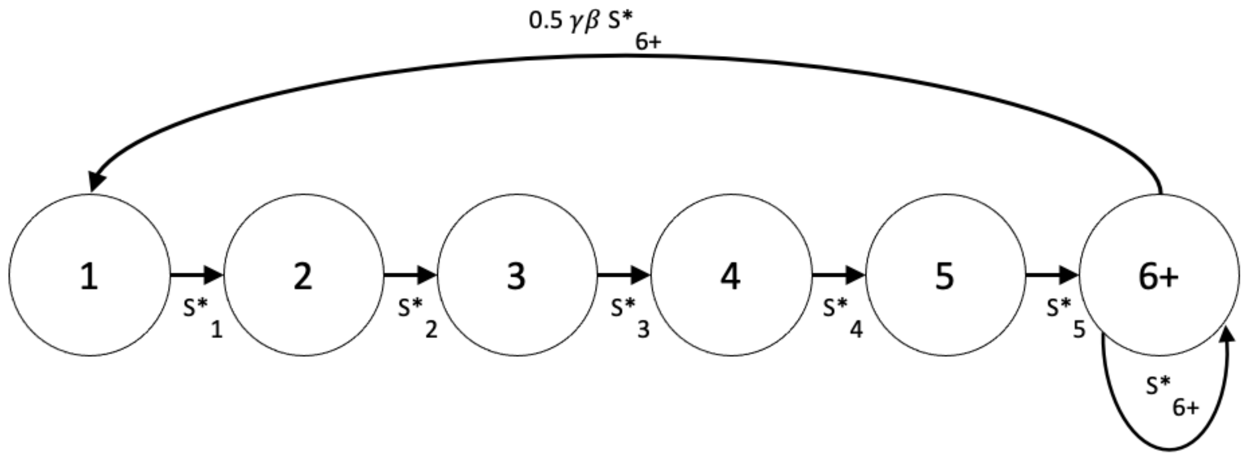

Figure 5E-2. Life Cycle Graph with Age-Structured Transition Parameters for the Population Dynamics Model

The life-cycle model shown in Figure 5E-2 is similar to the model developed by Griesemer and Holmes (2011). The circles, and numbers therein, correspond with a single age-class in the model. Birds aged 6 years and older were modeled as a self-loop group (i.e., senescence was not assumed to be a knife-edge where all birds die at a given age). The survival rates at age a, S_a^* are a function of predation and powerline mortality rates at age as well as the powerline strike minimization rates (Equation 3). For conciseness, the subscripts for year and area are dropped in the transition parameters shown in the figure.

Table 5E-6. Survival, Predation Mortality, and Fertility Rates by Age for Newell's Shearwater ('a'o)

Age	Natural Survival Rate[a]	Predation Mortality Rate without Predator Control or Fencing[b]	Predation Mortality Rate with Predator Control and Ungulate Fencing[b]	Predation Mortality Rate with Predator-Proof Fencing[d]	Natural Fertility[a]	Fertility without Predator Control or Fencing[e]
1	0.371	0	0	0	0	0
2	0.924	0	0	0	0	0
3	0.924	0.0023[c]	0.0023[c]	0.0023[c]	0	0
4	0.924	0.0023[c]	0.0023[c]	0.0023[c]	0	0
5	0.924	0.0023[c]	0.0023[c]	0.0023[c]	0	0
6+	0.924	0.0295	0.0046	0.0023[c]	0.416	0.243

[a] Natural survival and natural fertility represent the modeled rates in the absence of predation and powerline mortalities. The value of 0.924 for natural survival is based on survival rates estimated from studies of Manx shearwater and Hawaiian petrel ('ua'u) (Simmons 1984, 1985), with age 1 survival adjusted to result in ~25 percent of birds reaching breeding age, based on satellite tagging results for Newell's shearwater ('a'o) on Kaua'i (Raine et al. 2020).
[b] Estimated from burrow monitoring studies at conservation sites (e.g., Raine et al. 2022a), and assuming that ages 1 and 2 are not vulnerable to introduced predators on the island, because they are largely expected to be at sea.
[c] Taken from estimated barn owl predation rates for nesting birds and assumed in the model to be equal for age 3–5 birds (i.e., the barn owl predation rate is applied to this age under the assumption that ages 3–5 would be "prospectors" and predated by barn owls on the wing).
[d] All predation mortality rates are assumed to be reduced to zero by predator-proof fences, except for ages 3–6+ which are assigned the estimated barn owl predation rate on the wing.

[e] This fertility value corresponds to the Hanalei to Kekaha subpopulation with unminimized powerline strike mortality rates. The fertility values are a function of the adult powerline mortality rates and non-lethal injury calculations, and therefore change through time in the model as a function of the minimization schedule. Likewise, the fertility rates differ between areas in the model due to spatial differences in the adult powerline mortality rates between areas in the model. Because the Hanalei to Kekaha area has the highest powerline strike mortality rate, it also has the lowest modeled fertility rate, which reflects the expectation that if a nesting parent is killed, its egg/chick will not survive to fledge.

Table 5E-7. Reproductive Rates Assumed in the Population Dynamics Model

Vital Rate	Value
Sex ratio	0.5
Reproductive success rate without predator control and without fencing	0.558[a]
Reproductive success rate with predator control	0.867[a]
Reproductive success rate with predator-proof fencing	0.891[a]
Breeding probability	0.993[b]
Age at sexual maturity	6 yr

[a] Estimated from burrow monitoring studies at management sites prior to dedicated predator control ("Year 0") and after predator control measures (e.g., Raine et al. 2022a). The reproductive success rate with predator control measures is estimated from the 3-year, 2019–2021 average reproductive success rate and includes bycatch of seabirds in predator traps at conservation sites. The reproductive success rate at conservation sites with predator-proof fencing is assumed to be 2.23 percent greater than at conservation sites with trapping and ungulate fencing. This is comparable to reducing the estimated adult and chick predation rates (combined) from terrestrial predators at nests in those conservation sites to zero.
[b] Estimated from long-term studies of active breeders at the conservation sites (Raine et al. 2022b).

Table 5E-8. The Annual Powerline Minimization Schedule[a]

Year	Annual Island-Wide Powerline Mortality Minimization Rate[b]
2019	0
2020	0.127
2021	0.303
2022	0.550
2023–2053	0.653

[a] See Conservation Measure 1, *Implement Powerline Collision Minimization Projects*, in Chapter 4, *Conservation Strategy*, for details on the specific powerline minimization projects and the locations.
[b] Minimization represents the efficacy to reduce the mortality rate due to powerline strikes. In other words, minimization = 0.0 corresponds to no change in powerline mortality rate (without any minimization measures implemented). A minimization = 1.0 represents a scenario where a powerline was removed or modified so that bird collisions no longer occurred, and powerline mortality rates are zero. A minimization efficacy of 0.5 represents a 50 percent reduction in strike mortalities.

5E.1.3 Social Attraction Site Dynamics and Dispersal

The population dynamics model assumes natal fidelity and internal recruitment for each subpopulation, such that birds that fledge in area *i* return to the same area to breed for the remainder of their lives. The exception to this is immigration into social attraction sites. The numbers of new breeding birds that immigrate into each social attraction site each year following the installation of the site are shown in Table 5E-9. The model assumes that the number of breeding birds that immigrate into a social attraction site each year from area *i* is proportional to the abundance of the subpopulation in area *i* relative to total abundance that year. For example, if a subpopulation in area *i* in year *t* represents 50 percent of total abundance, then 50 percent of the immigrants into social attraction sites that year will be from that subpopulation. Age 3 subadults are the only age class assumed to immigrate into social attraction sites. This age class represents subadult "prospectors" that are searching for suitable habitat to establish a nest. The number of subadult prospectors immigrating into social attraction sites was determined such that the expected number of established breeding pairs 3 years later was matched (Table 5E-9). Immigration into social attraction sites is assumed to be permanent and once breeding pairs are established their offspring are assumed to have natal fidelity (Procellariids exhibit strong natal philopatry) and return to breed at the same social attraction site in subsequent years.

5E.1.3.1 Carrying Capacity

Because the proposed social attraction sites are relatively small compared to their surrounding management areas at the conservation sites, and because they are enclosed by a predator exclusion fence, we assume that each social attraction site has a finite carrying capacity. Suitable habitat within the proposed predator exclusion areas was used by ARC to estimate the carrying capacity of nesting Newell's shearwater ('a'o) breeding pairs for each site: 136 Pōhākea PF; 468 at Honopū PF; 396 at Conservation Site 10 (inside PF), and 453 at Upper Limahuli (inside PF). Once the carrying capacity of breeding pairs is reached within each predator exclusion fence, the subpopulation is held constant. Any reproduction that occurs within the predator exclusion fence in excess of this carrying capacity, and any immigration due to continued social attraction is assumed to result in new breeding age birds nesting in the adjacent management area of the same site, as seen in Figure 5E-3 for the four sites with predator exclusion fences. These are estimates only based on theoretical limits of carrying capacity. Current social attraction sites are nowhere near these limits and show no signs yet of slowing population growth.

5E.1.3.2 Kaua'i Seabird HCP Social Attraction Site

To accurately reflect the island-wide population of Newell's shearwater ('a'o), a additional social attraction site was added to this population dynamics model to account for the Kaua'i Seabird HCP[5] (KSHCP). The KSHCP, approved in 2020, began implementation in 2021. A primary conservation measure of the KSHCP is the establishment of a new social attraction at the Kahuama'a Seabird Preserve (abbreviated here to Kahuama'a). This site is approximately 5 acres (2 hectares) in size and is located on the Kalalau Rim in northwestern Kaua'i at approximately 3,500 feet in elevation (see Figure 5-1 in the KSHCP for specific location). The site is surrounded by a predator-proof fence (completed in 2021) and site management will be very similar to that proposed for this HCP (i.e., cat and rodent control, barn owl control, and invasive plant management). Because it is similar in size to Pōhākea PF, the same carrying capacity for breeding pairs was assumed.

The one exception in the KIUC HCP population dynamics model to the assumption for the number of new breeding pairs immigrating into social attraction sites is at the Kahuama'a site. The dynamics for this site assume that the number of new breeding pairs that become established each year is one

[5] See https://fws.gov/pacificislands/documents/KSHCP/Kauai-Seabird-HCP.pdf

half the number shown in Table 5E-9. This results in 511 new fledglings produced over the first 30 years of the modeled projection, given the assumed predation rates for sites with predator proof fences (Table 5E-5) and powerline mortality rates set equal to the Kalalau to Upper Mānoa area. The assumption of a lower immigration rate to this social attraction site is meant to mimic the assumed benefit in the KSHCP for the number of fledglings that would be produced at the Kahuama'a site over 30 years (Table 7 of KSHCP Appendix C under predation scenario 2, and 90–95 percent site fidelity, provides a comparable prediction of 462–932 new fledglings produced over 30 years at this site).

Table 5E-9. Number of Breeding Pairs Expected to Immigrate into Each Social Attraction Site from Other Areas Each Year Following the Introduction of Social Attraction Efforts

Immigration into social attraction sites is assumed in the model to be permanent. After 30 years, the rate of immigration due to social attraction is assumed to remain constant at the average immigration rate during years 20 to 30 modeled for each site. Once a social attraction site has reached the estimated carrying capacity of the predator fenced area, additional immigration and recruitment into the breeding colony is assumed to occur in the surrounding open management area.

Social Attraction Site Year	New Breeding Pairs[a]	Total Breeding Pairs
1	0	0
2	0	0
3	0	0
4	0	0
5	3	3
6	2	5
7	2	7
8	5	12
9	1	13
10	1	14
11	16.77	30.77
12	14.60	45.37
13	14.68	60.05
14	14.34	74.39
15	14.21	88.60
16	13.94	102.54
17	14.14	116.68
18	12.73	129.41
19	13.33	142.74
20	13.03	155.77
21	13.43	169.20
22	12.96	182.16
23	13.09	195.25
24	13.58	208.83
25	13.54	222.37
26	11.85	234.22
27	13.10	247.32
28	13.30	260.62
29	13.23	273.85
30	13.13	286.98

Source: Raine 2020

[a] The expected number of breeding pairs immigrating into social attraction sites is based on data collected at multiple existing social attraction sites, including those for Huttons shearwater (New Zealand), Bermuda petrel (Bermuda) and Newell's shearwater (ʻaʻo) (Makamakaʻole). All show the same pattern of slow establishment (low immigrantion in the first few years), and then immigration increases more quickly after year 10.

5E.2 Model Results

All model results for Newell’s shearwater (‘a‘o) are presented in Figures 5E-3 through 5E-7 at the end of this section. The population dynamics results in Figures 5E-3 and 5E-4 demonstrate that the conservation measures implemented will substantially benefit Newell’s shearwater (‘a‘o) relatively quickly at four of the conservation sites. Benefits to Newell’s shearwater (‘a‘o) are modest at three other conservation sites. The only conservation site with no benefit to Newell’s shearwater (‘a‘o) is Pihea, which is designed primarily to benefit Hawaiian petrel (‘ua‘u). HCP benefits are greatest at the four conservation sites with predator exclusion fencing and social attraction, as expected (Figure 5E-3).

The population trajectory for Newell’s shearwater (‘a‘o) at all conservation sites combined is shown in Figure 5E-5 and shows a similar pattern. According to the model, the total population size of Newell’s shearwater (‘a‘o) at all of the conservation sites is expected to increase immediately with the rate gradually increasing through approximately 2035. After that, the population increases steadily and more substantially due to the contributions of the newest social attraction sites (Upper Limahuli PF, Conservation Site 10 PF, Pōhākea PF[6], and Honopū PF[7]). By the end of the permit term the combined number of breeding pairs in all conservation sites is projected to be over 4,300.

Continued predator control by the HCP at the six conservation sites with ungulate fencing, combined with powerline collision minimization, will prevent substantial declines of existing subpopulations of Newell’s shearwater (‘a‘o) and likely prevent local extirpation (red lines in Figure 5E-4). Four of these conservation sites with predator control (Upper Limahuli, Pōhākea, Conservation Site 10, and Honopū) collectively contribute substantial numbers of new breeding pairs to the Kaua‘i metapopulation of Newell’s shearwater (‘a‘o) with the HCP (blue lines in Figure 5E-4). Combined, these four conservation sites are projected to have a breeding pair abundance of over 2,500 by the end of the permit term.

Figure 5E-6 shows the subpopulation trajectories at each of the five areas outside the conservation sites (see Figure 5E-1 for area locations), with and without the KIUC HCP. Hanalei to Kekaha is the largest subpopulation area, by far. This area is projected to be locally extirpated without the HCP, and severely depleted with a continued downward trend with the HCP, under the initial modeled rate of decline based on the Hanalei radar site. Without the HCP, local extirpation is projected to occur by approximately 2050. With the HCP, extirpation would be delayed beyond 30 years in the model, but not avoided in the more distant future. The difference in subpopulation declines is due largely to powerline minimization. Because 86 percent of powerline collisions for Newell’s shearwater (‘a‘o) are assumed to be from individuals associated with breeding colonies within this area (see Figure 5E-1), powerline minimization provides a greater benefit in this area than in other areas. This result is not surprising, because for all areas other than Hanalei to Kekaha and Waimea Canyon there is an assumed much lower risk of powerline collisions in the first place (Table 5E-3). By 2023 the rate of modeled decline has slowed from the initial 2016 applied radar trend in the Hanalei to Kekaha and Waimea Canyon areas due to powerline strike minimization (Table 5E-10). For Hanalei to Kekaha the rate of decline in abundance then increases again through time, due to the modeled effect of future powerline construction and fledgling fallout mortality.

[6] PF stands for predator exclusion fence
[7] Honopū PF awaits final approval from the landowner (State of Hawai‘i Division of Forestry and Wildlife).

The subpopulation trajectory in the Wainiha and Lumahaʻi Valleys area is similar with and without the HCP (Figure 5E-6). This is due to the assumptions that (1) powerline strikes are minimal in this area, so powerline minimization with the HCP has a small benefit, and (2) there is no predator control in this area. The trajectory of abundance starts off stable, which is consistent with the lack of trend in either direction estimated at the Wainiha and Lumahaʻi Valleys radar sites (Raine and Rossiter 2020). Because of the model assumptions for social attraction sites (Figure 5E-3), the stable trend becomes slightly negative due to emigration from this area to social attraction sites (Figure 5E-6). This "pull" of social attraction sites becomes more pronounced later in the permit term as all of the planned social attraction sites become operational, they have all reached a critical mass of breeding pairs increasing their attraction, and more breeding adults are assumed to be permanently dispersing into the social attraction sites (Table 5E-9). This modeled dynamic is not unique to Newell's shearwater (ʻaʻo) from the Wainiha and Lumahaʻi Valleys, but because this area has a relatively high abundance with a stable trend it is predicted to act as a substantial source of new breeding pairs into the social attraction sites. It is also the area where it is easiest to visualize the effect of the modeled emigration graphically (Figure 5E-6), and likewise the effect of emigration is also evident in the tabled values for the rates of change in abundance through time for this area (Table 5E-11). This emigration would be beneficial to the metapopulation of the species because it would mean that birds were being drawn from unprotected areas in these two valleys into management areas with predator exclusion fences and predator control measures.

Two of the remaining three areas in Figure 5E-6, Kalalau east to Upper Mānoa and the Nā Pali Coast area, are assumed to have relatively low vulnerabilities to powerline strikes, given their geographic remoteness (especially the Nā Pali Coast area) and orientation away from any existing powerlines and light sources. The initial stable trend modeled for the Nā Pali Coast area (Table 5E-10) matches observed patterns in Newell's shearwater (ʻaʻo) acoustic call detection data from that area. The overall trend in call rates in the Nā Pali Coast area has been stable in recent years, with no pattern of increase or decrease in call rates (Raine, unpublished data). Like discussed above for the Wainiha and Lumahaʻi Valleys, the modeled trend in the Nā Pali Coast area eventually turns to a small rate of decline, which is largely independent of powerline mortality, but results instead because a proportion of subadult birds are modeled to emigrate into social attraction sites. Again, while this dynamic reduces the number of modeled breeding pairs in certain areas like the Nā Pali Coast (Table 5E-11), there is a benefit to the metapopulation as a whole from individuals relocating to areas with predator exclusion fences and predator control measures.

The Waimea Canyon area has the second highest modeled vulnerability to powerline collisions and mortalities (Table 5E-2; based on 10.8 percent of all detected powerline strikes during 2013–2019 having occurred in this area (Travers et al. 2020; Travers, unpublished data). Unlike areas with lower powerline strike rates, the modeled trend in this area benefits from minimization efforts (Figure 5E-6). In other words, the trend becomes less negative due to the modeled reduction in powerline mortality rates in this area, moving from -6.9 percent without minimization to -3.3 percent per year under the HCP (Table 5E-10). Similar to the Hanalei to Kekaha area, the modeled slowdown in the rate of decline is not sufficient to prevent continued reductions in modeled abundance in these areas (Tables 5E-11 and 5E-12).

When all subpopulations are combined (Figure 5E-7), the Newell's shearwater (ʻaʻo) metapopulation on Kauaʻi is projected to continue to decline without the HCP (red line; unminimized take scenario). Without the HCP, the total population size is projected to continue to decline from approximately 12,600 breeding pairs at the start of the permit term to less than 3,000 by the end of 2073, a decline of over 70 percent (Figure 5E-7; red line). With the HCP conservation measures the Newell's shearwater (ʻaʻo) metapopulation on Kauaʻi is projected by the end of the permit term to reverse this decline and result in an increasing Kauaʻi metapopulation (Figure 5E-7, blue line). HCP conservation measures are projected to slow the metapopulation decline considerably between 2050 and 2060, stabilizing at approximately 6,400 breeding pairs during that time, before increasing (Table 5E-12).

The metapopulation is projected to increase gradually, as the continued increases in abundance of Newell's shearwater (ʻaʻo) colonies at the conservation sites overcomes the declines in abundance in the Kalalau east to Upper Mānoa, Hanalei to Kekaha, and Waimea Canyon areas (Figure 5E-7). The latter two areas have the highest initial modeled abundance, and in addition to the Kalalau to Upper Mānoa area, they also have a relatively high degree of uncertainty in terms of initial and therefore projected abundance (Table 5E-2). Therefore, the metapopulation projection, especially as it relates to the relative contribution of the abundance in the E-31forementioned areas to the overall island-wide trend, is also uncertain. However, the abundance and life history parameters of Newell's shearwater (ʻaʻo) within the conservation sites are relatively well understood given dedicated monitoring efforts at those sites, leading to higher confidence in the population projections in these areas. This means we have a relatively high confidence that the increase in subpopulations of the 10 conservation sites combined will provide a substantial net benefit to Newell's shearwater (ʻaʻo) on Kauaʻi.

Without the HCP, the Kauaʻi metapopulation of Newell's shearwater (ʻaʻo) would be approaching extirpation throughout much of its breeding range by 2073. Depending on the age structure and spatial distribution of the species at that time, it may become functionally extinct without conservation efforts under the HCP, due to the species' slow reproductive rate and other factors. However, with the continuation of conservation efforts associated with the HCP, by 2073 the metapopulation increase is forecast to continue. The 10 conservation sites are large enough in size and have such extensive suitable habitat for Newell's shearwater (ʻaʻo) that subpopulations (and densities) are expected to increase during the permit term without experiencing any density-dependent constraints outside of the smaller social attraction sites with predator exclusion fencing, assuming management actions continue at the same level as outlined in this HCP.

The cumulative number of strikes for each area from these modeled projections are provided in Table 5E-13. The predictions of strikes should be considered conservative (i.e., strike predictions may be too low) because these results are based on modeling a rate of decline for Hanalei to Kekaha that represents a worst-case scenario based on the most drastic rate of decline estimated from the 1993–2020 radar survey data. This rate of decline, while based on data, is more negative than the average rate of decline estimated across all radar sites in the Hanalei to Kekaha area during the same period; further, it does not reflect the more recent stabilization of trend across radar sites in this area during 2010–2020 (Raine and Rossiter 2020). Additionally, the 2010–2020 decade of radar data exhibiting a stable trend in relative abundance for the Hanalei to Kekaha area also overlaps in time with the estimate of unminimized seabird strikes from acoustic powerline monitoring data during 2013–2019 (Travers et al. 2020). Together, these two sources of monitoring data suggest that, at least during the last decade, the Hanalei to Kekaha subpopulation experienced a relatively high level of powerline mortality while also maintaining a stable abundance level. If this situation were to continue in the future (i.e., trends in both powerline strikes and abundance are stable), the modeled decline in abundance for Hanalei to Kekaha, and hence the modeled reduction in strikes associated with declining future abundance in this area, would underestimate future strikes.

Table 5E-10. Modeled Newell's Shearwater ('a'o) Subpopulation Lambda Values, Starting with the First Year of the HCP (2023), and then Shown at Five-Year Snap-Shot Intervals over the 50-year Permit Term (to 2073)

Lambda is the population multiplier, i.e., the rate of change in abundance from the prior year is equal to one minus Lambda. Values of Lambda less than 1.0 represent a decline in abundance; values greater than 1.0 represent an increase. For example, a Lambda value of 1.01 represents a positive rate of change of 1 percent per year. The maximum possible intrinsic value for Lambda in the model is 1.024 (2.4 percent growth), which is never achieved in practice because each subpopulation (even those behind predator-proof fences) is assumed to have some level of vulnerability to introduced predators (e.g., barn owl predation) and some level of vulnerability to powerline collisions. Values in the table greater than 1.024 include a combination of births and deaths plus the assumed level of future immigration associated with social attraction sites. "NA" represents pre-operational social attraction sites.

Area	2023	2028	2033	2038	2043	2048	2053	2058	2063	2068	2073
HCP Conservation Sites											
Upper Limahuli	1.013	1.014	1.010	1.008	1.008	1.008	1.009	1.017	1.017	1.017	1.032
Upper Limahuli PF	NA	NA	1.195	1.266	1.112	1.079	1.061	1.051	1.044	1.037	1.002
Conservation Site 10	1.014	1.014	1.011	1.009	1.009	1.008	1.008	1.008	1.008	1.050	1.047
Conservation Site 10 PF	NA	NA	1.195	1.266	1.113	1.08	1.061	1.052	1.045	1.005	1.000
Pōhākea	1.016	1.016	1.012	1.010	1.026	1.035	1.032	1.029	1.027	1.025	1.023
Pōhākea PF	NA	1.468	1.559	1.148	1.041	1.000	1.000	1.000	1.000	1.000	1.000
Pihea	1.012	1.013	1.009	1.006	1.007	1.008	1.008	1.007	1.010	1.008	1.008
North Bog	1.011	1.013	1.009	1.007	1.007	1.007	1.007	1.007	1.007	1.007	1.007
Hanakāpi'ai	1.014	1.015	1.011	1.009	1.009	1.009	1.009	1.009	1.009	1.009	1.009
Hanakoa	1.016	1.016	1.013	1.011	1.011	1.010	1.010	1.010	1.010	1.011	1.011
Honopū	1.016	1.016	1.013	1.010	1.010	1.010	1.010	1.010	1.010	1.098	1.078
Honopū PF	NA	1.468	1.559	1.148	1.090	1.067	1.057	1.048	1.043	1.006	1.000
Other Areas (outside conservation sites)											
Wainiha and Lumaha'i Valleys	1.000	1.000	0.997	0.994	0.994	0.994	0.994	0.994	0.994	0.994	0.994
Hanalei to Kekaha	0.929	0.939	0.935	0.930	0.928	0.924	0.919	0.91	0.894	0.864	0.882
Kalalau east to Upper Mānoa	0.971	0.971	0.968	0.965	0.965	0.965	0.965	0.965	0.965	0.965	0.966
Nā Pali Coast	1.001	1.001	0.998	0.995	0.995	0.995	0.995	0.995	0.995	0.995	0.995
Waimea Canyon	0.964	0.974	0.970	0.967	0.967	0.967	0.967	0.967	0.967	0.967	0.967
Kahuama'a (KSHCP)	NA	1.468	1.559	1.147	1.089	1.066	1.048	1.002	1.000	1.000	1.000

Table 5E-11. Modeled Newell's Shearwater (ʻaʻo) Breeding Pair Abundance (ages 6 years and older) at Five-Year Intervals for each Subpopulation over the 50-Year Permit Term (2023–2073)

Area	2023	2028	2033	2038	2043	2048	2053	2058	2063	2068	2073
HCP Conservation Sites											
Upper Limahuli	509	541	567	585	604	623	642	696	753	811	957
Upper Limahuli PF	0	0	11	64	114	170	230	299	373	453	454
Conservation Site 10	203	217	228	236	245	253	261	270	279	350	444
Conservation Site 10 PF	0	0	11	64	114	171	232	301	376	396	396
Pōhākea	298	319	338	353	380	453	532	611	695	782	874
Pōhākea PF	0	6	40	94	136	136	136	136	136	136	136
Pihea	0	0	0	0	0	0	0	0	0	0	0
North Bog	68	72	75	77	79	81	83	85	88	90	92
Hanakāpiʻai	78	83	88	91	95	98	102	105	109	113	117
Hanakoa	46	49	53	55	58	60	63	65	68	71	74
Honopū	90	97	103	107	112	117	122	127	133	199	301
Honopū PF	0	6	40	94	149	209	279	354	437	468	468
Other Areas (outside conservation sites)											
Wainiha and Lumahaʻi Valleys	2,338	2,339	2,311	2,242	2,178	2,113	2,046	1,980	1,918	1,859	1,805
Hanalei to Kekaha	4,625	3,433	2,477	1,745	1220	844	574	381	245	149	82
Kalalau east to Upper Mānoa	749	647	553	463	389	325	272	227	190	159	133
Nā Pali Coast	410	412	410	400	391	382	372	362	353	344	336
Waimea Canyon	773	682	588	497	421	356	300	253	214	181	153
Kahuamaʻa (KSHCP)	0	3	20	47	74	103	136	136	136	136	136
Total	**10,186**	**8,907**	**7,913**	**7,215**	**6,759**	**6,494**	**6,381**	**6,391**	**6,501**	**6,696**	**6,958**

Table 5E-12. Modeled Newell's Shearwater ('a'o) Total (non-chick) Abundance at Five-Year Intervals for each Subpopulation over the 50-Year Permit Term (2023–2073)

Initial abundance is based on the estimates of breeding pairs from ARC, with two exceptions: (1) Hanalei to Kekaha and (2) Waimea Canyon. In both cases, the pre-HCP abundance is estimated as a function of the allocated strikes for that area (86 percent and 10 percent of all strikes in each area) and trends in abundance from radar, which are assumed to be -10.7 percent and -6.9 percent per year in 2016, respectively, given the trend at the Hanalei radar site and the averaged trend across all radar sites on Kaua'i during 1993–2020 (Raine and Rossiter 2020).

Area	2023	2028	2033	2038	2043	2048	2053	2058	2063	2068	2073
HCP Conservation Sites											
Upper Limahuli	1,921	2,039	2,147	2,221	2,292	2,364	2,437	2,614	2,828	3,050	3,531
Upper Limahuli PF	0	0	35	195	397	609	838	1,099	1,379	1,684	1,761
Conservation Site 10	767	817	863	896	928	960	992	1,025	1,059	1,265	1,618
Conservation Site 10 PF	0	0	35	195	398	612	844	1,108	1,393	1,530	1,536
Pōhākea	1,123	1,204	1,280	1,338	1,421	1,672	1,967	2,271	2,588	2,920	3,268
Pōhākea PF	0	18	114	320	501	529	529	529	529	529	529
Pihea	1	1	1	1	1	1	1	1	1	1	1
North Bog	256	271	284	292	301	309	316	324	333	341	350
Hanakāpi'ai	294	314	332	346	359	373	386	399	414	429	445
Hanakoa	173	187	199	209	218	228	238	248	259	270	282
Honopū	341	365	389	408	426	445	463	483	503	687	1,063
Honopū PF	0	18	114	320	528	758	1,020	1,306	1,623	1,807	1,818
Other Areas (outside conservation sites)											
Wainiha and Lumaha'i Valleys	8,118	8,117	8,046	7,831	7,605	7,378	7,146	6,916	6,698	6,493	6,300
Hanalei to Kekaha	14,985	10,896	7,849	5,491	3,783	2,559	1,681	1,056	612	310	163
Kalalau east to Upper Mānoa	2,422	2,093	1,792	1,506	1,263	1,058	885	740	619	518	434
Nā Pali Coast	1,422	1,431	1,427	1,397	1,365	1,332	1,298	1,264	1,232	1,201	1,172
Waimea Canyon	2,724	2,362	2,047	1,738	1,471	1,244	1,050	885	747	631	534
Kahuama'a (KSHCP)	0	9	57	159	262	375	500	528	528	528	528
Total	**34,546**	**30,140**	**27,010**	**24,864**	**23,520**	**22,804**	**22,592**	**22,796**	**23,343**	**24,194**	**25,334**

Table 5E-13. Modeled Newell's Shearwater (ʻaʻo) Strikes, Starting with the First Year of the HCP (2023), and then Shown as a Cumulative Total at Five-Year Intervals for each Subpopulation until the End of the Permit Term (2073)

Area	2023	2028	2033	2038	2043	2048	2053	2058	2063	2068	2073
HCP Conservation Sites											
Upper Limahuli	19	115	217	324	434	548	665	788	919	1,061	1,218
Upper Limahuli PF	0	0	0	4	16	38	72	117	175	247	331
Conservation Site 10	6	36	67	100	135	171	208	246	285	327	379
Conservation Site 10 PF	0	0	0	3	12	30	56	91	136	191	250
Pōhākea	4	23	44	67	90	115	145	180	220	266	318
Pōhākea PF	0	0	1	3	10	19	28	37	46	55	64
Pihea	0	0	0	0	0	0	0	0	0	0	0
North Bog	3	19	36	54	72	91	110	130	150	171	192
Hanakāpiʻai	2	11	21	31	41	52	64	76	88	101	114
Hanakoa	0	2	3	4	6	8	9	11	13	15	17
Honopū	1	4	8	12	16	21	25	30	35	40	48
Honopū PF	0	0	0	2	6	12	20	32	46	63	82
Other Areas (outside conservation sites)											
Wainiha and Lumahaʻi Valleys	47	279	511	741	963	1,179	1,389	1,592	1,789	1,979	2,164
Hanalei to Kekaha	1,616	8,203	12,924	16,307	18,649	20,231	21,264	21,901	22,253	22,401	22,437
Kalalau east to Upper Mānoa	14	76	130	176	215	247	274	297	316	332	345
Nā Pali Coast	3	17	30	44	58	71	83	96	108	120	131
Waimea Canyon	266	1,483	2,520	3,420	4,184	4,831	5,377	5,839	6,228	6,556	6,834
Kahuamaʻa (KSHCP)	0	0	1	3	9	18	30	45	61	78	94
Total	**1,979**	**10,268**	**16,515**	**21,296**	**24,917**	**27,681**	**29,821**	**31,507**	**32,869**	**34,005**	**35,019**

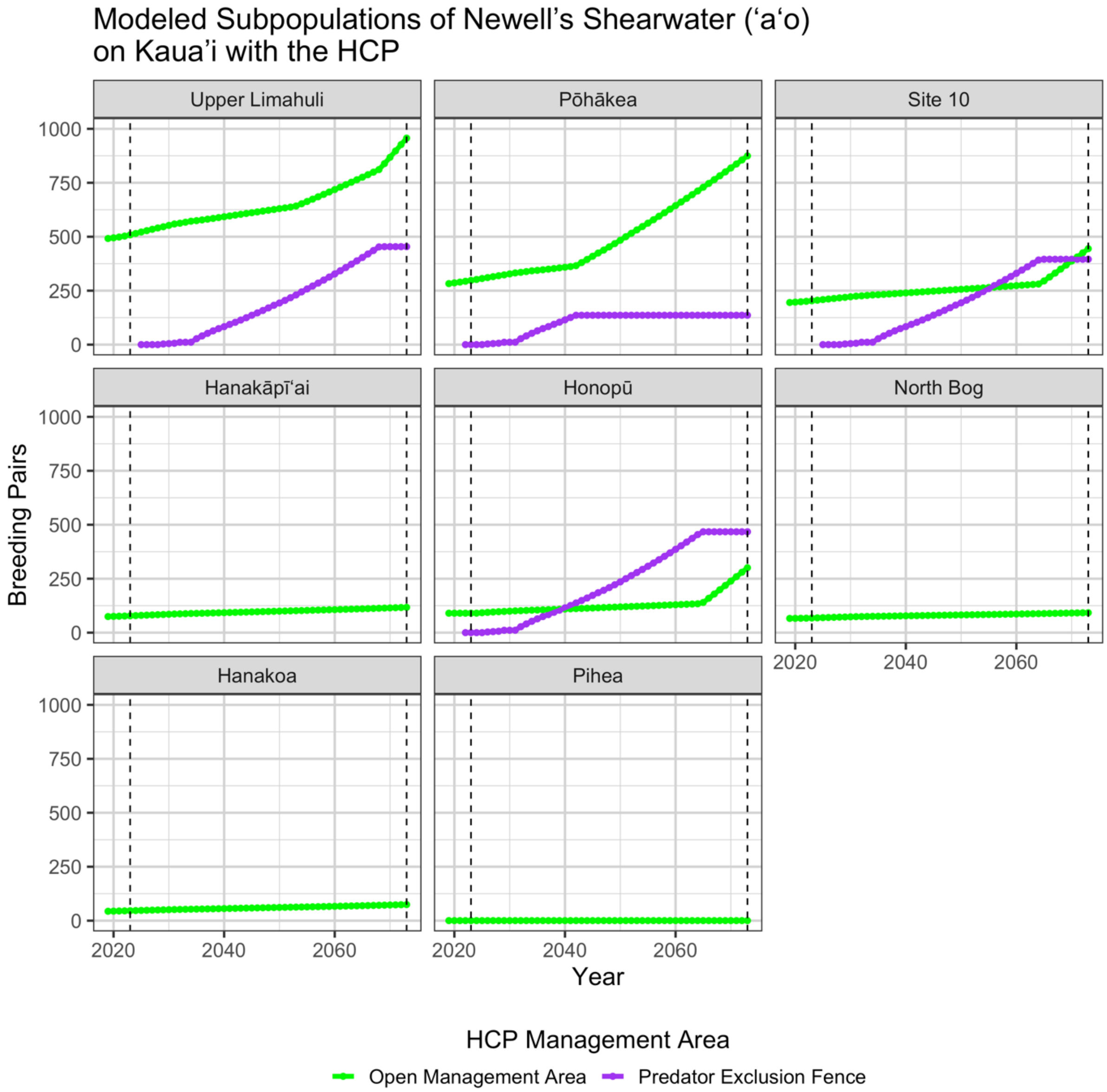

Figure 5E-3. Population Dynamics Model Results for Newell’s Shearwater (‘a‘o) for each Subpopulation at the Conservation Sites showing the Relative Contribution of Different Management Areas to Breeding Pair Abundance

Purple lines show breeding pair abundance in the social attraction sites enclosed with predator exclusion fences (PF). These trajectories plateau at the nesting burrow carrying capacities estimated for each site inside the proposed PF area. It is assumed that social attraction will continue in the future and that once the PF carrying capacities are reached, new breeding pairs (either those hatched in the PF, or prospecting subadults attracted from other areas) will spill over to nest in the surrounding open management area under predator control measures. Green lines show breeding pair abundance in the open management areas. The leftmost vertical dashed line denotes the first year of the proposed HCP (2023) and the rightmost vertical dashed line denotes the end of the 50-year permit term (2073). See Figure 5E-1 for site locations.

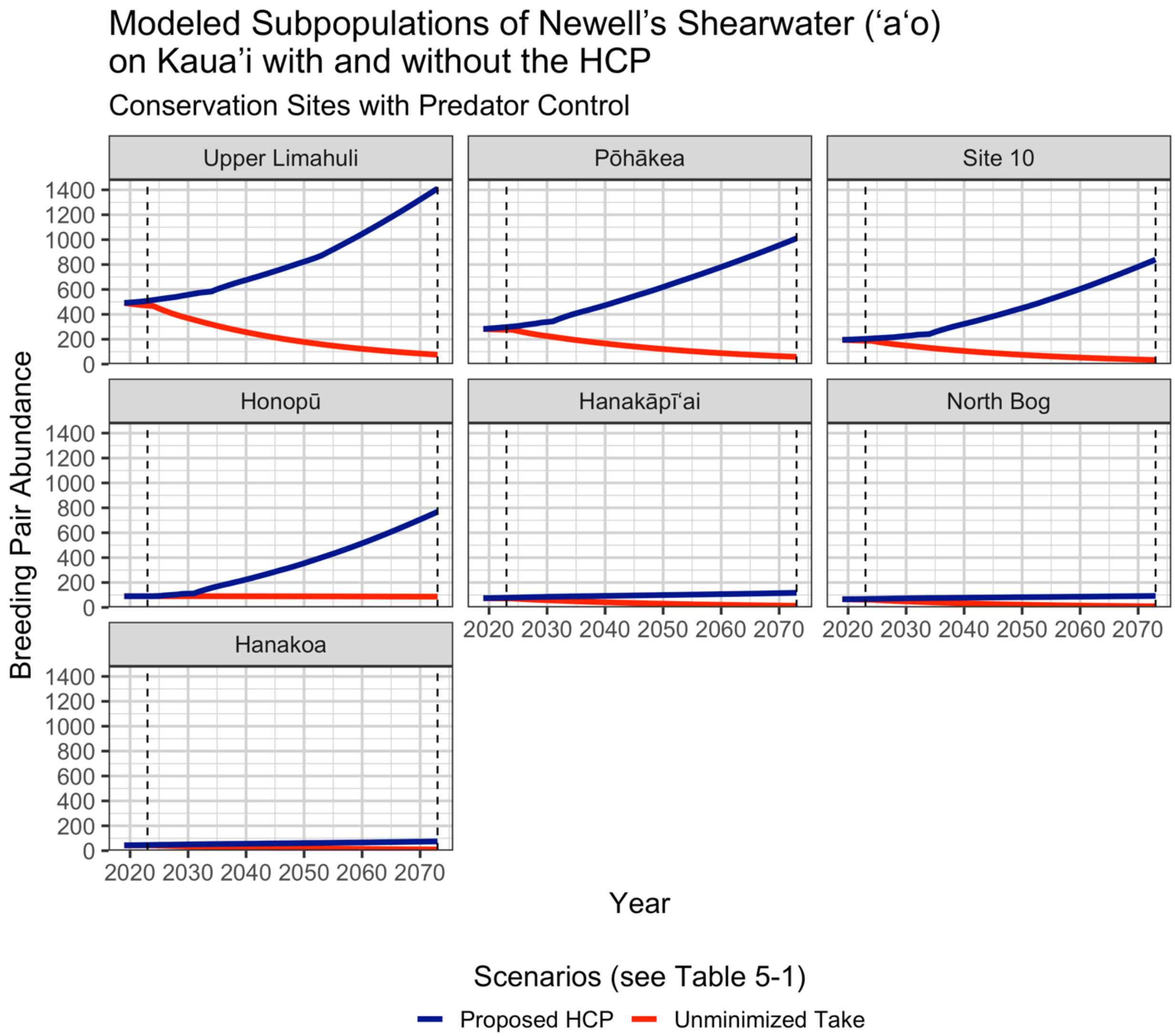

Figure 5E-4. Population Dynamics Model Results for Newell's Shearwater ('a'o) for each Subpopulation with Predator Control Measures and Ungulate Fencing

Red lines show the unminimized take model scenario without the HCP (take continues without powerline minimization, and without conservation measures; see Table 5-1 in Chapter 5). Blue lines are with the proposed HCP according to the schedule of conservation measures described in Chapter 4. The vertical dashed lines denote the first and last year of the permit term. See Figure 5E-1 for site locations. Note: Pihea is not shown in this plot because no appreciable number of Newell's shearwater ('a'o) are estimated to be associated with that area.

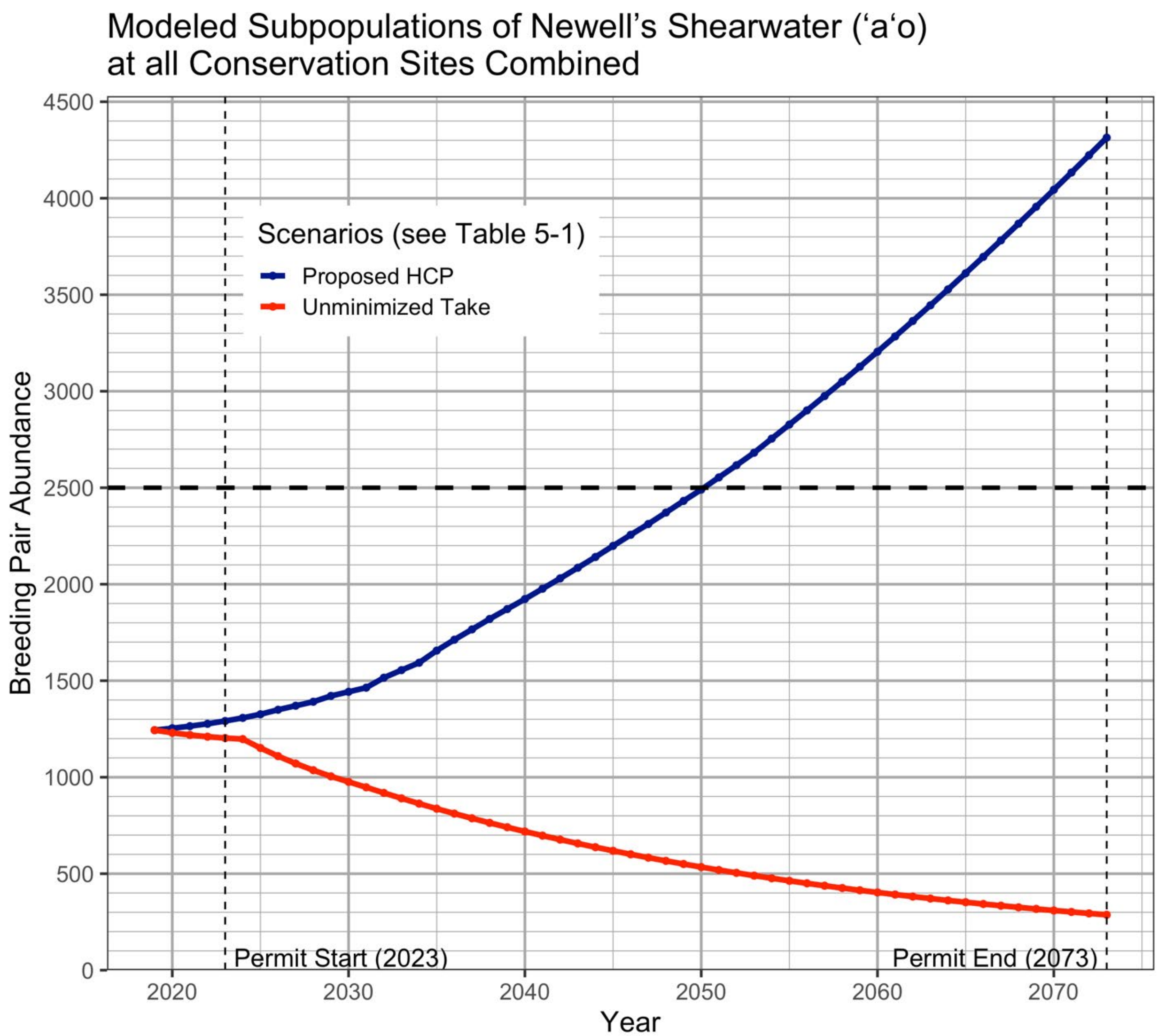

Figure 5E-5. Population Dynamics Model Results for Newell's Shearwater (‘a‘o) for all 10 Conservation Sites Combined

Red line shows the unminimized take scenario without the HCP (take continues without powerline minimization, and without conservation measures; see Table 5-1 in Chapter 5). Blue line is with the HCP according to the schedule of conservation measures described in Chapter 4. The benefits of the KSHCP Kahuama‘a social attraction site (with predator-proof fencing) are included in both lines. The horizontal dashed line highlights 2,500 breeding pairs, which the U.S. Fish and Wildlife Service considers to be a rough threshold for a viable metapopulation on the island (see Chapter 5 for details).

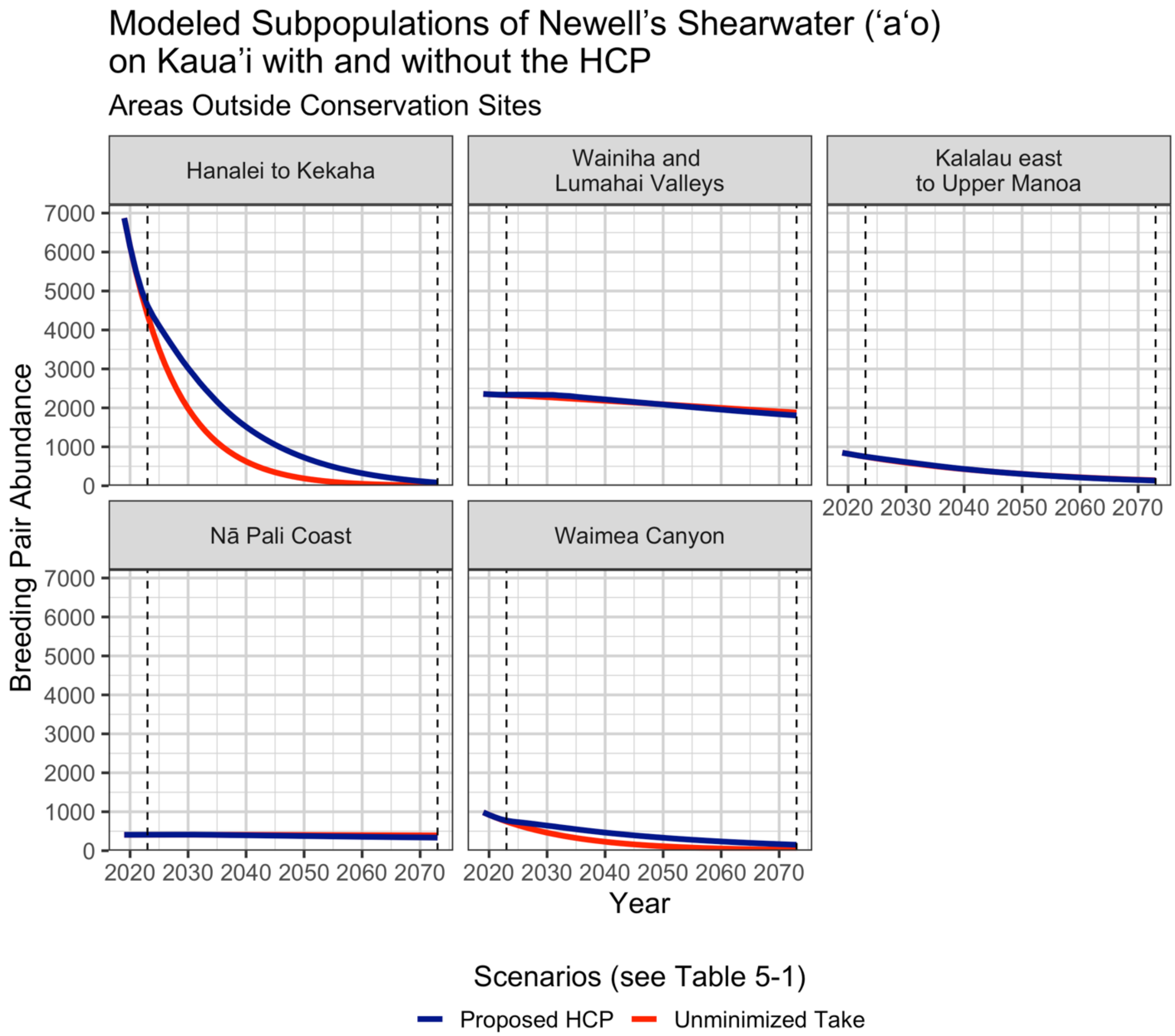

Figure 5E-6. Population Dynamics Model Results for Newell's Shearwater ('a'o) for each Subpopulation outside the Conservation Sites

Red lines show the unminimized take model scenario without the HCP (take continues without powerline minimization, and without conservation measures; see Table 5-1 in Chapter 5). Blue lines are with the proposed HCP according to the schedule of conservation measures (i.e., powerline collision minimization) described in Chapter 4. The vertical dashed lines denote the first and last year of the permit term. See Figure 5E-1 for site locations.

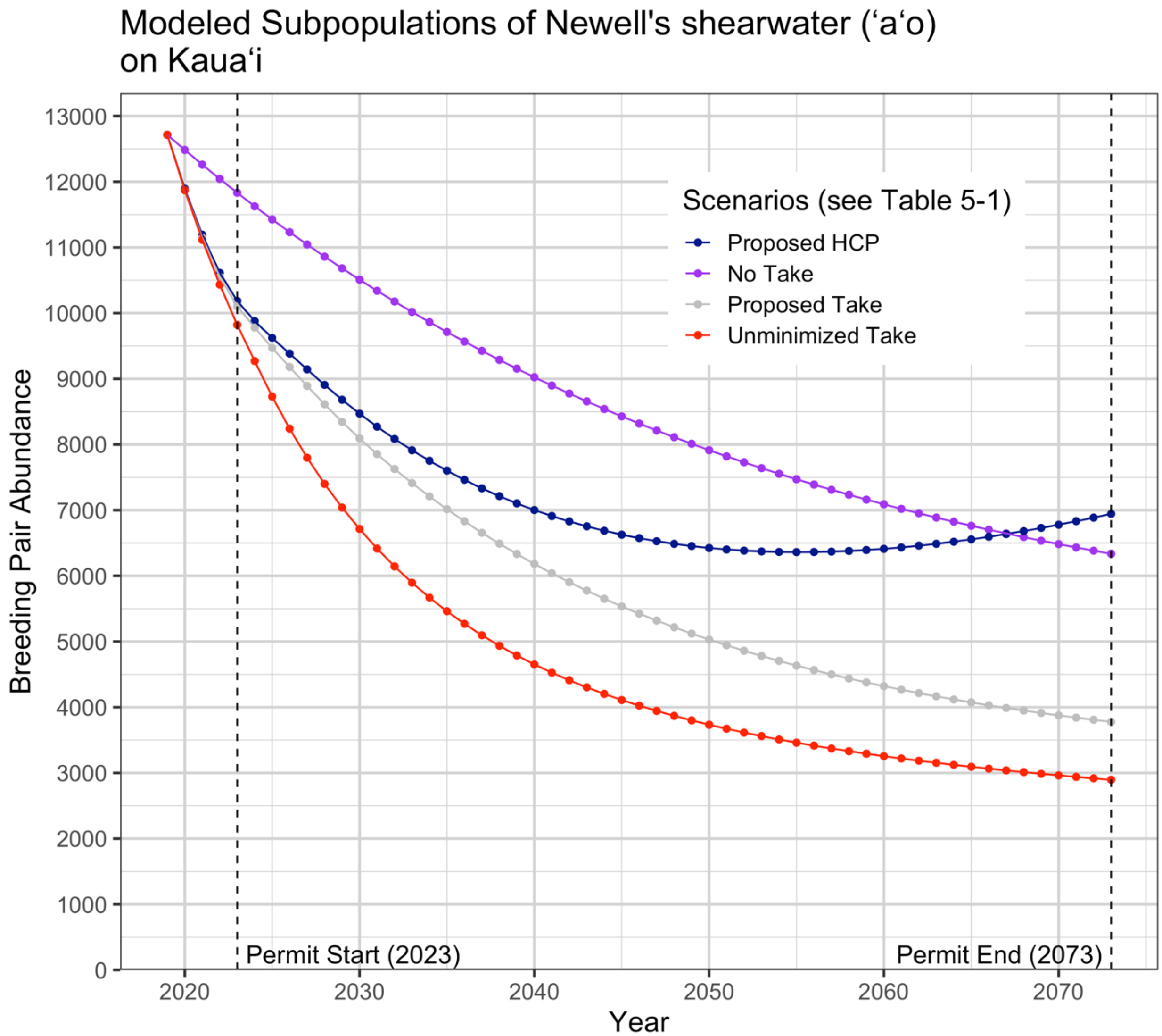

Figure 5E-7. Population Dynamics Model Results for Newell's Shearwater ('a'o) for all Subpopulations Combined (all of Kaua'i)

Red line is the unminimized take model scenario without the HCP (take continues without powerline minimization, and without conservation measures). Blue line is with the proposed HCP according to the schedule of conservation measures (i.e., powerline collision minimization) described in Chapter 4. The grey line is with the proposed minimized take; the purple line is with no take. See Table 5-1 in Chapter 5 for additional description of each model scenario. The vertical dashed lines denote the first and last year of the permit term.

5E.3 Model Limitations, Uncertainties, and Assumptions

The population dynamics model described in this appendix is a useful tool with which to compare outcomes to Newell's shearwater ('a'o) on Kaua'i both with and without the KIUC HCP. The model is also an important tool to confirm that the quantitative biological objectives for Newell's shearwater ('a'o), particularly at the conservation sites, can be achieved by the end of the permit term. However, as with all models there are uncertainties in model inputs and outputs that should be considered. Model limitations include, but are not limited to, the following.

- Lack of statistical confidence limits around the island-based estimates of abundance.
- Uncertainty in certain vital rates (e.g., barn owl predation rates on the wing and predation rates in areas without predator control and burrow monitoring).
- Uncertainty in the efficacy of future powerline strike minimization efforts (although continued powerline monitoring will help narrow those uncertainties within a few years).
- Logistical difficulties in monitoring the population outside of established conservation sites.

Due to these limitations, the uncertainty in the model results has not been quantified. However, any population dynamics model of Newell's shearwater ('a'o) relies on a suite of assumptions. The assumptions chosen for this model were selected to be as conservative as reasonably possible knowing that many model uncertainties have not been quantified. A list of the key assumptions is provided below for this model, with reasons these assumptions may be conservative or optimistic in terms of predicting effects of the HCP conservation measures on this species. These sections are intended to provide the reader with a qualitative understanding of the level and sources of uncertainty in model results.

5E.3.1 Conservative Assumptions

Reasons why the population dynamics model may be conservative (i.e., overestimates adverse effects or underestimates beneficial effects for Newell's shearwater ['a'o]) include the following.

- **Total powerline strikes.** The reported point estimate that is used as a model input for the annual average of seabird strikes corresponds to the mean of the Bayesian posterior predictive probability distribution, corrected to account for strikes that were subsequently recategorized as waterbirds (Travers et al. 2020; Travers, unpublished data). For a right skewed (longer right tail) probability distribution, like the Bayes posterior predictive probability distribution for seabird strikes, the mean is greater than the expectation of the estimate. Statistically, this results in using a conservative (i.e., higher) level of powerline collisions in the model than would be expected from the data.
- **Strike allocation.** Allocation of powerline strikes may be even lower at some or all of the conservation sites than estimated, given flight paths, and observed altitudes from satellite tagging. For example, the estimated breeding probability from burrow monitoring data at seven conservation sites for Newell's shearwater ('a'o) during 2012–2019 is 0.993 (Raine et al. 2022b), which indicates that non-predation sources of mortality for breeding adults were quite low in these areas.

- **Population trend and optimal growth rate.** The modeled population trend for the Hanalei to Kekaha area assumes a relatively steep rate of decline, based on the long-term trend from the Hanalei radar site. Given both recent and longer term radar trends from the other non-Hanalei radar sites, the population trend is unlikely to be that steep for all breeding colonies in this area.

  Raine and Rossiter (2020) have shown that the average trend in radar estimates across sites has leveled out since 2010, indicating that after a very large decline in abundance the population trend may now be relatively stable in the Hanalei to Kekaha area. For example, a regression of radar data including all 13 monitored sites was flat with no significant increase or decrease during the last decade (2010–2020). This seems to suggest that during the last decade mortality levels have decreased, perhaps due to mechanisms like remaining colonies being confined to habitat that is less accessible to introduced predators (Raine and Rossiter 2020).

  This pattern is also consistent with data on the amounts of rescues of Newell's shearwater (ʻaʻo) from the SOS Program, which are relatively stable over a similar period (Ainley et al. submitted).

  Therefore, based on these three data sources (radar signatures, SOS rescues, and acoustic call rates) the aggregate modeled population trend in the absence of minimization and mitigation is likely to be conservative, at least in terms of observed trends over the last decade. If the aggregate population trend is more positive (either a smaller negative number or a number close to zero for a stable population), then the effects of the HCP conservation strategy will result in a greater benefit to the island-wide metapopulation of Newell's shearwater (ʻaʻo) than what is estimated.

  It is also worth noting that the optimal rate of modeled population growth assumed in the model is much lower than has been estimated for the family Procellariidae (all petrels, prions and shearwaters) in many published allometric and demographic modeling studies. The results of those studies are consistent with species in this seabird family having expected maximum rates of population growth closer to 6.8 percent per year (Dillingham et al. 2016) or 7.1 percent per year (Dillingham and Fletcher 2011), depending on the methods used. This model assumed a maximum rate of modeled population growth (i.e., in the absence of introduced predators, powerline strikes or light fallout mortality) of 2.36 percent per year.

- **Social attraction.** Birds are assumed to be attracted to social attraction sites with an equal per capita probability from all other areas for which island-based abundance estimates are available.[8] This is a reasonable assumption without any data to suggest otherwise.[9] However, the assumption may be conservative. If birds attracted to social attraction sites come mostly from non-managed sites, then the benefits to the island-wide metapopulation of the social attraction sites would be even greater than what the model estimates.

  Additionally, the modeled dynamics of social attraction sites ignore any benefits that nearby nesting birds may have in terms of attracting prospecting birds. The modeled numbers at social attraction sites start at zero birds for the first 3 years, then slowly increase with an average of 1.6 new breeding pairs during the first 9 years, after which that number increases to an average of 13.7 new breeding pairs becoming established each year (Table 5E-9). In other words, there

[8] The exception to this is when a bird is born into a social attraction site after social attraction begins, that bird is assumed to return to that site or spillover and nest in the surrounding open management area for the rest of its life and not emigrate to another social attraction site. In general, the model assumes natal fidelity and internal recruitment to each modeled area, with the exception being dispersal of breeding age birds into the social attraction sites from other areas.

[9] Social attraction assumptions were based, in part, on published literature for similar seabirds outside of the Hawaiian Islands.

is a lag before social attraction sites reach a critical mass and start attracting more than 10 breeding pairs per year. Given that the planned social attraction sites exist in areas with existing breeding pairs nearby (e.g., at Upper Limahuli), there may be less of a time lag for the initial rate of attraction to social attraction sites than assumed in the model. If this is the case, the growth at a conservation site would be faster than predicted by the model, resulting in a larger conservation site subpopulation at the end of the permit term than predicted.

- **Fallout from light attraction.** A constant number of 92.6 age-1 (fledglings) from the Hanalei to Kekaha subpopulation are assumed to die annually from fallout associated with KIUC facilities and streetlights. The estimated level of fallout includes correction factors for the proportion of grounded seabirds that go undetected, e.g., for KIUC streetlights, 89.6% of grounded Newellʻs shearwater (ʻaʻo) are assumed to go undetected (Appendix 5C: *Light Attraction Modeling*). Fallout, whether detected or not, is assumed to result in 100% mortality in the model. This assumption is conservative for three reasons: (1) The estimate for fallout is based on the number of expected streetlights and facility lights at the end of the permit term, not at the beginning. Fallout from light attraction is therefore likely overestimated at the start of the projections; (2) This assumes zero individuals rehabilitated by the SOS program survive; and, (3) Fallout mortality is modeled as a fixed number of fledglings lost, not a mortality rate. In other words, even when the Hanalei to Kekaha subpopulation is much smaller at the end of 50 years, 92.6 fledglings (or the number of modeled fledglings produced, whichever is smaller) are still removed in the model from this area each year. Furthermore, the level of mortality from fallout is estimated to be less than five percent of the level of mortality estimated from powerline collisions. So, while fallout mortality is a contributing factor to metapopulation dynamics, it does not have as large of an effect on metapopulation trends as powerline collisions.
- **Conservation actions performed by others.** The population dynamics of the Kauaʻi metapopulation of Newell's shearwater (ʻaʻo) are modeled only assuming the full implementation of this HCP's conservation strategy and that of the KSHCP (i.e., the Kahuamaʻa social attraction site). Numerous federal, state, and local agencies and conservation organizations are either implementing or planning to implement additional conservation actions separately from this HCP and the KSHCP, and which will benefit Newell's shearwater (ʻaʻo). Similarly, due to a lack of available estimates for reductions in predation rates resulting from barn owl control at the conservation sites, no attempt has been made to include the benefit of that form of predator control effort at the conservation sites. Because this model does not consider these other current or planned conservation actions, the impacts of the taking of this HCP are conservative (i.e., overestimates effects).

5E.3.2 Potentially Optimistic Assumptions

Reasons why the population dynamics model for Newell's shearwater (ʻaʻo) may be too optimistic (i.e., underestimates adverse effects or overstates benefits) include the following.

- **Total metapopulation size.** The estimate of the island-wide metapopulation may be too high, despite the integration of multiple independent data sources, and what are thought to be conservative assumptions by experts. If this is true, then impacts of the taking would be greater than predicted by the model. However, all else being equal, the *relative* effects of the HCP would be the same because the comparison is made with and without the HCP using the same initial abundance estimate and estimates of trends in relative abundance (i.e., positive trends in call rates from the conservation sites and negative trends in relative abundance from the radar survey). Also, if a smaller value for metapopulation abundance were used, the modeled trend would become inconsistent with long-term monitoring data (e.g., the modeled rate of decline in the Hanalei to Kekaha area would be even more negative compared to the lowest estimated rates of decline from the radar survey). Such a steep rate of decline, which would result from the estimated number of powerline collisions if abundance was indeed lower would not be supported by the best available science on long-term trends in abundance.

- **Social attraction.** As noted above, birds are assumed to be attracted to social attraction sites with an equal per capita probability from all other sites (e.g., if half the island-wide population is estimated to be from Hanalei to Kekaha area in a given year, then half the number of birds immigrating into social attraction sites would be from Hanalei to Kekaha that year). Shearwaters and petrels are known to have a high level of natal fidelity (e.g., Harris 1966; Perrins et al. 1973; Warham 1980), however, and therefore this assumption could be optimistic because it would result in more immigration from areas with high predation and powerline mortality rates into "safe havens" than under a stronger model of natal fidelity.
- **Cat predation events.** The model is deterministic, which means that mortality and reproductive rates are assumed to be constant between years (with the exceptions of powerline collision minimization and the effects of immigration into social attraction sites). As such, interannual variation (stochasticity) in predation rates is not modeled even though the number of predations by cats can be variable between years. In particular, there have been instances of individual cats predating multiple nests during certain years before they have been caught. As such, a conservation site may have low predation mortality rates for a period of years, with an incursion of a single problem cat one year leading to a spike in predation mortality rates that year. Breeding pairs and chicks inside predator exclusion fences may be subject to such events in rare instances (i.e., before the cat incursion is caught on camera and additional control efforts can be deployed). Such events may also occur outside of conservation sites despite aggressive predator control techniques.

  The predation mortality rates used in the model are based on burrow monitoring data from multiple conservation sites over multiple years. The resulting estimate represents an average annual predation mortality rate under predator control that includes punctuated predation mortality events due to single cats. If the estimated predation mortality rate from burrow monitoring surveys does not fully capture the extent or frequency of these predation events, the model results with respect to the benefits of predator control at the conservation sites would be optimistic. However, independent acoustic monitoring data indicate that at least since 2014/2015, the extent of punctuated cat predation events has not resulted in negative trends in recruitment into the breeding colonies at the conservation sites. Instead, call rates have continued to increase, and have doubled at most of the conservation sites under predator control efforts (Raine et al. 2022a). Call rates have continued to increase, despite predation events having occured during the same time.
- **Carrying capacity.** Social attraction sites inside predator exclusion fenced sites are modeled using estimates of carrying capacity for the number of breeding pairs that could nest in these areas. These sites are relatively small and available nesting habitat is well defined by the fenced permiter. Additionally, the rate of increase in breeding pairs in these areas is assumed to be relatively high after 10 years, given the expected number of new immigrants attracted to these areas once they reach a critical mass (Table 5E-9). Therefore, reaching carrying capacity of breeding pairs during the permit term seems likely.

Conversely, there is no assumption in the model that population growth in the adjacent management areas will be limited by carrying capacity during the 50-year permit term. If, in the future, population growth in the adjacent mangement areas is limited by the carrying capacity of suitable nesting habitat, and there is emigration out of those conservation sites to areas without the benefit of predator control and where powerline collision vulnerability may be higher, the model results would overestimate the long-term benefit of the conservation sites to the metapopulation. However, not only are carrying capacities difficult to estimate reliably for the large, adjacent management areas, but estimates of predation rates prior to dedicated predator control in the conservation sites in combination with the assumed low rates of population recovery suggest that reaching carrying capacity in the adjacent management areas is not likely during the permit term.

- **Allee effects.** The model does not account for compensatory or depensatory density dependence on the population growth rate. The former would account for higher expected population growth rates at lower population sizes, for example due to decreasing competition for resources. The latter, also known as "Allee" effects, arises in situations where population growth rates might be expected to decrease at lower abundance levels, for example due to difficulties finding a mate at low densities. Given that Newell's shearwater (ʻaʻo) is a threatened species with a low intrinsic rate of increase, there does not seem to be support for considering compensatory density dependence during the permit term. However, if modeled subpopulations that are predicted to be vulnerable to large declines (e.g., Waimea Canyon and Hanalei to Kekaha areas) experience Allee effects at lower densities in the future, the degree of the modeled declines there could be optimistic. There is no indication that Allee effects are occurring at recent abundance levels, at least at the broader scales monitored by the radar survey. Recent population trends from the radar data seem to be generally flattening out instead of showing accelerating rates of decline (Raine and Rossiter 2020), but Allee effects are a possibility at smaller spatial scales with remnant breeding colonies in areas of the island without predator control.

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Appendix 5F

Population Dynamics Model for Hawaiian Petrel (‘ua‘u) on Kaua‘i

The purpose of this appendix is to describe the population dynamics models developed by KIUC for Hawaiian petrel (ʻuaʻu). The population dynamics model for Newell's shearwater (ʻaʻo) is presented in Appendix 5E, *Population Dynamics Model for Newell's Shearwater (ʻaʻo) on Kauaʻi*.

A population dynamics model was not developed for band-rumped storm-petrel (ʻakēʻakē) because of the lack of data on this species.

The population dynamics model for Hawaiian petrel (ʻuaʻu) was developed for the following specific uses in the HCP.

1. To evaluate the effects of the requested take authorization of the species from KIUC's covered activities (described in Chapter 5, *Effects*) in the absence of any mitigation.
2. To quantify the benefits of the conservation measures proposed in Chapter 4, *Conservation Strategy*, to the Kauaʻi metapopulations of these species.
3. To determine the net effects of the HCP covered activities and conservation measures on the Kauaʻi metapopulation of this species and to quantify the net benefit provided by the HCP.
4. To track population trends during HCP implementation over the 50-year permit term.

This appendix is divided into four sections: (1) Overview of the model, including methods, initial conditions, technical specifications, and tables with model input values, (2) Model results, (3) A discussion of model limitations, uncertainties, and assumptions, and (4) References cited.

The appendix and population dynamics models were developed by John R. Brandon, PhD, Senior Biometrician at ICF with extensive review by David Zippin, PhD, Senior Conservation Biologist. Dr. Brandon designed the mathematics and code for the modeling framework. Model inputs were developed in close collaboration with André F. Raine, PhD, Science Director for Archipelago Research and Conservation (ARC) and Marc Travers, MS, Senior Scientist at ARC, both of whom are experts on seabird biology and lead scientists on multiple studies of endangered seabirds on Kauaʻi. Dr. Raine and Mr. Travers provided input and data for many of the model parameters as cited throughout the appendix.

5F.1 Overview of the Population Dynamics Models

The model for Hawaiian petrel (ʻuaʻu) is composed of nine distinct subpopulations. Six of the subpopulations correspond to conservation sites proposed in the HCP where Hawaiian petrel (ʻuaʻu) breeding pairs are estimated to occur. Breeding pairs of Hawaiian petrel (ʻuaʻu) have not been observed and are not predicted based on habitat suitability models (Troy et al. 2017) to nest at Conservation Site 10.[1] Hence, unlike Newell's shearwater (ʻaʻo) a subpopulation of Hawaiian petrel (ʻuaʻu) was not modeled for this conservation site. Likewise, it was assumed that the planned social attraction site at Conservation Site 10 would not benefit this species. In general, the social attraction site efforts are not aimed at attracting Hawaiian petrel (ʻuaʻu). For example, species-specific playback calls are only planned for Newell's shearwater (ʻaʻo). Therefore, it is assumed that no Hawaiian petrel (ʻuaʻu) will immigrate into the social attraction sites. The modeled subpopulations

[1] KIUC will select a tenth conservation site (Conservation Site 10) but the final location of this site is still under evaluation. See Figure 4-6 for the general location of the site. The conservation benefits of Site 10 are based on the previously selected site that proved infeasible (Upper Mānoa Valley). KIUC will ensure that Site 10 will provide equal or greater benefit than the Upper Mānoa Valley site it is replacing.

are listed in Table 5F-1 with their locations illustrated in Figure 5F-1 (see Chapter 4, *Conservation Strategy*, and Appendix 4A, *Conservation Site Selection*, for a map and details of the corresponding conservation sites).

Outside of the six conservation sites with Hawaiian petrels (ʻuaʻu), the rest of Kauaʻi was subdivided into three subregions[2] that correspond to the known metapopulation distribution of this species on Kauaʻi (see Figure 2 in Appendix 3A, *Species Accounts*). Unlike Newell's shearwater (ʻaʻo), no Hawaiian petrel (ʻuaʻu) are estimated to occur in the Waimea Canyon area, but they are known to occur in the Hanalei to Kekaha area, the Wainiha and Lumahaʻi Valleys area, and the Kalalau east to Upper Mānoa area, so these areas were included in the model for this species. Each area in the model encompasses a geographic portion of the island that has similar conservation threats and management efforts for the species, as well as similar available data sources for estimating the abundance and trends of breeding pairs that nest there (Table 5F-2).

The modeling framework allows each subpopulation to have its own set of vital rate values and therefore different trends in abundance through time. This reflects the fact that pressures such as powerline collisions and predation vary depending on region and topography. For example, the remote areas in the northwestern region of the island do not have powerlines (see Figure 5F-1). Available tagging data is consistent with the flyways of breeding colonies in those areas, resulting in little to no vulnerability to powerline collisions (e.g., Raine et al. 2017a). For breeding colonies in northwestern Kauaʻi (including the conservation sites), where powerline collision vulnerability is low and predator control efforts have been effective, acoustic monitoring data has demonstrated increases in abundance since 2014–2015 (Raine et al. 2022). The opposite is true in other areas of the island where breeding colonies are particularly vulnerable to powerline collisions and light attraction. Examples include those sites that have flyways crossing the Powerline Trail in the middle of the island, where collisions are known to be highest (Travers et al. 2020; also see Figure 5-1 for estimated relative rates of bird strikes per wire span).

Furthermore, available monitoring data also differs by each area. For example, radar survey data, which is the longest running systematic monitoring study to estimate trends in relative abundance for this species on Kauaʻi, are only available from areas with road access (the radar system is mounted on a vehicle).

The spatially explicit model developed here accounts for these differences and complexities in the overall metapopulation dynamics and allows monitoring data (e.g., trends) from different areas to be incorporated in the model. The vital rates for each subpopulation are also modeled to change through time as future management efforts are implemented, corresponding to the timeline of these measures described in Chapter 4, *Conservation Strategy*. For example, increases in estimated powerline strike minimization efficacy are modeled through time to reduce powerline strike mortality rates. Similarly, the timing of installation of predator exclusion fencing around particular management sites are modeled to reduce predation mortality rates for the corresponding subpopulations at those sites in future years.

Island-based estimates of abundance for each subpopulation are used to initialize population trajectories, which are then projected forward in time through the 50-year permit term. For

[2] Unlike Newell's shearwater (ʻaʻo; Appendix 5E), there were zero Hawaiian petrel (ʻuaʻu) breeding pairs estimated in one of the four subregions of Kauaʻi outside the conservation sites. The breeding pair estimates for Hawaiian petrel (ʻuaʻu) are described in Section 1.1, *Initial Conditions*. Subpopulation dynamics of Hawaiian petrel (ʻuaʻu) were not modeled for those subregions with zero estimated breeding pairs.

simplicity, the model does not assume any dispersal among the Kauaʻi subpopulations, which is reasonable because shearwaters and petrels exhibit strong natal philopatry[3] (e.g., Harris 1966; Perrins et al. 1973; Warham 1980) and established breeding pairs typically return to the same nesting burrow year after year. The model also does not assume any dispersal between Kauaʻi and other islands in Hawaiʻi.

Table 5F-1. Modeled Subpopulations, HCP Status, and Associated HCP Management Actions

Modeled Subpopulation	HCP Status	HCP Management Actions (see Chapter 4 for details)
Pihea[a]	Conservation site	Predator control[b] and partial pig fence
North Bog[a]	Conservation site	Predator control[b] and partial pig fence
Pōhākea[a]	Conservation site	Predator control[b] and partial pig fence
Hanakāpiʻai[a]	Conservation site	Predator control[b]
Hanakoa[a]	Conservation site	Predator control[b]
Upper Limahuli Preserve[a]	Conservation site	Predator control[b] and ungulate exclusion fencing
Hanalei to Kekaha	N/A	None
Wainiha and Lumahaʻi Valleys	N/A	None
Kalalau east to Upper Mānoa (excluding conservation sites)	N/A	None

[a] Ungulate (deer, pig, and goat) exclusion or partial pig exclusion fence is already in place. Partial pig exclusion fences block pigs from accessible portions of a site's perimeter.
[b] Predator control involves species specific efforts for ungulates, cats, rodents, and barn owls.

[3] *Natal philopatry* is the tendency of an animal to return to breed in the place of its birth.

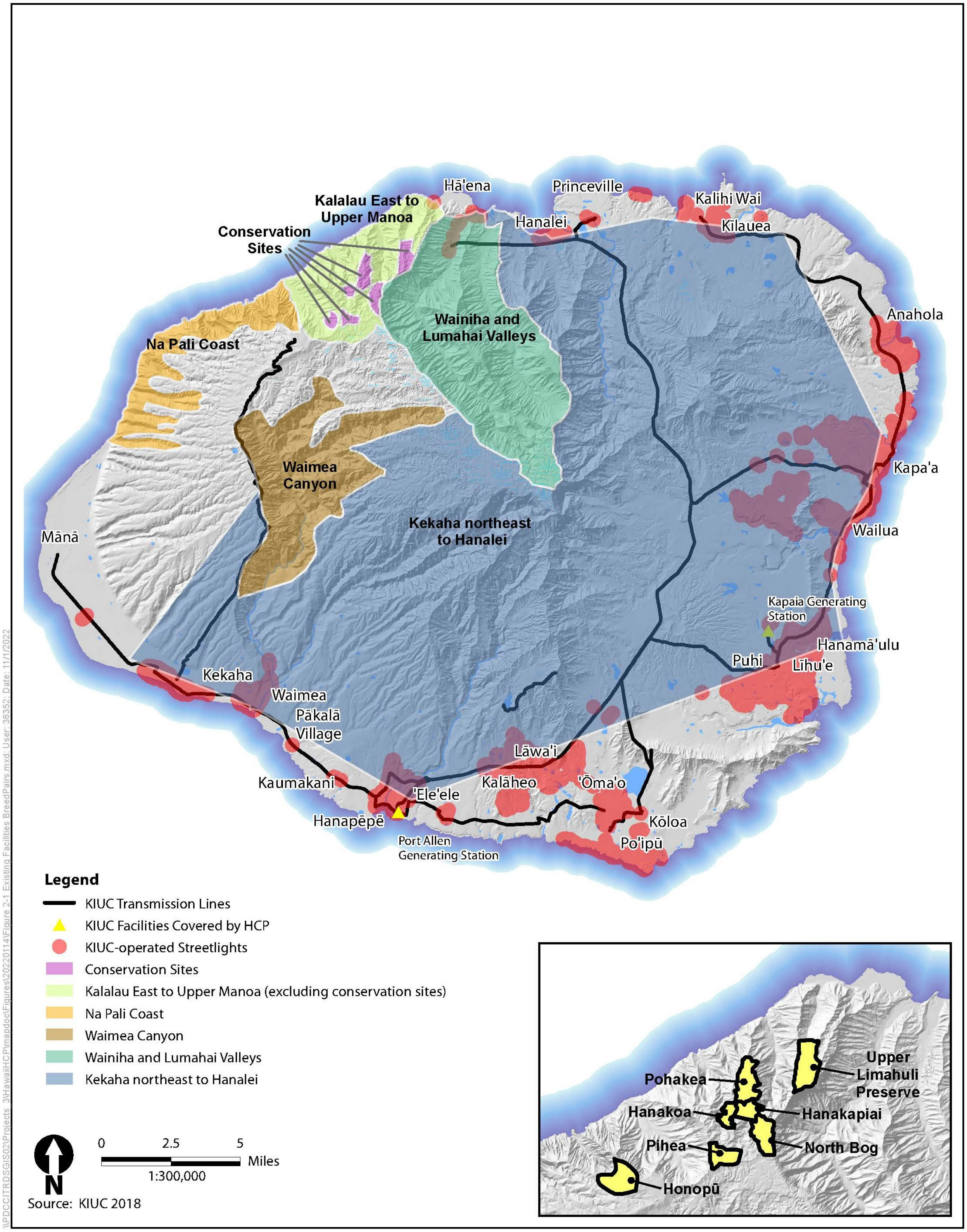

Figure 5F-1. Locations of Regional Subpopulations in Population Dynamics Models for Hawaiian Petrel (‘ua‘u) and Location of KIUC’s Covered Facilities

5F.1.1 Initial Conditions

The initial conditions for the model were set in 2019, before projections forward in time from that year were carried out. Modeled reductions in powerline line mortality rates due to minimization efforts that are accounted for in the model start in 2020. Population trajectories for Hawaiian petrel (ʻuaʻu) were based on the following parameter categories, each of which is described below:

1. Estimates of **abundance** on Kauaʻi.
2. **Vital rates** by age class under optimal conditions (i.e., natural mortality rates in the absence of introduced predators and powerlines).
3. Estimates of **powerline injury and mortality**, prior to 2020 minimization efforts.
4. Estimates of **predation rates** with and without predator control measures.
5. For the Hanalei to Kekaha area and the Waimea Canyon area, the modeled abundance was initialized based on **trends from the long-term radar survey**, in combination with estimates of powerline injury and mortality, prior to 2020 minimization efforts.

5F.1.1.1 Estimates of Abundance on Kauaʻi

All population dynamics models must begin with an estimate of initial population size to forecast future abundance levels. Published estimates of abundance for Hawaiian petrel (ʻuaʻu) are available from transect surveys conducted on ships at sea (Spear et al. 1995; Joyce 2016). Because of the use of these estimates in previous studies for listed seabirds on Kauaʻi, the at-sea population estimates and their limitations are summarized below. This summary is followed by an explanation of the methods used for this HCP to develop a spatially explicit metapopulation abundance estimate of Hawaiian petrel (ʻuaʻu) on Kauaʻi.

At-Sea Abundance Estimates

Seabird populations are often estimated using counts of birds observed at sea and calculations of what proportion of the total population may have been sampled. This technique is used because (1) a substantial fraction of seabirds remain at sea prior to reaching breeding age, and (2) at-sea surveys can enumerate populations which may have breeding colonies spread over different islands or geographic locations, and which can otherwise be difficult to locate and count on land during the breeding season. This is the case for Hawaiian petrel (ʻuaʻu)—nesting adults are nocturnal, and nests are located underground in densely vegetated and rugged, remote montane environments.

At-sea estimates were not adopted for the HCP seabird population dynamics models because they include serious spatial deficiencies in geographical survey coverage. For example, during the breeding season adult Hawaiian petrel (ʻuaʻu) are known to forage in the North Pacific (e.g., Adams and Flora 2010), outside the survey areas included in the at-sea abundance estimates, leading to uncorrected sources of statistical bias. Further, at-sea estimates alone, even if they could be corrected for these biases, provide only a single population estimate. That single estimate would need to be split into the proportion of the at-sea population of Hawaiian petrel (ʻuaʻu) that are associated with breeding colonies on Kauaʻi, and then further subdivided for different areas (e.g., the conservation sites) on Kauaʻi, given the spatial complexities that are relevant to conservation and management. In other words, what proportion of the at-sea estimates of abundance represents those birds associated with the conservation sites? Such assumptions would have a high degree of uncertainty, so it is preferable to use available survey data from the conservation sites themselves. Survey data at the conservation sites provide a more current and defensible estimate of covered seabird abundance than older at-sea estimates.

For all of these reasons we chose not to utilize at-sea population estimates. Instead, the population estimates used to initialize the model are based on different Kaua'i-specific data sets, as described below.

Breeding Pair Population Estimates on Kaua'i

Given the serious limitations of the at-sea abundance estimates, which miss a significant (but as of yet unquantified) proportion of the island's breeding population—as well as the fact that breeding colonies in different areas of Kaua'i are not uniformly vulnerable to threats such as introduced predators, light fallout, or powerline strike mortalities —staff at ARC developed spatially explicit estimates of Hawaiian petrel ('ua'u) breeding pair abundance on Kaua'i for this HCP.

These estimates were adopted as the basis for calculating the initial model population size in the HCP population dynamics model. They also allow for a modeling approach that can help to address the fundamental question of whether localized conservation efforts (e.g., predator control, predator-proof fencing, or social attraction sites) in targeted breeding areas on Kaua'i can result in a sufficient net benefit to offset future minimized powerline strike mortalities for the island-wide population (i.e., metapopulation) on Kaua'i. An important innovation of the HCP population dynamics model is that it considers important spatial differences in mortality risk in different areas of Kaua'i, as discussed below.

Breeding pair abundance in 2021 was estimated for each of the modeled subpopulations (Table 5F-2, Figure 5F-1). The approach used to estimate the number of breeding pairs differed between areas, dictated in part by the extent to which various data sources are available (or lacking) for each area. In general, however, the breeding pair estimates developed by ARC are informed by acoustic call rate and nesting burrow monitoring studies, which have demonstrated a significant relationship between call rates and estimated densities of active nesting burrows (e.g., Raine et al. 2019). These acoustic call rates are used in combination with published habitat suitability models (Troy et al. 2014, 2017). To the extent possible, the most recently analyzed study data from 2021 have been used to inform the resulting breeding pair estimates.

For the single modeled area of Kaua'i that has the highest level of powerline collisions (Hanalei to Kekaha; Travers et al. 2020), preliminary model results indicated that ARC's estimates of breeding pairs for this area was, in combination with the biological assumptions in the model, incompatible with the observed trends from the radar survey and the level of mortality from the average annual unminimized strike estimate during 2013–2019. In other words, preliminary model results for the Hanalei to Kekaha area, when based on ARC's breeding pair estimates and the low modeled maximum population growth rate (i.e., resiliency), produced modeled subpopulation trends from unminimized powerline strike mortality rates that were much more negative (i.e., much greater projected declines) than any trends estimated from the radar survey since that systematic survey began collecting data in 1993.

Therefore, an alternative approach was used to calculate the breeding pair abundance necessary to sustain the rate of decline observed in the radar data (Raine et al. 2017b; Raine and Rossiter 2020), given the estimated average annual number of unminimized powerline collisions during 2013–2019 for these two areas (Travers et al. 2020). This approach to initialize the breeding pair abundance in the model for the Hanalei to Kekaha area is described in more detail under the area-specific descriptions of breeding pair abundance estimation process and background considerations for each modeled subpopulation below. Using estimated trends from radar data to initialize the model also integrates the effects of powerline collisions and light fallout prior to the HCP, to the extent available data allow, because the trend estimate is based on radar survey data starting in 1993.

Table 5F-2 provides a summary of the approach used for each modeled subpopulation as well as a relative comparison of mortality sources (the differences in mortality help explain why individual subpopulations were modeled) and uncertainty in the estimate of abundance. Where certainty in abundance was “moderate” and habitat suitability modeled was used (i.e., Kalalau east to Upper Mānoa), nesting densities were extrapolated from other areas with available data and expert opinion was used to derive density correction factors to account for lower expected nest densities in areas with higher levels of mortality (i.e., due to unmanaged predation outside the conservation sites).

Table 5F-2. Summary of Approach to Initial Population Estimate, Relative Mortality Levels by Source, and Data Availability by Modeled Subpopulation for Hawaiian Petrel (ʻuaʻu)

Modeled Subpopulation	Data Sources Used for Initial Population Estimate	Relative Population-Level Mortality by Source			Certainty in Abundance Estimate
		Powerlines	Light Attraction	Predation	
Existing Conservation Sites (6)[a]	Habitat suitability model and auditory survey polygons (based on annual surveys)	Low	Low	Low	High
Wainiha and Lumahaʻi Valleys	Habitat suitability model and auditory survey polygons	Low	Low	Moderate	Moderate
Kalalau east to Upper Mānoa	Habitat suitability model and cover ratios[b] calculated from auditory survey polygons in Wainiha & Lumahaʻi	Low	Low	Moderate	Moderate
Hanalei to Kekaha	Radar trend and powerline strike estimate	**High**	Moderate	**High**	Low

[a] There are six existing conservation sites where Hawaiian petrel (ʻuaʻu) are known to occur: (1) Upper Limahuli Preserve; (2) Pihea; (3) North Bog; (4) Pōhākea; (5) Hanakāpīʻai; and, (6) Hanakoa.
[b] Cover ratios were used to extrapolate the fraction of suitable habitat used by nesting seabirds detected through acoustic surveys to areas without available acoustic survey data, before applying density correction factors to account for lower nesting densities in areas that have been more greatly impacted by powerline strike, light attraction, and predation mortalities (Raine et al. 2019).

Hanalei to Kekaha

This area is the most affected by powerline collisions, light attraction, and predation (e.g., Troy et al. 2017; Figure 5F-1). It is also the area of the island for which trends in relative abundance have been estimated through the long-term systematic radar survey since 1993 (e.g.,Day and Cooper 1995; Raine et al. 2017b). Thirteen radar sites have been surveyed since 1993 in the Hanalei to Kekaha area. Two additional radar sites have also been surveyed in Wainiha and Lumahaʻi Valleys starting in 2006, where trends have been stable (Raine and Rossiter 2020; see below for details).

The radar survey on Kauaʻi represents the longest systematic monitoring study of trends in abundance for this species. Raine et al. (2017a) estimated the average rate of decline in Newell's shearwater (ʻaʻo) abundance, between 1993 and 2013, across all radar sites in the Hanalei to Kekaha area at approximately -6 percent per year. Since that study, Raine and Rossiter (2020) present the most recent estimates for the long-term subpopulation trend for this area. When averaged across all radar sites in this area, the more recent estimate of the average annual rate of decline is -4.7 percent per year during 1993–2020. During those three decades, the most extreme rate of decline for any of the 13 individual radar sites in this area has been estimated at the Waiakalua Stream site. The trend in relative abundance from that radar site is -8.1 percent per year during 1993–2020.

As noted above, the total breeding pair estimates developed by ARC for Hanalei to Kekaha were found through preliminary modeling results to be incompatible with the estimated number of powerline collisions, associated mortalities, and the most negative trend estimated from radar survey data. Given the biological assumptions in the model, this combination of factors, as initially explored (i.e., relatively small abundance relative to the magnitude of powerline collision mortalities for a species with low maximum rates of modeled population growth) led to modeled rates of decline that were much greater than any trends that have been observed through the radar surveys in this area, or elsewhere.

To correct this inconsistency, an alternative approach to initializing abundance for the Hanalei to Kekaha area was developed so the model would match both the magnitude of powerline collisions estimated from acoustic monitoring and trends in abundance estimated from the long-term systematic radar surveys.

The initialization approach for Hanalei to Kekaha involved solving for the combination of (1) abundance at age, and (2) the subadult and adult powerline mortality rates that result in the estimated number of collision mortalities, while matching the -8.1 percent rate of decline estimated from the radar survey at the Waiakalua Stream radar site (a worst-case recent trend) and the assumed proportions of powerline collisions that are subadults and adults. The solutions for abundance and powerline mortality rates at age were found using non-linear numerical optimization (a penalized maximum likelihood approach) as implemented in the Stan programming language using the *cmdstanr* package (Stan Development Team 2022; Gabry and Češnovar 2022). The specific penalties used to fit the model were as follows.

1. The Bayes acoustic estimate of powerline strikes was assumed to follow a log-normal distribution with a mean in log-space corresponding to the strike allocation for this area (described below), and a coefficient of variation assumed to be 0.01, which ensures the resulting modeled number of strikes matches the mean of the reported estimate.
2. The trend from the radar data was modeled as a normally distributed random variable with a standard error of 0.01, which again ensured the resulting modeled trend matched the point estimate for the rate of decline.

3. The proportion of powerline collisions that were subadult was assumed to follow a Beta (11, 3) probability distribution, which corresponds to the sample of 14 downed Newell's shearwaters (ʻaʻo) examined by Cooper and Day (1998), with 11 of those birds categorized as subadults and 3 as adults, i.e., the expected proportional age-class split for Hawaiian petrel (ʻuaʻu) was assumed to be the same as estimated for Newell's shearwater (ʻaʻo) and was 79 percent subadult and 21 percent adult.

The estimate of powerline collisions is an annual average during 1993–2019. It was assumed that this estimate pertained to 2016, the midpoint year of the acoustic monitoring data analyzed by Travers et al. (2020). In an analogous example, this approach is to the same as solving a problem where one wants to calculate the amount of money in a stock market account one year earlier. If one knows the rate of decline in the market from one year to the next was -10 percent, and the account lost $10 last year, there must have been $100 in the account before the loss.

The resulting abundance at age from this approach was then projected forward from 2016, under the assumption of a stable age distribution at the -8.1 percent rate of decline, through 2019, after which time the initial unminimized powerline mortality rates at age were reduced each year according to the modeled minimization schedule under the HCP.

Estimates for the number of annual powerline collisions are not available prior to 2013. However, incorporating estimated trends from radar data to initialize the model integrates the effects of powerline collisions and other sources of mortality prior to 2013, to the extent available data allow, because the radar trend is based on observations starting in 1993.

Upper Limahuli Preserve, Pihea, North Bog, Pōhākea, Hanakāpiʻai, and Hanakoa)

These conservation sites have the highest level of management (mainly predator control) and are in northwest Kauaʻi away from most powerlines and light sources (Figure 5F-1). The Upper Limahuli Preserve and North Bog conservation sites are close to the towns of Hāʻena and Wainiha and thus closer to powerlines and light sources. There is one streetlight at Hāʻena Beach Park that is approximately 0.4 mile (0.64 kilometer [km]) north of the Upper Limahuli Preserve; however, all lights and powerlines are over 1 mile (1.6 km) to the east. The remaining four conservation sites, which are in the Hono O Nā Pali Natural Area Reserve, are west of the Upper Limahuli Preserve and North Bog conservation sites, and thus are over 3 miles (4.8 km) from the nearest powerlines or light sources to the east.

The covered seabirds in this area are expected to be affected the least of any area by all stressors (Table 5F-2). This area also has the best available data (e.g., annual auditory surveys, extensive burrow searches) for abundance estimates based on annual monitoring surveys (e.g., Raine et al. 2022). Breeding pair estimates have been conducted on an individual basis for the conservation sites and have been presented previously in annual ARC monitoring reports (e.g., Archipelago Research and Conservation 2021; Raine et al. 2022).

In 2017, the first population estimates were produced for all monitored management areas using two independent methods: a habitat suitability model, which utilized the peer-reviewed models presented in Troy et al. (2014, 2017) where suitable habitat ranked 7+ and an average nearest-neighbor distance was used from known burrows at monitored colonies to model density, and a regression analysis of acoustic monitoring data, which provides an estimate of active burrows (i.e., breeding pairs) as a function of call detections, given previous studies comparing paired visual and acoustic data in the same nesting areas. Based on the outputs of the two models, it was decided that the habitat suitability model was the most appropriate way of providing population estimates and that the acoustic method would need to be further refined before it could be used for this metric (see Raine et al. 2019). For these sites, habitat suitability modeling (Troy et al. 2014, 2017) is also employed for portions of the conservation sites outside the acoustic arrays, using the estimated nearest neighbor distances between active burrows (i.e., burrow densities) to predict breeding pair numbers outside the acoustic array footprint.

The habitat suitability model was updated in 2021 by including (i) new polygons from auditory surveys undertaken in 2021 and (ii) total surface area to take into account vertical space such as drainages and cliff walls. Two population estimates were then created for each site: (i) a low population estimate using only polygons related to “hot spot heavy” or “ground calling activity” and (ii) a high population estimate using *all polygons* collected during auditory surveys. In areas where suitable nesting habitat overlapped between Newell’s shearwater (ʻaʻo) and Hawaiian petrel (ʻuaʻu), i.e., where the habitat is suitable for nesting for either species, the habitat was partitioned between species to prevent double counting of available nesting habitat.

The breeding pair abundance in 2021 in the population dynamics model is equal to the lower of the two estimated values for all areas except for Hanalei to Kekaha, where the approach to estimating initial modeled abundance is described in the respective area description.

Kalalau East to Upper Mānoa

This area is in the northwest of Kauaʻi away from most powerlines and light attraction issues. However, this area is unmanaged and thus more heavily affected by predators than adjacent conservation sites. Like Hanalei to Kekaha, the Troy et al. (2014, 2017) habitat suitability model was used to estimate breeding pairs in this area, but only included suitable habitat with the highest probability of nesting occurrence (i.e., suitable habitat with less than the highest ranking was assumed to contain zero breeding pairs). The modeled suitable habitat was also further reduced by an elevation cutoff, such that suitable habitat below 1,922 feet (585.9 meters) above sea level for Hawaiian petrel (ʻuaʻu) was assumed to contain zero breeding pairs. This altitude represents the lowest height above sea level that an active nest has been detected during burrow monitoring studies in the conservation sites. The Kalalau east to Upper Mānoa area is largely unsurveyed, and therefore the estimated densities of active nests from Lumahaʻi Valley were used with the nearest neighbor distance from the conservation sites multiplied by 1.5, to account for active nests being more dispersed in this unmanaged area due to a lack of predator control measures.

Wainiha and Lumahaʻi Valleys

This area encompasses two of the largest valleys on Kauaʻi with Hawaiian petrel (ʻuaʻu). While affected to some degree by powerlines and light attraction, radar data has shown no trend since monitoring began in 2006 (e.g., Raine and Rossiter 2020) and tracking data shows that birds transiting over this area are predominantly higher than powerlines (Raine et al. 2017a). There is no predator management in this area, but in order to match the stable radar trend since 2006, it was assumed that predation rates were 25 percent of those in other unmanaged areas (i.e., that birds in these valleys have been confined to very steep and less accessible habitat and have reduced predation rates).

Auditory surveys were conducted in portions of Lumahaʻi Valley in 2020, and the corresponding call rate data was combined with survey data in both valleys in 2012–2014 and used after filtering out any call rates that did not meet the “heavy” and “ground calling” criteria (e.g., Raine et al. 2020), which excluded any breeding pairs associated with low-density nesting areas. Like other areas, habitat suitability modeling was also incorporated, and the breeding pair estimate for Wainiha and Lumahaʻi Valleys only included suitable habitat ranked at 8+ (i.e., suitable habitat ranked lower than 8 was assumed to contain zero breeding pairs). For areas within each valley that were not surveyed a cover ratio was applied. This was created by considering all areas within each site where auditory surveys were undertaken, drawing a. 0.6-mile (1-km) radius around each survey point, and creating a cover ratio within that survey radius of seabird activity polygons (heavy and ground calling) to suitable habitat. The cover ratio was then extrapolated to unsurveyed areas. The modeled suitable habitat was also further reduced by an elevation cutoff, such that suitable habitat below 1,922 feet (585.9 meters) above sea level for Hawaiian petrel (ʻuaʻu) was assumed to contain zero breeding pairs. This altitude represents the lowest height above sea level that an active nest has been detected during burrow monitoring studies in the conservation sites. The estimated densities of active nests were multiplied by 1.5, which reduced the breeding pair estimate, to account for active nests being more dispersed in unmanaged areas.

Table 5F-3. Abundance Estimates of Hawaiian Petrel (ʻuaʻu) on Kauaʻi in 2020 by Subpopulation and Age Class (males and females combined)

Subpopulation (see Figure 5F-1 for locations)	2021 Breeding Adults (ages 6+)[a]	2021 Subadults (ages 1–5)[b]	2021 Total Abundance (ages 1+)	Fraction of Total Powerline Strikes[c]	2016 Powerline Mortalities (all ages) per 100 breeding adults
Pihea	1,291	736	2,027	0.005	0.5
North Bog	1,759	1,002	2,761	0.020	1.5
Pōhākea	321	183	504	0.002	1.0
Hanakāpīʻai	578	330	908	0.004	1.0
Hanakoa	342	195	536	0.001	0.5
Upper Limahuli Preserve	224	127	351	0.003	2.5
Wainiha and Lumahaʻi Valleys	2,383	1,358	3,741	0.027	1.5
Hanalei to Kekaha	9,215	5,635	14,850	0.925	13.7
Kalalau east to Upper Mānoa (excluding conservation sites)	1,361	775	2,136	0.015	1.5
Total Kauaʻi abundance	**17,473**	**10,341**	**27,814**		

[a] Values for breeding adults correspond with the minimum theoretical estimate of abundance based on several alternative data sources, methods for estimation, and expert opinion (e.g., Raine et al. 2019; Raine et al. 2022). Estimates for all conservation sites with established subpopulations (first 3 rows) were derived from 2021 burrow monitoring data. Estimates of unmanaged subpopulations (last 3 rows) are derived from the habitat suitability analysis of Troy et al. (2017) restricted to 1,922 feet (585.6 meters) above sea level and above (the lowest elevation in managed colonies with a known burrow) correcting for the more dispersed nature of unmanaged colonies as compared to managed colonies.
[b] Except for the Hanalei to Kekaha area, the initial number of subadults was derived under the assumption that subadults comprise 36.3 percent of the age 1+ (non-chick) component of the population (Ainley et al. 2001).
[c] The powerline strike allocation is based on the percentage of acoustically detected strikes that have been analyzed to estimate strike numbers (Travers et al. 2020). The empirical strike percentages are: 89.1 percent of strikes in the

Hanalei to Kekaha area, 10.8 percent of strikes in the Waimea area, and 0.1 percent of strikes from the Wainiha and Lumahaʻi Valleys area (Travers et al. 2020; Travers, unpublished data). The modeled allocation differs slightly from these values to account for a percentage of strikes that are seabirds associated with different breeding colonies transiting across powerlines in other areas (e.g., to account for breeding adults at the conservation sites having some vulnerability to colliding with powerlines).

5F.1.1.2 Vital Rates under Optimal Conditions

A critical set of assumptions used in the KIUC HCP population dynamics model relate to the vital rates of the target species. *Vital rates* for any population dynamics model dictate population trajectories in the absence of any external factors, also referred to here as *optimal conditions*. Estimated reductions in vital rates relative to optimal conditions allow for the modeling of expected impacts on population dynamics from combined threats (e.g., mortalities due to introduced predators and powerline collisions). Likewise, the estimated effects of conservation measures on vital rates allow for the modeling of expected benefits of mitigation and minimization measures. Vital rates for this model include the following.

- Survival from one age class to the next age class
- Age at first reproduction (also termed the “adult” age)
- Annual breeding probability for adults (expressed as a fraction of adult birds that breed each year)
- Reproductive success rate (i.e., the fraction of eggs laid by adults that survive to emerge from the nest as fledglings)

During the last decade, burrow monitoring and other studies have led to a substantial increase in available species-specific estimates of endangered seabird vital rates on Kauaʻi (e.g., Archipelago Research and Conservation 2021; Raine et al. 2022). Likewise, advances in powerline monitoring methods have resulted in estimates of powerline strike numbers, resulting mortalities, and locations (e.g., Travers et al. 2020, 2021). In addition to recent estimates of vital rates related to reproduction and recruitment from burrow monitoring studies, acoustic monitoring of call rates and satellite tagging studies also provide information on trends in abundance and relative vulnerability to powerline collisions for breeding colonies in conservation sites in northwestern Kauaʻi. These newly available estimates serve to inform the biological assumptions of the KIUC HCP population dynamics model.

However, even with the improved estimates of vital rates and additional information on trends in abundance that recent monitoring efforts provide, there remains a high level of uncertainty for many of the biological assumptions that are input parameters for the population dynamics model. For example, the most recently reported estimate of the number of seabird powerline strikes from the Bayesian analysis of acoustic strike monitoring data collected between 2013 and 2019 has a 95 percent posterior predictive probability interval of 4,417–56,903 strikes per year (Travers et al. 2020). Moreover, in some instances, the parameter values adopted for this set of biological assumptions may be based wholly, or in part, upon expert opinion, and therefore confidence intervals cannot be calculated. Despite these limitations, the biological assumptions described here represent the best available scientific data, which is the regulatory standard for HCPs under the federal Endangered Species Act and Hawaiʻi Endangered Species Act.

The optimal rate of population growth is related to (but might be less than) the intrinsic rate of growth of the population, which is the maximum expected exponential growth rate that populations can achieve in the absence of density dependent competition for resources and decreases in vital rates through anthropogenic effects and nonnative predators (e.g., Caughley 1977). The optimal rate of population growth is a key parameter in conservation risk assessments and management strategy evaluations (e.g., Niel and Leberton 2005). However, the optimal population growth rate is also a difficult parameter to estimate, especially for species without long-term surveys of abundance to monitor the rate of recovery from low population levels. At present, no empirical estimate exists for the optimal rate of population growth for Hawaiian petrel (ʻuaʻu).

Given the biological assumptions for the vital rates of this model, the resulting optimal rate of modeled population growth (i.e., in the absence of introduced predators, powerline strike or light fallout mortality) is 2.0 percent per year. This is similar to the optimal rate of population growth modeled by Griesemer and Holmes (2011:30) for Newell's shearwater (ʻaʻo), which was 2.3 percent per year.

In practice, however, the optimal rate of population growth is never achieved in the KIUC model, because even for those sites with predator-proof fences, birds are still assumed to be vulnerable to powerline strike mortalities (albeit at relatively low levels) and aerial predation by introduced barn owls. The highest rate of population growth achieved in the model is at the Pihea and Hanakoa conservation sites. These sites have a relatively low powerline strike mortality rate in the model (0.5 unminimized powerline mortalities per 100 breeding adults), due to their remote geographic location. The underlying modeled population growth rate reaches 1.1 percent per year at Pihea and Hanakoa.

The optimal rate of population growth in a population dynamics model is a function of the optimal input values for the vital rates. All else being equal, higher optimal input values for survival or reproductive rates (or lower age at reproduction) result in higher values of optimal population growth rates and vice versa (e.g., Caswell 2001). The biological assumptions for the individual component life history values in the model are as follows.

Fledgling Survival Rates

Fledgling (age 1) survival rates and subsequent survival rates to breeding age are not available from empirical data. Instead, the modeled Hawaiian petrel (ʻuaʻu) survival rates were assumed to be equal to those employed for Newell's shearwater (ʻaʻo; Appendix 5E, *Population Dynamics Model for Newell's Shearwater (ʻaʻo) on Kauaʻi*). These rates were derived from the satellite tagging study reported by Raine et al. (2020). In that study, 12 Newell's shearwater (ʻaʻo) fledglings were tracked at sea. From the tag signals it was possible to estimate if a fledgling had died at sea (i.e., the tag stopped reporting movements in a manner that indicated it had not simply fallen off). Based on the observations of tagged fledglings, only 25 percent of tagged fledglings survived their first month at sea, suggesting that this percentage (or lower) would reach breeding age (Raine et al. 2020). This low level of fledgling survival was also assumed for Hawaiian petrel (ʻuaʻu); the fledgling survival rate assumed in the model was set such that, in combination with the assumed subadult survival rate, 25 percent of fledglings in the model (under near-optimal conditions) would reach breeding age. Combined with the subadult survival rates at age described below, this assumption yields a fledgling survival rate of 0.371 (i.e., survival from age 1 to age 2). Accounting for fallout from light attraction further reduces the fledgling survival rate in the Hanalei to Kekaha area of the model (see Section 3.1, *Conservative Assumptions*). The estimated level of fallout includes correction factors for the proportion of grounded seabirds that go undetected, e.g., for KIUC streetlights, 89.6% of grounded Hawaiian petrel ('ua'u) are assumed to go undetected (Appendix 5C: *Light Attraction Modeling*). Fallout, whether detected or not, is assumed to result in 100% mortality in the model.

Subadult and Adult Survival Rates

There are no available empirical estimates of adult survival rates for Hawaiian petrel ('ua'u). Instead, adult survival rates were based on multiple studies undertaken on the similar Manx shearwater (Harris 1966; Perrins et al. 1973; Brooke 1977) and were set to 0.924. Subadult survival rates (ages 2–5 years) were set equal to the adult survival rate, which is consistent with a life history punctuated by very high first year at-sea mortality rates for fledglings, followed by relatively low natural mortality rates for subadults and adults. The exact values for subadult survival rates at age are uncertain, in part because subadults may spend several years at sea, making conventional approaches for estimating survival rates, like mark-recapture, impracticable. The values for subadult survival rates at age assumed in the model are consistent with the Raine et al. (2020) satellite tagging study on Kaua'i for Newell's shearwater ('a'o), described above in *Fledgling Survival Rates* and result in 25 percent of modeled fledglings reaching breeding age (age 6) under near-optimal conditions.

Age at First Breeding

The age at first breeding was assumed to occur at six years, following the common assumption for Newell's shearwater ('a'o) and the similarity between demographic traits for these two seabird species.

Reproductive Success Rate

The reproductive success rate (RS) in the model measures the fraction of eggs that develop into a chick that survives to fledge. This is consistent with how RS rates have been defined in the burrow monitoring study data. RS rates have been estimated from burrow monitoring studies at the conservation sites, both before (RS = 0.413) and after (RS = 0.787) dedicated predator mitigation measures. The RS rate at the conservation sites is taken from a 3-year average value estimated across sites during 2019–2021 (e.g., Archipelago Research and Conservation 2021; Raine et al. 2022). For areas in the model without predator mitigation, the RS rate is assumed to be equal to that estimated at the conservation sites prior to dedicated mitigation measures. An adjustment was made for the Wainiha and Lumaha'i Valleys area, given that the radar trend for this area has been stable (neither increasing or decreasing) since monitoring began in 2006, which in combination with the assumed low population growth rate and relatively low vulnerability to powerline strikes, suggests that predation mortality rates in this area are 25 percent of those in estimated at the conservation sites prior to dedicated predator control measures (see also *Predation Rates*). It was also assumed that the RS rate in the Wainiha and Lumaha'i Valleys area is 25 percent greater than in other unmanaged areas (RS = 0.516).

The RS rates in areas with predator-proof fences were based on the estimated RS rates at the conservation sites following dedicated predator mitigation, with an upward percentage adjustment corresponding to observed predation rates on nests without predator proof fences, which were 0.0023 for adults and 0.02 for chicks (Raine et al. 2022; Raine, unpublished data). This resulted in a modeled RS rate inside predator-proof fences of 0.872 * (1 + 0.0023 + 0.02) = 0.805, or a 2.23 percent increase compared to the estimated RS rate from burrow monitoring studies at the conservation sites.

An additional area-specific adjustment was made to the RS values to account for powerline collisions that result in injury but not mortality and might cause breeding individuals to be unable to fledge a chick successfully (e.g., due to an inability to forage effectively that season). Following the observations of Travers et al. (2021), 24.5 percent of powerline collisions were assumed to result in nonlethal injury. These were individuals with post-collision elevation loss that were not assigned to immediate grounding mortality or short-term grounding mortality (within 3,609 feet [1,100 meters] of wires). The observed elevation loss of these birds not assigned as grounded/mortality, was used as a proxy for injury. That is, the elevation loss indicates the collision was more severe or affected the bird more than those that flew off without elevation loss.

Future powerline collision levels, and their non-lethal effects, were derived from the powerline mortality rate calculations described below, under the assumption that mortalities were 28.8 percent of all collisions. The derived number of collisions was then multiplied by 24.5 percent to calculate the associated number of collisions resulting in non-lethal injuries. This number was multiplied by 21.4 percent to account for the proportion of collisions that are expected to be breeding adults (Cooper and Day 1998). And the resulting number of collisions resulting in non-lethal injuries of breeding age birds was divided by the number of breeding birds in an area each year, and used as a percentage reduction in reproductive success rate in that area that year.

Breeding Probability

Breeding probability is the percentage of adults (age 6 or older) that breed each year. This probability has been estimated through long-term studies of active breeders at the conservation sites and is 0.982 for Hawaiian petrel (‘ua‘u) (Raine et al. 2022). The breeding probability value is assumed to be constant across all geographic areas and through time in the model.

5F.1.1.3 Powerline Mortality

The powerline mortality rate for each area *I* with no minimization was calculated for subadults and adults by dividing the proportion of unminimized powerline mortalities for each age class by the corresponding estimate of abundance for that area:

$$\psi_{a,i}^{sa} = \frac{p_i \Omega \rho \nu \pi_{sa}}{\sum_{a=3}^{5} \hat{N}_{a,i}^{sa}}$$

(Equation 1)

$$\psi_{6+,i} = \frac{p_i \Omega \rho \nu (1 - \pi_{sa})}{\hat{N}_{6+,i}}$$

Where:

- $\psi_{a,i}^{sa}$ and $\psi_{6+,i}$ are the annual powerline mortality rates for subadults, ages 3–5 years, and adults (ages 6 years and older, denoted as age “6+”; Figure 5F-2) in area *i* prior to any minimization (i.e., unminimized). In the context of powerline strikes, subadults refer to ages 3–5 years because ages 1 and 2 are assumed to be at sea and are not vulnerable to powerline strikes in the model (Equation 3). The powerline mortality rates are assumed to be equal for subadults of each vulnerable age.

- p_i is the modeled fraction of total powerline strikes for each species that are associated with birds from area *i* in 2016 (see Table 5F-2 for list of areas).
- Ω is the estimated number of seabird powerline strikes in 2016 (Hawaiian petrels ['ua'u] and Newell's shearwater ['a'o] combined).
- ρ is the proportion of total strikes that are Hawaiian petrel ('ua'u; Travers et al. 2021).
- ν is the total grounding rate (i.e., the proportion of strikes that result in mortality; Travers et al. 2021).
- π_{sa} is the proportion of powerline strikes that are subadults.
- $\widehat{N}_{a,i}^{sa}$ is the number of subadults at age (ages 3–5 years) and $\widehat{N}_{6+,i}$ is the number of adults in 2019, which when projected forward in the model 1 year, equal the island-based estimates from 2021 (see Table 5F-3). The initial age structure in the model, for those areas outside Hanalei to Kekaha, assumes that 63.7 percent of the population is composed of breeding adults (the remaining 36.3 percent are assumed to be ages 1–5), following Ainley et al. (2001).

Table 5F-4 shows the assumed values for most of the variables above. The text below the table explains the rationale for these variables.

Table 5F-4. Powerline Strike Assumptions for the Population Dynamics Model

Powerline Strike Variable	Model Variable	Assumed Value
2016 Annual powerline strikes of Newell's shearwater ('a'o) and Hawaiian petrel ('ua'u) combined, before minimization (i.e., average annual unminimized strike estimate during 2013–2019)	Ω	15,853[a]
Total grounding rate	ν	0.288[b]
Proportion of strikes that are Hawaiian petrel ('ua'u)	ρ	0.30[c]
2016 annual estimated mortalities of Hawaiian petrel ('ua'u)	calculation	1,370[d]
Proportion of powerline strikes that are subadults	π_{sa}	0.79[e]

[a] Total number of estimated seabird powerline strikes of Newell's shearwater ('a'o) and Hawaiian petrels ('ua'u) combined. Estimate excludes waterbird strikes and strikes minimized during the Short-Term HCP. Based on 2013–2019 acoustic data and the Bayesian estimate model described in Travers et al. (2020).
[b] The total grounding rate includes 13 percent immediately grounded, 10.2 percent unknown outcome, and 5.6 percent of birds that strike powerlines having been observed with the most severe of post-flight behaviors and that are hence assumed to have eventually died (Travers et al. 2021).
[c] Travers et al. 2021
[d] Mortalities are calculated as the proportion of unminimized seabird strikes for each species, multiplied by the total grounding rate.
[e] See text for additional explanation. Assumes Hawaiian petrel ('ua'u) vulnerability at age to powerline strikes is the same as that of Newell's shearwater ('a'o), i.e., follows the sampling distribution of 11 out of 14 downed birds categorized as subadults by Cooper and Day (1998).

Powerline Strike Allocation by Subpopulation

The powerline strike allocation by subpopulation is based on the percentage of acoustically detected strikes that have been analyzed to estimate strike totals across the island (Travers et al. 2020). The empirical distribution of seabird strikes during 2013–2019 was: 89.1 percent of strikes in the Hanalei to Kekaha area, 10.8 percent of strikes in the Waimea Canyon area, and 0.1 percent of strikes from the Wainiha and Lumaha'i Valleys area (Travers et al. 2020; Travers, unpublished data).

Some variance from the empirical acoustic detections was incorporated in the modeled allocation because, for example, Hawaiian petrel (ʻuaʻu) are not assumed to occur in the modeled Waimea area, and likewise approximately 5 percent of strikes were assumed to result from collisions by individuals from breeding colonies in the remote northwestern areas. This allowed the model to incorporate a low level of powerline collision vulnerability for individuals associated with the conservation sites and surrounding areas, which is consistent with observations from tagging studies (Raine et al. 2017a). In general, the spatial differences that have been observed through acoustic powerline collision monitoring data served as a key motivating factor for developing a spatially explicit population dynamics modeling framework.

Powerline Strike Allocation by Species

As described in Chapter 5, *Effects*, estimates of powerline strikes of the covered seabirds are derived from acoustic data on strikes for all seabirds combined. Acoustic data cannot be separated by species. Instead, we must assume of the proportion of strikes allocated to either Newell's shearwater (ʻaʻo) or Hawaiian petrel (ʻuaʻu). Travers et al. (2021) has reported that powerline collisions directly observed in the field occur in a proportion of 70.5 percent Newell's shearwater (ʻaʻo) to 29.5 percent Hawaiian petrel (ʻuaʻu). The modeling assumption corresponds to these proportions, with 70 percent of all estimated strikes assumed to be Newell's shearwater (ʻaʻo) and 30 percent assumed to be Hawaiian petrel (ʻuaʻu) (Table 5F-3).

Powerline Strike Allocation by Age Class

Birds detected colliding with powerlines through acoustic monitoring, which is used to estimate strike numbers, cannot be identified to age class. However, the proportions of strikes that are subadults and adults are important for the population dynamics model. Although there are no available estimates for Hawaiian petrel (ʻuaʻu), limited evidence suggests that Newell's shearwater (ʻaʻo) subadults are more susceptible to powerline strikes than adults. For the purposes of this model, powerline strikes of Hawaiian petrel (ʻuaʻu) are assumed to be composed of 79 percent subadults (ages 3–5 years) and 21 percent adults (ages 6 years and older) (Table 5F-3).

This assumption corresponds to the proportions estimated by Cooper and Day (1998), who analyzed brood patch vascularization and wear of rectrices[4] for 14 downed Newell's shearwater (ʻaʻo) collected on powerline mortality searches during 1993–1994. Three of those downed Newell's shearwaters (ʻaʻo) had highly vascularized brood patches and worn rectrices, which suggests those birds were incubating eggs in burrows, and hence they were classified as breeding adults (age 6+). The remaining 11 birds either had no brood patch (n=10) or a downy brood patch (n=1); all but the latter had unworn rectrices. Those 11 birds (78.6 percent) were classified as subadults, and the three others (21.4 percent) were classified as breeding adults.

Mortality from Future Powerlines

Mortality due to construction of future powerlines was assumed to apply only to the Hanalei to Kekaha area (Figure 5F-1). The vast majority (more than 99 percent) of new powerlines are expected to be constructed in this area, which is where human population growth is forecast to occur on Kauaʻi (see Chapter 2, *Covered Activities*, for details). As described in Chapter 5, *Effects*, at

[4] A brood patch is a featherless patch of skin near the belly, which allows heat transfer from nesting parents to their eggs during incubation. Rectrices are the larger tail feathers, which may show signs of wear associated with nesting.

the end of the 50-year permit term, powerline strikes would be increased by an estimated 6.8 percent. The species-specific increase in future strikes was calculated by applying the species split to this percentage, and then applying a linear increase in the strike mortality rate each year, such that by the end of the permit term, the strike mortality rate was equal to the estimated percent increase in strikes.

Mortality from Fallout from Existing and Future Streetlights and Covered Facility Lights

Appendix 5C, *Light Attraction Modeling*, describes the process for quantifying take of the covered seabirds from attraction to lights owned and operated by KIUC. Mortality due to fallout from light attraction was assumed to affect fledglings (age 1 year) only in the Hanalei to Kekaha area. Fallout is assumed to result in 100% mortality in the model, so as a conservative approach the benefits of Save Our Shearwaters (SOS) rehabilitation efforts are not counted (given that there is little data on survival once the birds are released). Based on this assumption, and the light attraction modeling (Appendix 5C), the number of mortalities from fallout each year for Hawaiian petrel (ʻuaʻu) was set to 5.3 in the model. This estimate represents expected mortalities resulting from existing and future light sources anticipated by the end of the 50-year permit term. However, this value was applied at the start of the population trajectories as a conservative approach for modeling fallout mortality levels through time, i.e., annual fallout mortalities from attraction to lights owned and operated by KIUC is likely overestimated at the start of the metapopulation projections.

5F.1.1.4 Predation Rates

Predation mortality rates have been estimated at the conservation sites, both with and without trapping and fencing (i.e., mitigation). Prior to dedicated predator control, predation mortality rates for all predators combined were estimated to be 0.18 for chicks in the nest, and 0.0272 for breeding adults[5] at the nest (Raine et al. 2022; Raine, unpublished data). For areas outside the conservation sites (with no active management), predation rates at the nest were assumed to be equal to the estimates for the conservation sites prior to dedicated predator control, with one exception. The exception was the Wainiha and Lumahaʻi Valleys area, where predation mortality rates are assumed to be 25 percent of the unmitigated rates. This reduction in assumed predation rates allowed the model to match the stable trend in abundance that has been observed through the radar survey data (Raine and Rossiter 2020). This observed stable trend in the Wainiha and Lumahaʻi Valleys area, where powerline strikes are relatively uncommon, would be consistent with lower predation rates, perhaps due to the remaining breeding colonies being confined to areas that are less accessible to mammalian predators.

With predator control measures at the conservation sites, predation mortality rates were estimated to decrease to 0.02 for chicks and 0.0023 for adults (Raine et al. 2022; Raine, unpublished data). The effect of these reductions in predation rates at the nests is also evident in the RS rates estimated before (41.3 percent RS rate) and after dedicated predator control measures (78.7 percent RS rate)

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[5] In other words, 18 percent of all chicks at all conservation sites are assumed to be lost to predators in the absence of any dedicated predator control structures or actions. Similarly, 2.7 percent of all adults at the conservation sites are assumed to be lost to predators annually in the absence of any predator control structures or actions. Chicks are not tracked explicitly in the model, but chick survival (and mortality from predation) is measured in the estimated RS rates of adults from burrow monitoring studies, and those RS rate estimates (and hence chick mortality) from monitoring studies are explicitly included in the model.

at the conservation sites. Although predation mortality rates for chicks are not explicitly included as a variable in the model and are therefore not considered further, they are subsumed in the RS rate estimates used in the model, as discussed above under RS rates.

Barn owl predation rates on the wing for adults were assumed to be equal to the adult predation rate at the nest (0.0023; Raine et al. 2022; Raine, unpublished data), and the same barn owl predation rate on the wing was assumed for ages 3–6+ in the absence of additional information. The assumed barn owl predation rate on the wing was added to the terrestrial predation rates at the nest for all areas. For example, in the Kalalau east to Upper Mānoa area, the adult predation rates at the nest were assumed to be equal to those estimated at the conservation sites prior to dedicated predator control measures (0.0272) plus the assumed barn owl predation rate on the wing (0.0023), or a total adult predation rate of 0.0295 (Table 5F-5). Predation rates at the nests were assumed to vary between different areas according to different management measures (Table 5F-5).

The predation rate for ages 3–5 was set to 0.0023, under the assumption that those ages are not vulnerable to terrestrial predators because they are not nesting, but they are vulnerable as prospectors to being killed by barn owls on the wing (Table 5F-5).

Table 5F-5. Assumptions for Annual Predation Rates, with and without Predator Control

	Without Predator Control[a]		With Predator Control[b]	
Site	Adults	Subadults (3–5 yrs)	Adults	Subadults (3–5 yrs)
Conservation Sites	--	--	0.0046	0.0023
Kalalau east to Upper Mānoa[c]	0.0295	0.0023	--	--
Hanalei to Kekaha	0.0295	0.0023	--	--
Wainiha and Lumahaʻi Valleys[c]	0.0074	0.0006	--	--

[a] Without predator control is defined as no fencing, no predator trapping, and no predator removal efforts. With predator control includes trapping and ungulate fences for the conservation sites, or sites with predator-proof fences (second row).
[b] See Table 5F-6 for differences in predation mortality rates assumed for different age classes.
[c] Reduced predation rates were assumed for the Wainiha and Lumahaʻi Valleys area in order for the initial modeled trend to match the stable trend in radar survey data at the two monitoring sites for these valleys during 2006–2020 (Raine and Rossiter 2020).

5F.1.2 Population Dynamics Model and Projections of Abundance

This section describes the model structure, each of the model parameters, and the rationale for each model input.

The population dynamics model is described below in terms of the numbers of females-at-age for each species, under the assumption of a 50:50 sex-ratio:

$$N_{1,t,i} = 0.5\gamma_{t-1,i}\beta N_{6+,t-1,i}S^*_{6+,t-1,i} - F_{t,i} \qquad \text{(Equation 2)}$$

$$N_{2,t,i} = N_{1,t-1,i}S^*_{1,t-1,i}$$
$$N_{3,t,i} = N_{2,t-1,i}S^*_{2,t-1,i}$$
$$N_{4,t,i} = N_{3,t-1,i}S^*_{3,t-1,i}$$
$$N_{5,t,i} = N_{4,t-1,i}S^*_{4,t-1,i}$$

$$N_{6+,t,i} = N_{5,t-1,i}S^*_{5,t-1,i} + N_{6+,t-1,i}S^*_{6+,t-1,i}$$

Where:

- $N_{a,t,i}$ is the number of female birds at age a during year t in area i. Birds aged 6 years and older (age 6+) are modeled as a plus-group, *aka* a self-loop group (Figure 5F-2). Fledglings are denoted as age 1 in the model.
- $\gamma_{t,i}$ is the RS rate during year t in area i. RS rates in the model vary between conservation sites and unmanaged areas, and can change with time for areas with future predator control measures (e.g., predator-proof fences).
- β is the breeding probability for sexually mature birds (assumed constant across areas).
- "Fertility" is defined here as the product: $0.5\gamma_{t-1,i}\beta S^*_{6+,t-1,i}$

  Hence, fertility, or the number of female fledglings produced per breeding female per year, is a function of the adult survival rate. Chick mortality rates, which are subsumed in the reproductive success rate variable, are therefore directly related to parental mortality rates in the model vis-à-vis reductions in the numbers of fledglings produced.
- $F_{t,i}$ is the number of age 1 birds that die from fallout due to KIUC lights during year t in area i. This term is included with a time and area component for generality, but in practice, fallout is assumed to be limited to the Hanalei to Kekaha subpopulation with 2.65 age 1 female mortalities per year (i.e., 5.3 fallout mortalities per year for age 1 males and females combined).
- $S^*_{a,t,i}$ is the survival rate of birds at age a during year t in area i, which for ages 3 years and older is a function of the estimated predation and powerline mortality rates-at-age, as well as the powerline minimization level in year t:

$$\begin{aligned} S^*_{1,t,i} &= S_1 \\ S^*_{2,t,i} &= S_2 \\ S^*_{3,t,i} &= S_3(1-\phi_{3,t,i})[1-\psi_{3,i}(1-\delta_t)] \\ S^*_{4,t,i} &= S_4(1-\phi_{4,t,i})[1-\psi_{4,i}(1-\delta_t)] \\ S^*_{5,t,i} &= S_5(1-\phi_{5,t,i})[1-\psi_{5,i}(1-\delta_t)] \\ S^*_{6+,t,i} &= S_{6+}(1-\phi_{6+,t,i})[1-\psi_{6+,i}(1-\delta_t)] \end{aligned} \quad \text{(Equation 3)}$$

Where:

- S_a is the natural survival rate at age a prior to any mortalities from predators or powerlines (Table 5F-5).
- $\phi_{a,t,i}$ is the predation mortality rate at age a during year t in area i (Tables 5F-5 and 5F-6). Predation rates vary through time in the model in the areas where future predator control measures will occur or where predator-proof fences are installed.
- $\psi_{a,i}$ is the unminimized powerline mortality rate at age a in area i. The unminimized powerline mortality rates vary by area due to unequal per-capita vulnerability to powerline strikes (Equation 1; Table 5F-3).

- δ_t is the minimization efficacy in terms of reducing powerline strikes during year t. The minimization rate varies between years according to the strike minimization schedule under the HCP (Table 5F-8).

Table 5F-6. Survival, Predation Mortality, and Fertility Rates by Age for Hawaiian Petrel ('ua'u)

Age	Natural Survival Rate[a]	Predation Mortality Rate without Predator Control or Fencing[b]	Predation Mortality Rate with Predator Control and Ungulate Fencing[c]	Predation Mortality Rate with Predator-Proof Fencing[d]	Natural Fertility[a]	Fertility without Predator Control or Fencing[e]
1	0.371	0	0	0	0	0
2	0.924	0	0	0	0	0
3	0.924	0.0023[c]	0.0023[c]	0.0023[c]	0	0
4	0.924	0.0023[c]	0.0023[c]	0.0023[c]	0	0
5	0.924	0.0023[c]	0.0023[c]	0.0023[c]	0	0
6+	0.924	0.0295	0.0046	0.0023[c]	0.416	0.182

[a] Natural survival and natural fertility represent the modeled rates in the absence of predation and powerline mortalities. The value of 0.924 for natural survival is based on survival rates estimated from studies of Manx shearwater and Hawaiian petrel ('ua'u) (Simmons 1984, 1985), with age 1 survival adjusted to result in ~25 percent of birds reaching breeding age, based on satellite tagging results for Newell's shearwater ('a'o) on Kaua'i (Raine et al. 2020).
[b] Estimated from burrow monitoring studies at conservation sites (Raine et al. 2022; Raine, unpublished data), and assuming that ages 1 and 2 are not vulnerable to introduced predators on the island because they are largely expected to be at sea. Predation mortality rates for the Wainiha and Lumaha'i Valleys area are reduced to 25 percent of the values at other unmanaged sites to match the stable trend in abundance from the radar survey data in that area during 2006–2020 (Raine and Rossiter 2020).
[c] Taken from estimated barn owl predation rates for nesting birds and assumed in the model to be equal for age 3–5 birds (i.e., the barn owl predation rate is applied to this age under the assumption that ages 3–5 would be "prospectors" and predated by barn owls on the wing).
[d] All predation mortality rates are assumed to be reduced to zero by predator proof fences, except for ages 3–6+ which are assigned the estimated barn owl predation rate on the wing.
[e] This fertility value corresponds to the Hanalei to Kekaha subpopulation with unminimized powerline strike mortality rates. The fertility values are a function of the adult powerline mortality rates, and therefore change through time in the model as a function of the minimization schedule. Likewise, the fertility rates differ between areas in the model due to spatial differences in the adult powerline mortality rates between areas in the model. Because the Hanalei to Kekaha area has the highest powerline strike mortality rate, it also has the lowest modeled fertility rate, which reflects the expectation that if a nesting parent is killed, it's egg/chick will not survive to fledge.

Table 5F-7. Reproductive Rates Assumed in the Population Dynamics Model

Vital Rate	Value
Sex ratio	0.5
Reproductive success rate without predator control and without fencing	0.413[a]
Reproductive success rate with predator control	0.787[a]
Breeding probability	0.982[b]
Age at sexual maturity	6 yr

[a] Estimated from burrow monitoring studies at management sites before (in parentheses) and after predator control measures (e.g., Raine et al. 2022; Raine unpublished data).
[b] Estimated from long-term studies of active breeders at the conservation sites (Raine et al. 2022).

Table 5F-8. Annual Powerline Minimization Schedule[a]

Year	Annual Island-Wide Powerline Mortality Minimization Rate[b]
2019	0
2020	0.127
2021	0.303
2022	0.550
2023–2053	0.653

[a] See Conservation Measure 1, *Implement Powerline Collision Minimization Projects*, in Chapter 4, *Conservation Strategy*, for details on the specific powerline minimization projects and the locations.
[b] Minimization represents the efficacy to reduce the mortality rate due to powerline strikes. In other words, minimization = 0.0 corresponds to no change in powerline mortality rate (without any minimization measures implemented). A minimization = 1.0 represents a scenario where a powerline was removed or modified so that bird collisions no longer occurred, and powerline mortality rates are zero. A minimization efficacy of 0.5 represents a 50 percent reduction in strike mortalities.

The life-cycle model shown in Figure 5F-2 is similar to the model developed by Griesemer and Holmes (2011). The circles, and numbers therein, correspond with a single age class in the model. Birds aged 6 years and older were modeled as a self-loop group (i.e., senescence was not assumed to be a knife-edge where all birds die at a given age). The survival rates at age a, S_a^* are a function of predation and powerline mortality rates at age as well as the powerline strike minimization rates (Equation 3). For conciseness, the subscripts for year and area are dropped in the transition parameters shown in the figure.

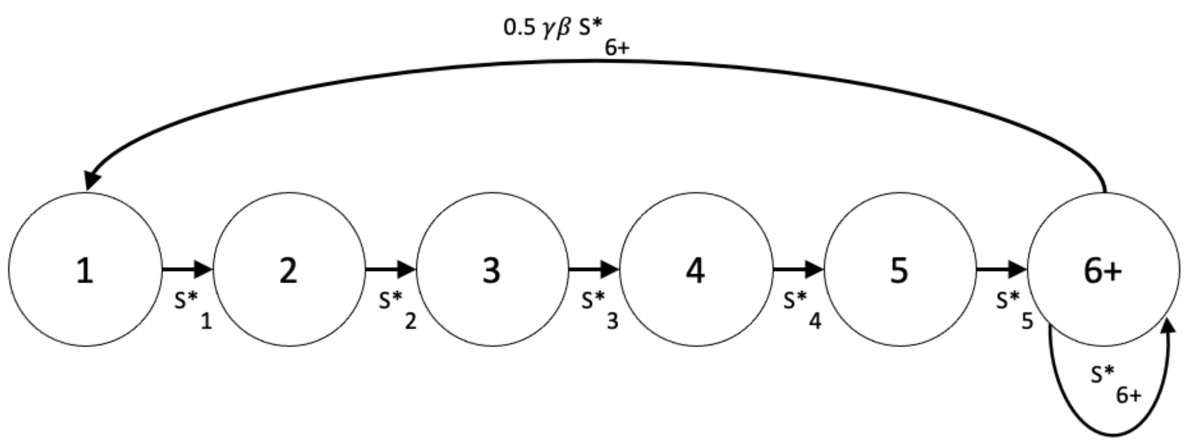

Figure 5F-2. Life Cycle Graph with Age-Structured Transition Parameters for the Population Dynamics Model

5F.2 Model Results

All model results for Hawaiian petrel (ʻuaʻu) are presented in Figures 5F-3 through 5F-6. The population dynamics results in Figures 5F-3 and 5F-4 demonstrate that the conservation measures implemented will substantially benefit Hawaiian petrel (ʻuaʻu) relatively quickly at all conservation sites where Hawaiian petrel (ʻuaʻu) are modeled and expected to occur.

The population trajectory for Hawaiian petrel (ʻuaʻu) at all conservation sites combined is shown in Figure 5F-4 and shows a similar pattern. According to the model, the total population size of Hawaiian petrel (ʻuaʻu) at all of the conservation sites is expected to increase immediately, consistent with observed increases in call rates at the conservation sites that have been ongoing with predator control since 2014–2015 (Raine et al. 2022). Of the conservation sites, North Bog and Pihea contribute the greatest number of new birds because of their much larger starting populations (Figure 5F-3).

Continued predator control by the HCP at the conservation sites, combined with powerline collision minimization, will prevent substantial declines of existing subpopulations of Hawaiian petrel (ʻuaʻu) and likely prevent local extirpation (red lines in Figure 5F-3). Three of these conservation sites with predator control (North Bog, Pihea, and Hanakāpiʻai) collectively contribute substantial numbers of new breeding pairs to the Kauaʻi metapopulation of Hawaiian petrel (ʻuaʻu) with the HCP (blue lines in Figure 5F-3). Combined, the six conservation sites are projected to have more than 3,100 Hawaiian petrel (ʻuaʻu) breeding pairs by the end of the permit term.

Figure 5F-5 shows the subpopulation trajectories at each of the three areas outside the conservation sites (see Figure 5F-1 for area locations), with and without the KIUC HCP. Hanalei to Kekaha is the largest subpopulation in the area, by far. This area is projected to be approaching extirpation without the HCP by approximately 2060. With the HCP, the negative rate of modeled decline is slowed, but not reversed by the end of the permit term (2073). The difference in declines between these scenarios is due largely to powerline minimization. Because 92 percent of all powerline collisions are assumed to involve Hawaiian petrel (ʻuaʻu) associated with breeding colonies within the Hanalei to Kekaha area (see Figure 5F-1), powerline minimization provides a greater benefit in this area compared to other areas. This result is not surprising, because for all areas other than Hanalei to Kekaha the risk of powerline collisions is assumed to be much lower in the first place (Table 5F-3). By 2023 the rate of modeled decline has slowed from the initial 2016 radar trend in the Hanalei to Kekaha area due to powerline strike minimization (Table 5F-9). For Hanalei to Kekaha the rate of decline in abundance then increases again through time, due to the modeled effect of future powerline construction and fledgling fallout mortality.

The subpopulation trajectory in the Wainiha and Lumahaʻi Valleys area benefits with the HCP (Figure 5F-5). This is due to the area having vital rates modeled to match a stable trend (based on radar data) prior to minimization, and as minimization decreases mortality rates in the future, abundance is projected to have a positive trend. The remaining area in Figure 5F-5, Kalalau east to Upper Mānoa, is assumed to have relatively low vulnerabilities to powerline strikes, given its geographic remoteness. Therefore, powerline strike minimization is not predicted to have much of an effect on the modeled trend in abundance for this area, i.e., the blue (with HCP) and the red (without HCP) trajectories of abundance overlap. Nevertheless, Hawaiian petrel (ʻuaʻu) are modeled to decline in this area throughout the permit term. This decline is therefore almost completely due to the assumed effect of unmitigated mortality from introduced predators in this area. In other words, given the assumption of a low rate of maximum population growth, when the predation mortality rates are applied from the conservation sites prior to dedicated control measures, the trend in modeled abundance for the Kalaua to Upper Mānoa area is approximately -3 percent per year.

When all subpopulations are combined (Figure 5F-6), the Hawaiian petrel (ʻuaʻu) metapopulation on Kauaʻi is projected to continue to decline without the HCP (red line). Without the HCP, the total population size is projected to continue to decline from approximately 9,200 breeding pairs at the start of the permit term to just under 1,500 by the end of the permit term (2073), a decline of over 80 percent. With the HCP conservation measures the Hawaiian petrel (ʻuaʻu) metapopulation on Kauaʻi is projected by the end of the permit term to stabilize and begin to experience a small net increase in the Kauaʻi metapopulation (Figure 5F-6, blue line). HCP conservation measures are projected to slow the metapopulation decline considerably between 2050 and 2060, stabilizing at approximately 5,200 breeding pairs, before increasing (Table 5F-11).

If conservation efforts are maintained for 50 years, the metapopulation is projected to increase gradually, governed in part by the assumed low maximum rate of population growth, as the continued increases in abundance of Hawaiian petrel (ʻuaʻu) colonies at the conservation sites overcomes the declines in abundance in the Hanalei to Kekaha area (Figure 5F-7; Tables 5F-10 and 5F-11). The Hanalei to Kekaha area has the highest initial modeled abundance, and in addition to the Kalalau to Upper Mānoa area, it also has a relatively high degree of uncertainty in terms of initial and therefore projected abundance (Table 5F-2). Therefore, the metapopulation projection, especially as it relates to the relative contribution of the abundance in the aforementioned areas to the overall island-wide trend, is also uncertain. However, the abundance and life history parameters of Hawaiian petrel (ʻuaʻu) within the conservation sites are relatively well understood, leading to higher confidence in the population projections in these areas. This means that we have a relatively high confidence that the increase in subpopulations of the conservation sites combined will provide a substantial net benefit to Hawaiian petrel (ʻuaʻu) on Kauaʻi.

Without the HCP, the Kauaʻi metapopulation of Hawaiian petrel (ʻuaʻu) would be greatly reduced by 2073. Depending on the age structure and spatial distribution of the species at that time, the viability of the metapopulation may be compromised without conservation efforts under the HCP, due to the species' slow reproductive rate and other factors. However, with the continuation of conservation efforts associated with the HCP, by 2073 the stabilization and eventual increase of the metapopulation is forecast. The conservation sites are large enough in size and have such extensive suitable habitat for Hawaiian petrel (ʻuaʻu) that subpopulations (and densities) are expected to continue to increase without experiencing any density-dependent constraints, assuming management actions continue at the same level as outlined in this HCP.

The cumulative number of strikes for each area from these modeled projections are provided in Table 5F-12. The predictions of strikes should be considered conservative (i.e., strike predictions may be too low) because these results are based on modeling a rate of decline for Hanalei to Kekaha that represents a worst-case scenario based on the most drastic rate of decline estimated from the 1993–2020 radar survey data. This rate of decline, while based on data, does not represent the less drastic average rate of decline estimated across all radar sites in the Hanalei to Kekaha area during the same period; further, it does not reflect the more recent stabilization of trend across radar sites in this area during 2010–2020 (Raine and Rossiter 2020). Additionally, the 2010–2020 decade of radar data exhibiting a stable trend in relative abundance for the Hanalei to Kekaha area also overlaps in time with the estimate of unminimized seabird strikes from acoustic powerline monitoring data during 2013–2019 (Travers et al. 2020). Together, these two sources of monitoring data suggest that, at least during the last decade, the Hanalei to Kekaha subpopulation experienced a relatively high level of powerline mortality while also maintaining a stable abundance level. If this situation were to continue in the future, i.e., trends in both powerline strikes and abundance area remain stable, the modeled decline in abundance for Hanalei to Kekaha (and hence the modeled reduction in strikes associated with declining future abundance in this area) would underestimate future strikes.

Table 5F-9. Modeled Hawaiian Petrel ('ua'u) Subpopulation Lambda values, Starting with the First Year of the HCP (2023), and then Shown at Five-Year Snap-Shot Intervals Over the 50-year Permit Term (to 2073).

Lambda is the population multiplier, i.e., the rate of change in abundance from the prior year is equal to one minus Lambda. Values of Lambda less than 1.0 represent a decline in abundance, and values greater than 1.0 represent an increase. The maximum possible value for Lambda in the model is 1.02 (2.0 percent population growth), which is never achieved in practice because each subpopulation is assumed to have some level of vulnerability to introduced predators (e.g., barn owl predation on the wing) and some level of vulnerability to powerline collisions.

Area	2023	2028	2033	2038	2043	2048	2053	2058	2063	2068	2073
HCP Conservation Sites											
Upper Limahuli	1.008	1.009	1.009	1.009	1.009	1.009	1.009	1.009	1.009	1.009	1.009
Pōhākea	1.009	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.01
Pihea	1.010	1.011	1.011	1.011	1.011	1.011	1.011	1.011	1.011	1.011	1.011
North Bog	1.008	1.009	1.009	1.009	1.009	1.009	1.009	1.009	1.009	1.009	1.009
Hanakāpi'ai	1.009	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.01
Hanakoa	1.010	1.011	1.011	1.011	1.011	1.011	1.011	1.011	1.011	1.011	1.011
Other Areas											
Wainiha and Lumaha'i Valleys	1.000	1.001	1.001	1.001	1.001	1.001	1.001	1.001	1.001	1.001	1.001
Hanalei to Kekaha	0.937	0.943	0.942	0.942	0.942	0.942	0.941	0.941	0.941	0.940	0.939
Kalalau east to Upper Mānoa	0.955	0.955	0.955	0.955	0.955	0.955	0.955	0.955	0.955	0.955	0.955

Table 5F-10. Modeled Hawaiian Petrel (ʻuaʻu) Breeding Pair Abundance (ages 6 years and older) at Five-Year Intervals for each Subpopulation over the 50-year Permit Term (2023–2073)

Area	2023	2028	2033	2038	2043	2048	2053	2058	2063	2068	2073
HCP Conservation Sites											
Upper Limahuli	114	119	124	130	135	141	148	154	161	168	176
Pōhākea	164	172	181	190	199	209	219	230	241	253	265
Pihea	664	700	737	777	819	863	909	958	1,010	1,064	1,121
North Bog	894	933	974	1,018	1,063	1,110	1,159	1,211	1,265	1,321	1,380
Hanakāpiʻai	296	310	325	341	358	376	394	413	434	455	477
Hanakoa	176	185	195	206	217	228	241	254	267	282	297
Other Areas											
Wainiha and Lumahaʻi Valleys	1,183	1,188	1,193	1,199	1,204	1,210	1,216	1,221	1,227	1,233	1,238
Hanalei to Kekaha	5,503	4,118	3,061	2,275	1,690	1,253	929	687	508	375	276
Kalalau east to Upper Mānoa	588	468	372	296	236	187	149	119	95	75	60
Total	**9,580**	**8,191**	**7,162**	**6,429**	**5,918**	**5,576**	**5,362**	**5,245**	**5,205**	**5,223**	**5,288**

Table 5F-11. Modeled Hawaiian Petrel (ʻuaʻu) Total (non-chick) Abundance at Five-Year Intervals for each Subpopulation over the 50-year Permit Term (2023–2073)

Initial abundance is based on the estimates of breeding pairs from ARC, with the exception of the Hanalei to Kekaha area, where the pre-HCP abundance is estimated as a function of the allocated strikes (92 percent) for that subpopulation and trends in abundance from radar, which is assumed to be -8.1 percent per year in 2016 and corresponds to the trend for Hawaiian petrel (ʻuaʻu) at the Waiakalua Stream radar site, the most negative rate of decline observed at any single radar site for this species during 1993–2020 (Raine and Rossiter 2020).

Area	2023	2028	2033	2038	2043	2048	2053	2058	2063	2068	2073
HCP Conservation Sites											
Upper Limahuli	417	435	455	475	496	518	541	565	591	617	644
Pōhākea	603	633	664	696	731	766	804	844	885	928	974
Pihea	2,441	2,572	2,710	2,856	3,010	3,171	3,342	3,522	3,711	3,911	4,121
North Bog	3,281	3,426	3,578	3,737	3,904	4,077	4,259	4,448	4,646	4,852	5,068
Hanakāpiʻai	1,086	1,139	1,195	1,254	1,315	1,380	1,447	1,519	1,593	1,671	1,753
Hanakoa	646	680	717	756	796	839	884	932	982	1,035	1,091
Other Areas											
Wainiha and Lumahaʻi Valleys	4,131	4,149	4,168	4,188	4,207	4,227	4,247	4,267	4,286	4,306	4,326
Hanalei to Kekaha	16,228	12,060	8,968	6,662	4,944	3,664	2,712	2,004	1,478	1,087	797
Kalalau east to Upper Mānoa	1,723	1,371	1,090	868	690	549	437	348	276	220	175
Total	**30,557**	**26,464**	**23,546**	**21,491**	**20,093**	**19,193**	**18,674**	**18,447**	**18,448**	**18,628**	**18,950**

Table 5F-12. Modeled Hawaiian Petrel ('ua'u) Powerline Strikes, Starting with the First Year of the HCP (2023), and then Shown as a Cumulative Total at Five-Year Intervals for each Subpopulation until the End of the Permit Term (2073)

Area	2023	2028	2033	2038	2043	2048	2053	2058	2063	2068	2073
HCP Conservation Sites											
Upper Limahuli	5	31	57	85	115	145	177	210	245	281	319
Pōhākea	5	30	56	83	112	142	174	207	242	279	317
Pihea	10	61	114	171	230	293	359	429	502	579	661
North Bog	39	241	452	672	901	1,141	1,392	1,654	1,927	2,213	2,511
Hanakāpi'ai	9	54	101	150	202	256	313	373	436	502	571
Hanakoa	3	16	30	45	61	77	95	113	133	153	175
Other Areas											
Wainiha and Lumaha'i Valleys	47	284	522	761	1,002	1,243	1,485	1,729	1,974	2,219	2,467
Hanalei to Kekaha	840	4,337	6,935	8,880	10,335	11,420	12,229	12,831	13,278	13,608	13,851
Kalalau east to Upper Mānoa	16	86	142	187	222	250	272	290	304	316	325
Total	**974**	**5,139**	**8,409**	**11,034**	**13,179**	**14,969**	**16,497**	**17,837**	**19,041**	**20,150**	**21,196**

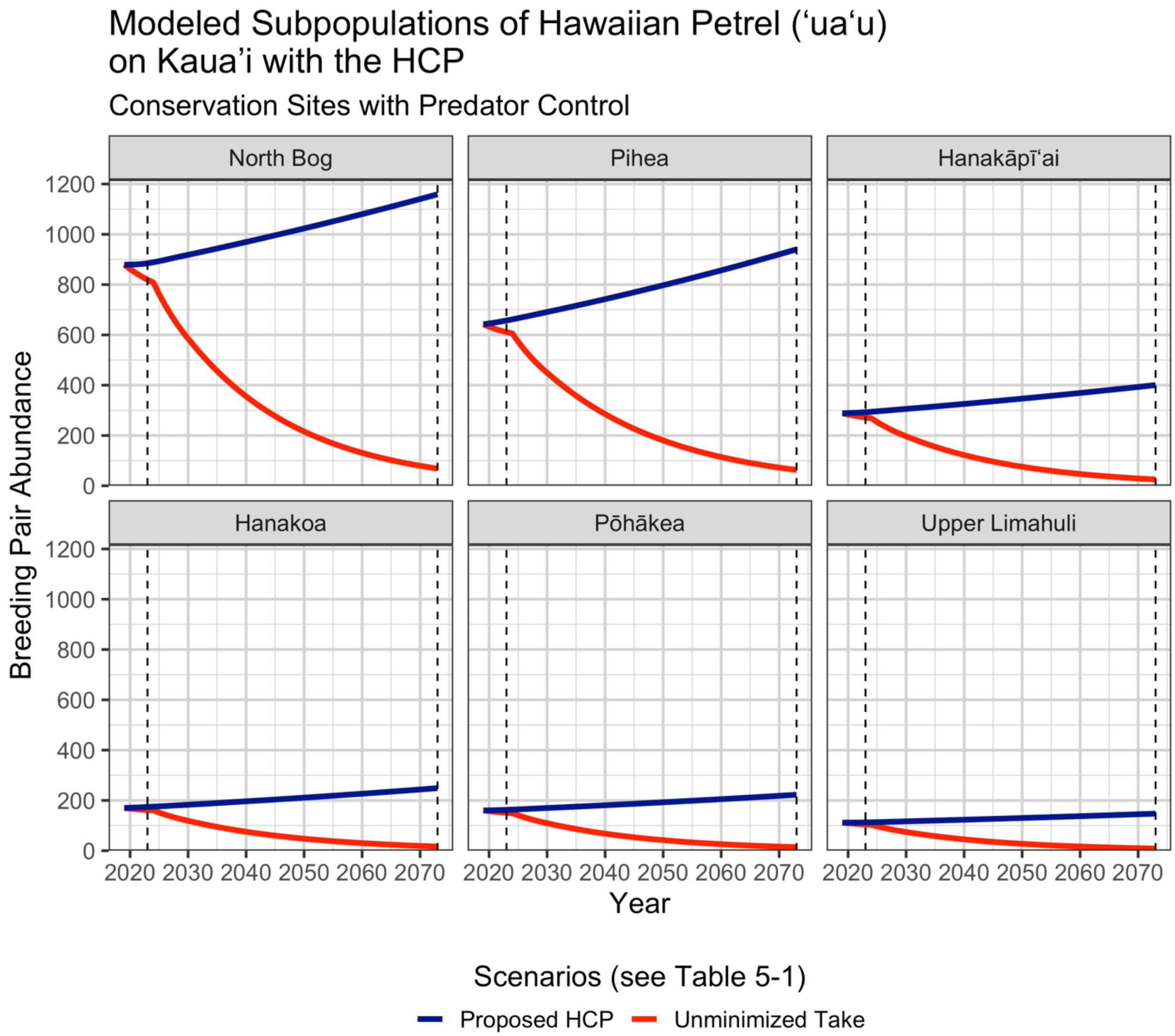

Figure 5F-3. Population Dynamics Model Results for Hawaiian Petrel ('ua'u) for each Subpopulation with Predator Control Measures and Ungulate Fencing

Red lines show the unminimized take model scenario without the HCP (take continues without powerline minimization, and without conservation measures; see Table 5-1 in Chapter 5). Blue lines are with the proposed HCP according to the schedule of conservation measures described in Chapter 4. The vertical dashed lines denote the first and last year of the permit term. See Figure 5F-1 for site locations.

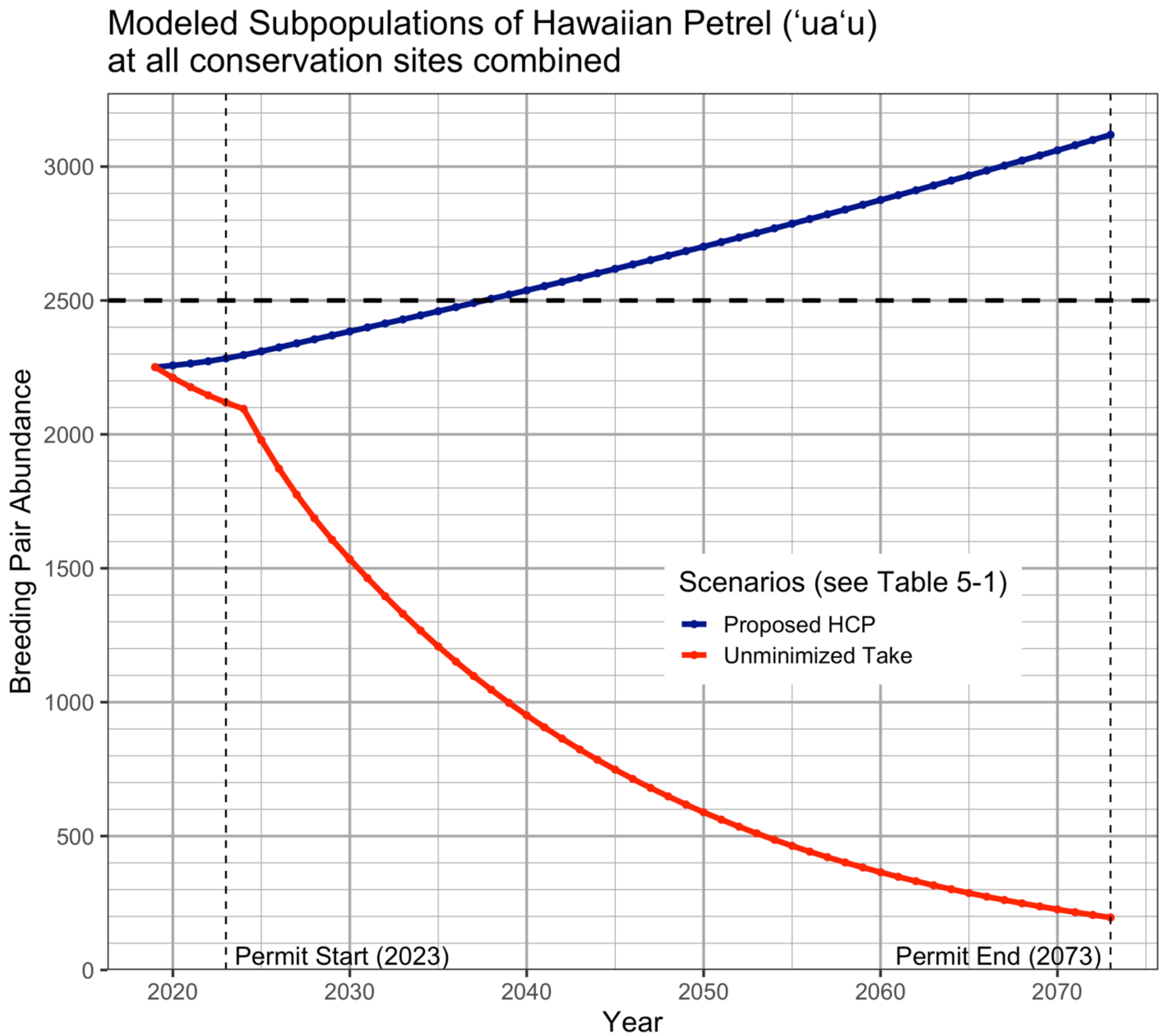

Figure 5F-4. Population Dynamics Model Results for Hawaiian Petrel (ʻuaʻu) for all Conservation Sites Combined

Red line shows the unminimized take scenario without the HCP (take continues without powerline minimization, and without conservation measures; see Table 5-1 in Chapter 5). Blue line is with the HCP according to the schedule of conservation measures described in Chapter 4. The horizontal dashed line highlights 2,500 breeding pairs, which USFWS considers to be a rough threshold for a viable metapopulation on the island (see Chapter 5 for details).

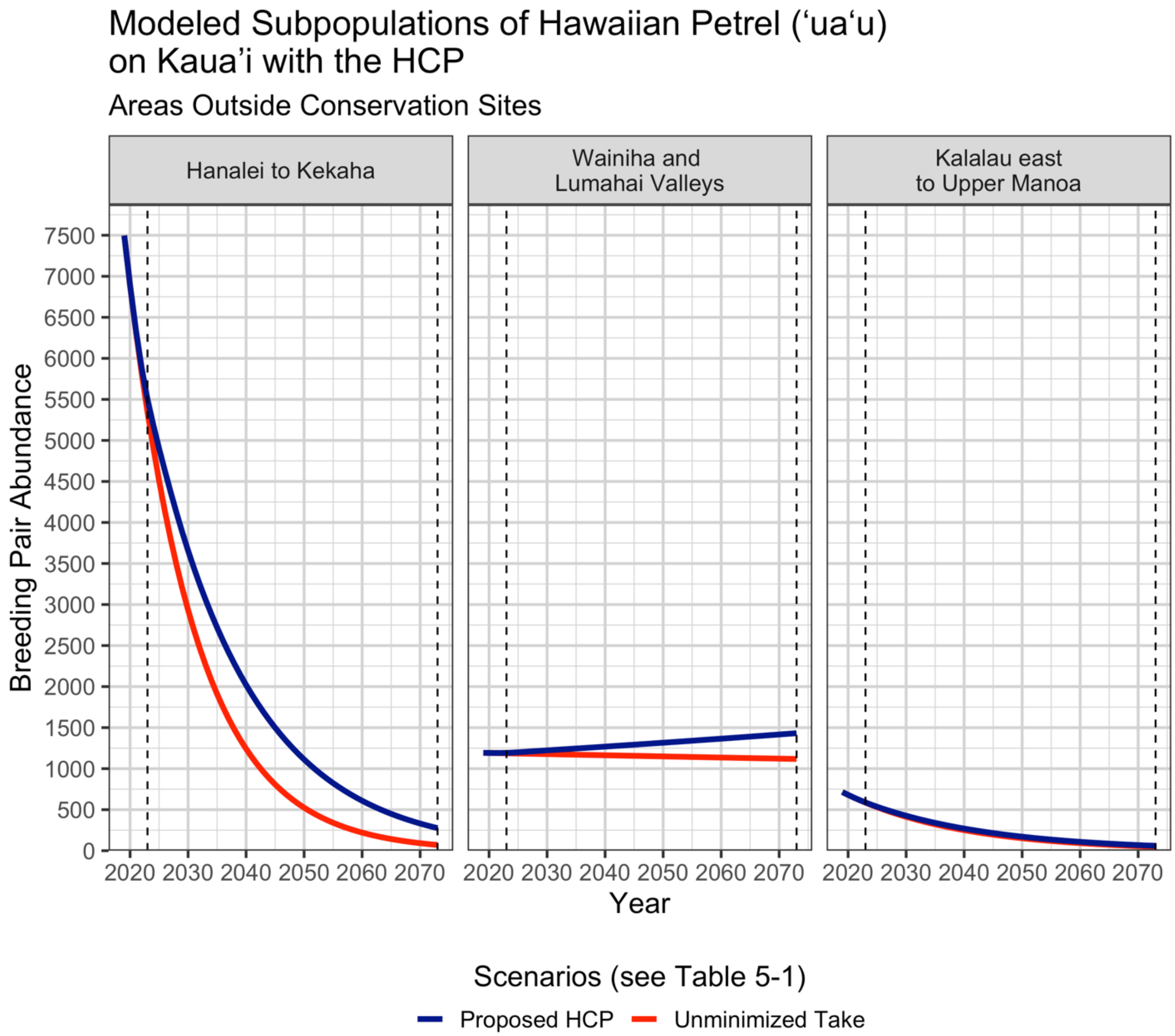

Figure 5F-5. Population Dynamics Model Results for Hawaiian Petrel (ʻuaʻu) for each Subpopulation outside the Conservation Sites

Red lines show the unminimized take model scenario (take continues without powerline minimization, and without conservation measures; see Table 5-1 in Chapter 5). Blue lines are with the proposed HCP according to the schedule of conservation measures (i.e., powerline collision minimization) described in Chapter 4. The vertical dashed lines denote the first and last year of the permit term. See Figure 5F-1 for site locations.

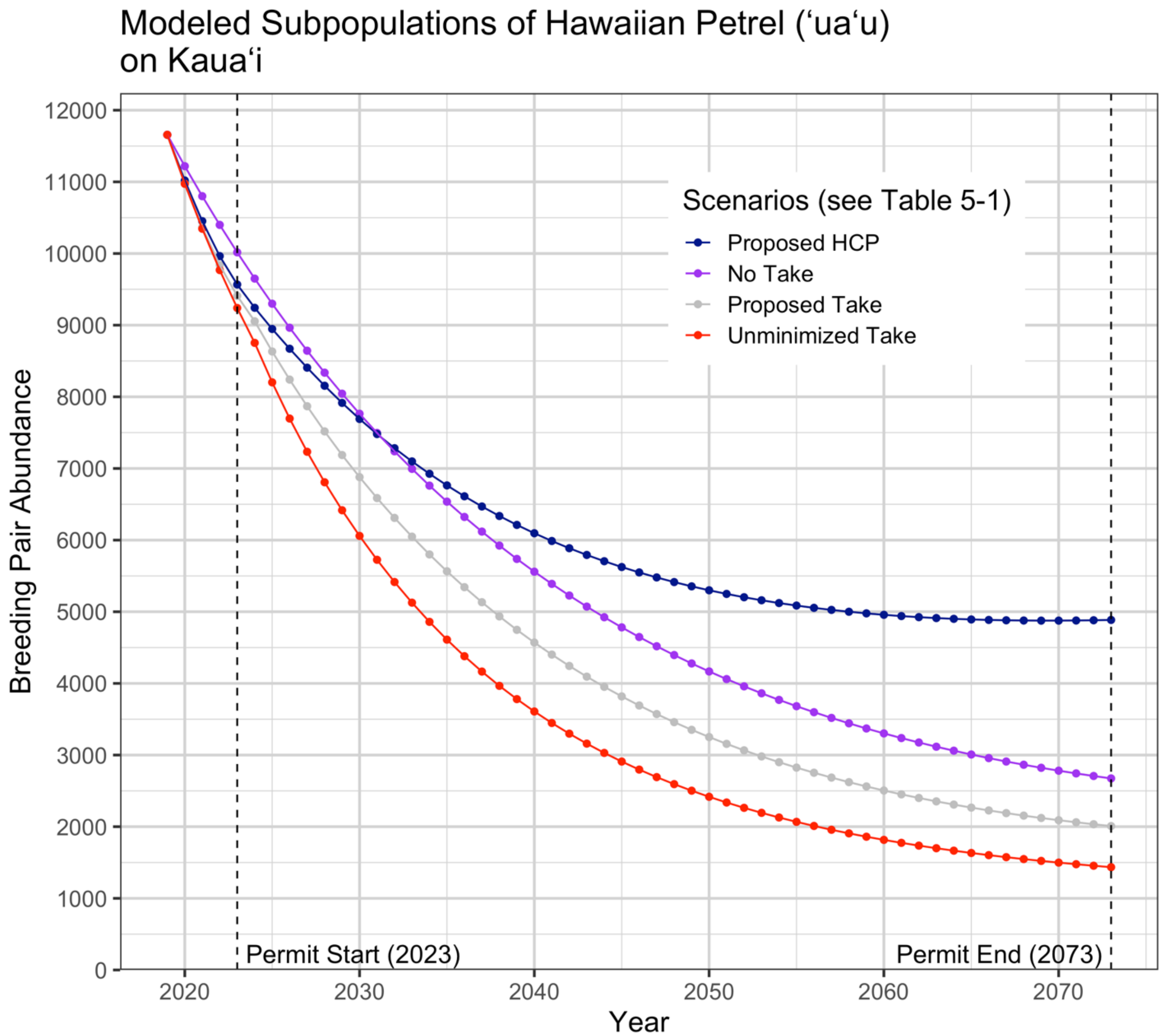

Figure 5F-6. Population Dynamics Model Results for Hawaiian Petrel (ʻuaʻu) for all Subpopulations Combined (all of Kauaʻi)

Red line is the unminimized take model scenario without the HCP (take continues without powerline minimization, and without conservation measures). Blue line is with the proposed HCP according to the schedule of conservation measures (i.e., powerline collision minimization) described in Chapter 4. The grey line is with the proposed minimized take; the purple line is with no take. See Table 5-1 in Chapter 5 for additional description of each model scenario. The vertical dashed lines denote the first and last year of the permit term.

5F.3 Model Limitations, Uncertainties, and Assumptions

The population dynamics model described in this appendix is a useful tool with which to compare outcomes to Hawaiian petrel (ʻuaʻu) on Kauaʻi both with and without the KIUC HCP. The model is also an important tool to confirm that the quantitative biological objectives for Hawaiian petrel (ʻuaʻu), particularly at the conservation sites, can be achieved by the end of the permit term. However, as with all models there are uncertainties in model inputs and outputs that should be considered. Model limitations include, but are not limited to, the following.

- Lack of statistical confidence limits around the island-based estimates of abundance.
- Uncertainty in certain vital rates (e.g., barn owl predation rates on the wing and predation rates in areas without predator control).
- Uncertainty in the efficacy of future powerline strike minimization efforts (although continued powerline monitoring will help narrow those uncertainties within a few years).
- Logistical difficulties in monitoring the population outside of established conservation sites.

Due to these limitations, the uncertainty in the model results has not been quantified. However, any population dynamics model of Hawaiian petrel (ʻuaʻu) relies on a suite of assumptions. The assumptions chosen for this model were selected to be as conservative as reasonably possible knowing that many model uncertainties have not been quantified. A list of the key assumptions is provided below for this model, with reasons these assumptions may be conservative or optimistic in terms of predicting effects of the HCP conservation measures on this species. These sections are intended to provide the reader with a qualitative understanding of the level and sources of uncertainty in model results.

5F.3.1 Conservative Assumptions

Reasons the population dynamics model may be conservative (i.e., overestimates adverse effects or underestimates beneficial effects for Hawaiian petrel [ʻuaʻu]) include the following.

- **Total powerline strikes.** The reported point estimate that is used as a model input for the annual average of seabird strikes corresponds to the mean of the Bayesian posterior predictive probability distribution, corrected to account for strikes that were subsequently recategorized as waterbirds (Travers et al. 2020; Travers unpublished data). For a right skewed (longer right tail) probability distribution, like the Bayes posterior predictive probability distribution for seabird strikes, the mean is greater than the expectation of the estimate. Statistically, this results in using a conservative (i.e., higher) level of powerline collisions in the model.
- **Strike allocation.** Allocation of powerline strikes may be even lower at some or all of the conservation sites than estimated, given flight paths, and observed altitudes from satellite tagging. For example, the estimated breeding probability from burrow monitoring data at seven conservation sites for Hawaiian petrel (ʻuaʻu) is 0.982 (Raine et al. 2022), which indicates that non-predation sources of mortality for breeding adults were quite low in these areas.
- **Population trend and optimal growth rate.** The modeled population trend for the Hanalei to Kekaha area assumes a relatively steep rate of decline, based on the long-term trend from the

Waiakalua Stream radar site. Based on recent (and longer-term) radar trends from the other radar sites, the population trend is unlikely to be that steep for all breeding colonies in this area.

Raine and Rossiter (2020) have shown that the average trend in radar estimates have leveled out since 2010, indicating that after a very large population decline the population trend may now be relatively stable on an island-wide basis. For example, a regression of radar data including all 13 monitored sites was flat with no significant change during the last decade (2010–2020).

This pattern is consistent with data on the amounts of rescues of Hawaiian petrel (ʻuaʻu) from the SOS Program, which are relatively stable over a similar period (Ainley et al. submitted).

Therefore, based on these three data sources (radar signatures, SOS rescues, and acoustic call rates) the aggregate modeled population trend in the absence of minimization and mitigation is likely to be conservative, at least in terms of observed trends over the last decade. If the aggregate population trend is more positive (either a smaller negative number or a number close to zero for a stable population), then the effects of the HCP conservation strategy will result in a greater benefit to the island-wide metapopulation of Hawaiian petrel (ʻuaʻu) than what is estimated.
Also, the optimal rate of modeled population growth assumed in the model is much lower than has been estimated for the family Procellariidae (all petrels, prions and shearwaters) in published allometric and demographic modeling studies. The results of those studies are consistent with species in this seabird family having expected optimal rates of population growth closer to 6.8 percent per year (Dillingham et al. 2016) or 7.1 percent per year (Dillingham and Fletcher 2011), depending on the methods used. This model assumed an optimal rate of modeled population growth (i.e., in the absence of introduced predators, powerline strikes or light fallout mortality) of 2.0 percent per year.

- **Fallout from light attraction.** Currently a constant amount of 5.3 age-1 (fledglings) from the Hanalei to Kekaha subpopulation are assumed to die annually from fallout associated with KIUC streetlights. The estimated level of fallout includes correction factors for the proportion of grounded seabirds that go undetected, e.g., for KIUC streetlights, 89.6% of grounded Hawaiian petrel (ʻuaʻu) are assumed to go undetected (Appendix 5C: *Light Attraction Modeling*). Fallout, whether detected or not, is assumed to result in 100% mortality in the model. This assumption is conservative for three reasons: (1) The estimate for fallout is based on the number of expected streetlights and facility lights at the end of the permit term, not at the beginning. Fallout from light attraction is therefore likely overestimated at the start of the projections; (2) This assumes zero individuals rehabilitated by the SOS program survive; and, (3) Fallout mortality is modeled as a fixed number of fledglings lost, not a mortality rate. In other words, even when the Hanalei to Kekaha subpopulation is much smaller towards the end of 50 years, 5.3 fledglings (or the number of modeled fledglings, whichever is smaller) are still removed in the model from this area each year. Furthermore, the level of mortality from fallout is estimated to be less than five percent of the level of mortality estimated from powerline collisions. So, while fallout mortality is a contributing factor to metapopulation dynamics, it does not have as large of an effect on metapopulation trends as powerline collisions.
- **Conservation actions performed by others.** The population dynamics of the Kauaʻi metapopulation of Hawaiian petrel (ʻuaʻu) are modeled only assuming the full implementation of this HCP's conservation. Numerous federal, state, and local agencies and conservation organizations are either implementing or planning to implement additional conservation actions

separately from this HCP, which will benefit Hawaiian petrel (‘ua‘u). Similarly, due to a lack of available estimates for reductions in predation rates resulting from barn owl control at the conservation sites, no attempt has been made to include the benefit of that form of predator control effort at the conservation sites. Because this model does not consider these other current or planned conservation action, the impacts of the taking of this HCP are conservative (i.e., overestimate effects).

5F.3.2 Potentially Optimistic Assumptions

Reasons the population dynamics model for Hawaiian petrel (‘ua‘u) may be too optimistic (i.e., underestimates adverse effects or overstates benefits) include the following.

- **Total metapopulation size.** The estimate of the island-wide metapopulation may be too high, despite the integration of multiple indpendent data sources, and what are thought to be conservative assumptions by experts. If this is true, then impacts of the taking would be greater than predicted by the model. However, all else being equal, the *relative* effects of the HCP would be the same because the comparison is made with and without the HCP using the same initial abundance estimate and estimates of trends in relative abundance (i.e., positive trends in call rates from the conservation sites and negative trends in relative abundance from the radar survey). Also, if a smaller value for metapopulation abundance were used, the modeled trend would become inconsistent with long-term monitoring data, e.g., the modeled rate of decline in the Hanalei to Kekaha area would be even more negative compared to the lowest estimated rates of decline from the radar survey. Such a steep rate of decline, which would result from the estimated number of powerline collisions if abundance was indeed lower, would not be supported by the best available science on long-term trends in abundance.
- **Cat predation events.** The model is deterministic, which means that mortality and reproductive rates are assumed to be constant between years (with the exceptions of powerline collision minimization and the effects of immigration into social attraction sites). As such, interannual variation (stochasticity) in predation rates is not modeled even though the number of predations by cats can be variable between years. In particular, there have been instances of individual cats predating multiple nests during certain years before they have been caught. As such, a conservation site may have low predation mortality rates for a period of years, with an incursion of a single problem cat one year leading to a spike in predation mortality rates that year. Breeding pairs and chicks inside predator exclusion fences may be subject to such events in rare instances (i.e., before the cat incursion is caught on camera and additional control efforts can be deployed). Such events may also occur outside of conservation sites despite aggressive predator control techniques.

  The predation mortality rates used in the model are based on burrow monitoring data from multiple conservation sites over multiple years. The resulting estimate represents an average annual predation mortality rate under predator control that includes punctuated predation mortality events due to single cats. If the estimated predation mortality rate does not fully capture the extent or frequency of these predation events, for example because they are not observed during the burrow monitoring surveys (i.e., predations are occurring at burrows that are yet undiscovered and are not currently monitored), the model results with respect to the benefits of predator control at the conservation sites would be optimistic. However, independent acoustic monitoring data indicate that at least since 2014–2015, the extent of punctuated cat predation events has not resulted in negative trends in recruitment into the breeding colonies at the conservation sites—call rates have continued to increase and have doubled at many conservation sites under predator control efforts (Raine et al. 2022), despite such predation events having occured during the same time.

- **Carrying capacity.** There is no assumption in the model that Hawaiian petrel (ʻuaʻu) population growth in the conservation sites will be limited by carrying capacity during the 50-year permit term. If, in the future, population growth is limited by the carrying capacity of suitable nesting habitat, the model results would overestimate the long-term benefit of the conservation sites to the metapopulation. However, not only are carrying capacities difficult to estimate reliably for these large management areas, but estimates of predation rates prior to dedicated predator control in the conservation sites in combination with the assumed low rates of population recovery suggest that reaching carrying capacity in the adjacent management areas is not likely during the permit term.
- **Allee effects.** The model does not account for either compensatory, or depensatory, density dependence on the population growth rate. The former would account for higher expected population growth rates at lower population sizes, for example due to decreasing competition for resources. The latter, also known as "Allee" effects, arises in situations where population growth rates might be expected to decrease at lower abundance levels, for example due to difficulties finding a mate at low densities. Given that Hawaiian petrel (ʻuaʻu) is an endangered species with a low intrinsic rate of increase, there does not seem to be support for considering compensatory density dependence within the permit term. However, if modeled subpopulations that are predicted to be vulnerable to large declines (e.g., breeding colonies in the Hanalei to Kekaha area) experience Allee effects at lower densities in the future, the degree of the modeled declines there could be optimistic. There is no indication that Allee effects are occurring at recent abundance levels, at least at the broader scales monitored by the radar survey. Recent population trends from the radar data seem to be generally flattening out instead of showing accelerating rates of decline, but Allee effects are a possibility at smaller spatial scales in areas of the island without predator control.

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Appendix 6A
Adaptive Management Comparison Tables

Table 6A-1. Newell's Shearwater (ʻaʻo) Powerline Collisions: Projected 5-year Rolling Averages

year	5-yr ave.	year	5-yr ave.	year	5-yr ave.	year	5-yr ave.	year	5-yr ave.
2027	1,763	2037	1,010	2047	583	2057	353	2067	235
2028	1,658	2038	956	2048	553	2058	337	2068	227
2029	1,554	2039	905	2049	525	2059	322	2069	220
2030	1,463	2040	856	2050	498	2060	309	2070	214
2031	1,386	2041	809	2051	473	2061	296	2071	209
2032	1,315	2042	765	2052	450	2062	284	2072	205
2033	1,250	2043	724	2053	428	2063	272	2073	203
2034	1,186	2044	685	2054	407	2064	262		
2035	1,125	2045	649	2055	388	2065	252		
2036	1,066	2046	615	2056	370	2066	243		

Table 6A-2. Hawaiian Petrel (ʻuaʻu) Powerline Collisions: Projected 5-year Rolling Averages

year	5-yr ave.	year	5-yr ave.	year	5-yr ave.	year	5-yr ave.	year	5-yr ave.
2027	878	2037	548	2047	370	2057	274	2067	225
2028	833	2038	525	2048	358	2058	268	2068	222
2029	790	2039	503	2049	346	2059	262	2069	219
2030	752	2040	483	2050	335	2060	256	2070	216
2031	717	2041	464	2051	325	2061	251	2071	214
2032	684	2042	446	2052	315	2062	245	2072	211
2033	654	2043	429	2053	306	2063	241	2073	209
2034	625	2044	413	2054	297	2064	236		
2035	598	2045	398	2055	289	2065	232		
2036	572	2046	384	2056	282	2066	229		

Table 6A-3. Newell's Shearwater (ʻaʻo) Breeding Pairs: Projected 5-year Rolling Averages

year	5-yr ave.	year	5-yr ave.	year	5-yr ave.	year	5-yr ave.	year	5-yr ave.
2027	1,329	2037	1,657	2047	2,198	2057	2,828	2067	3,612
2028	1,349	2038	1,710	2048	2,256	2058	2,902	2068	3,697
2029	1,372	2039	1,765	2049	2,314	2059	2,976	2069	3,783
2030	1,395	2040	1,819	2050	2,372	2060	3,052	2070	3,869
2031	1,418	2041	1,871	2051	2,432	2061	3,128	2071	3,957
2032	1,447	2042	1,924	2052	2,493	2062	3,206	2072	4,045
2033	1,480	2043	1,977	2053	2,555	2063	3,285	2073	4,134
2034	1,514	2044	2,031	2054	2,619	2064	3,365		
2035	1,557	2045	2,086	2055	2,687	2065	3,446		
2036	1,606	2046	2,142	2056	2,756	2066	3,529		

Table 6A-4. Hawaiian Petrel (ʻuaʻu) Breeding Pairs: Projected 5-year Rolling Averages

year	5-yr ave.	year	5-yr ave.	year	5-yr ave.	year	5-yr ave.	year	5-yr ave.
2027	2,311	2037	2,460	2047	2,618	2057	2,787	2067	2,967
2028	2,325	2038	2,475	2048	2,635	2058	2,804	2068	2,985
2029	2,340	2039	2,491	2049	2,651	2059	2,822	2069	3,004
2030	2,355	2040	2,506	2050	2,668	2060	2,840	2070	3,023
2031	2,370	2041	2,522	2051	2,684	2061	2,857	2071	3,042
2032	2,385	2042	2,538	2052	2,701	2062	2,875	2072	3,061
2033	2,399	2043	2,554	2053	2,718	2063	2,893	2073	3,080
2034	2,414	2044	2,570	2054	2,735	2064	2,911		
2035	2,429	2045	2,586	2055	2,752	2065	2,930		
2036	2,445	2046	2,602	2056	2,769	2066	2,948		

Appendix 6B

KIUC Site Monitoring Protocols & Procedures for Protected Seabirds

KIUC

Site Monitoring Protocols & Procedures for Protected Seabirds

Table of Contents

1. Introduction & Site Monitoring
2. Protected Seabird Species
3. Seabird Recovery Reporting Form
4. Contents of Oppenheimer Seabird Recovery Kit
5. SOS Aid Stations
6. Backup paper processing

Section 1

Introduction & SiteMonitoring

(Electronic Inspection Log)

INTRODUCTION

KIUC has developed a variety of support materials to assist its employees in executing the requirements of site monitoring, recovery, and reporting of protected seabirds that are found downed, injured, or dead at KIUC facilities. This manual includes information and guidance about the following:

1. Site monitoring protocol for all KIUC personnel
2. Threatened and endangered seabird species
3. Recovery and reporting process when dealing with a downed, injured, or dead seabird
4. KIUC Oppenheimer Seabird Recovery Kit
5. Location of SOS Aid Stations

SITE MONITORING

ALL PERSONNEL will report any downed seabirds they encounter during their daily work routine immediately to the Operations Shift Supervisor/Designee or Warehouse Supervisor/Designee for recovery and reporting.

DESIGNEE FOR EACH RESPECTIVE FACILITY shall watch for downed seabirds as they conduct their routine plant inspections throughout the year.
During the seabird fallout season (September 15 - December 15), searches targeted specifically at finding downed seabirds will be conducted as per the table in Figure 1, 7 days a week. The results of daily inspections conducted during the seabird season shall be recorded on the Electronic Seabird Weekly Inspection Log (see next page). Any downed seabirds shall be recovered and reported following the established protocols detailed in the KIUC Seabird Recovery Reporting Form under Section 3 of this manual. **In the event that a scheduled search cannot be conducted due to an operational emergency, the Operations Shift Supervisor or Designee will conduct the survey as soon as possible. A notation should be made on the inspection log accordingly.**

Figure 1:

	FREQUENCY		
FACILITY	3 to 4 hours after sunset	1 hour before sunrise	weekends & holidays
PAGS	x	x	x*
Kapaia GS	x	x	

** note : On Saturdays, Sundays and company holidays, PAGS will conduct an additional search for downed seabirds between 7:00 AM and 8:00 AM.*

ELECTRONIC SEABIRD INSPECTION LOG

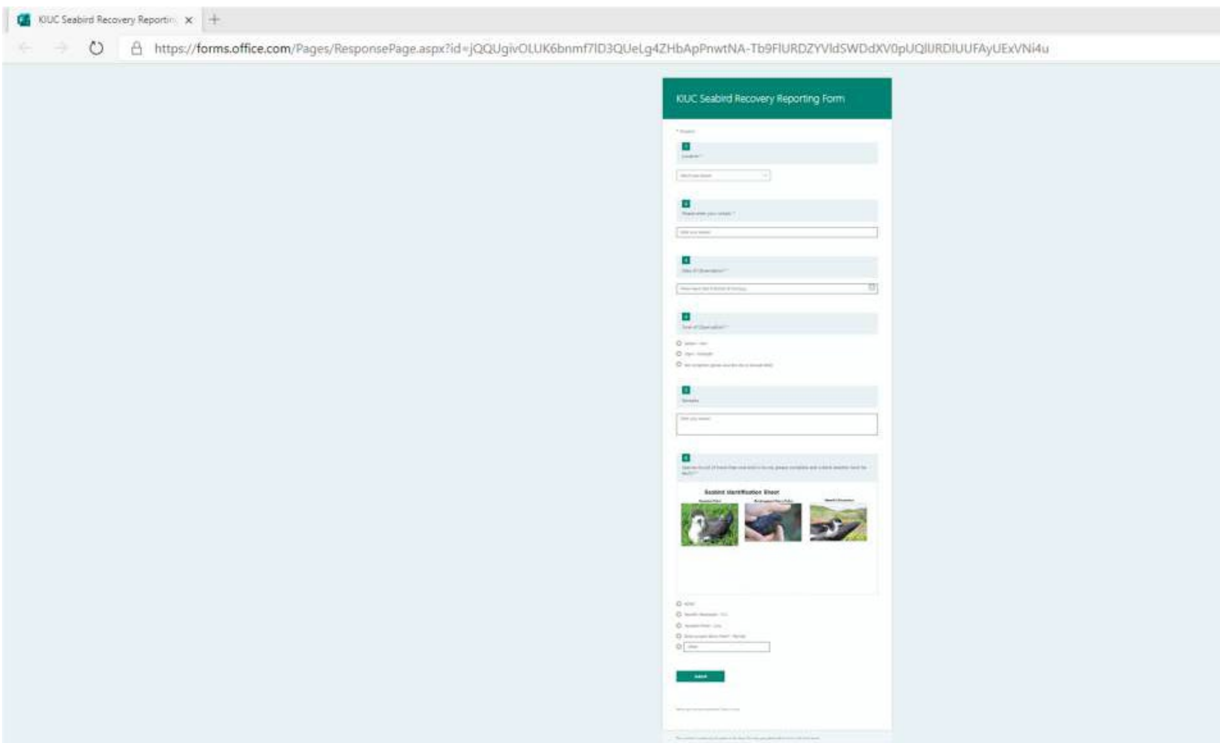
KIUC has developed an electronic inspection log to make the process more efficient. Using Microsoft Forms and the below link, anyone can get to and submit an inspection using a desktop computer, smart phone, or tablet.

Link to the electronic seabird inspection log can be found here:

KIUC Seabird Recovery Reporting Form

or by copy/paste the below into your browser:

https://forms.office.com/Pages/ResponsePage.aspx?id=jQQUgivOLUK6bnmf7lD3QUeLg4ZHbApPnwtNA-Tb9FlURDZYVldSWDdXV0pUQlJRDlUUFAyUExVNi4u



Please coordinate with your team to ensure your inspection frequencies are met for your respective facility. If ever in doubt if an inspection occurred or not, it's best to submit one again anyway (better to double up rather than missing an inspection).

A weekly report will be run and distributed to the teams so all submissions to date can be reviewed, corrected, and/or actioned. Please contact Chris Yuh for any issues or questions about the form (cyuh@kiuc.coop; 808-246-8281; 808-679-2388).

As a last resort backup, the paper documents from previous seasons can be found in Section 6.

Section 2

Protected Seabird Species

PROTECTED SEABIRD SPECIES

Why is KIUC taking special precautions with respect to protected seabirds?

KIUC's electrical transmission and distribution system is largely above ground and consists of poles and wires that extend from 25 to more than 100 feet above ground. The overhead wires and poles occupy airspace through which birds fly, and collisions between birds and these facilities have been reported. Covered facilities, which include the Port Allen and Kapaia Generating Stations, are of less concern, but there is potential for take.

In addition to collisions, urban lights, including KIUC's covered facility lights and streetlights KIUC owns and operates on behalf ofthe County of Kaua‘i, State of Hawai‘i, and private entities, can attract and/or disorient fledglingsof these species making their first flights to sea. Birds that become disoriented by these lights can exhaust themselves by flying around the lighted areas before eventually landing, and can also collide with obstacles such as power lines, utility poles, buildings, and other tall structures. The protected seabirds have very limited ability to resume flight from flat surfaces, therefore once on the ground they are highly subject to predation by dogs, cats, and other mammals, and to injury and death by vehicles, other human activity, or due to dehydration or starvation.

Studies indicate that KIUC's existing facilities have affected three species of seabirds that are protected by the Federal Endangered Species Act (ESA), the Hawai‘i Endangered Species Act, and other federal and state laws and regulations. All three species are also listed by the State of Hawai‘i as threatened or endangered species. The species are:

- the Federally listed endangered **Hawaiian Petrel** (*Pterodroma sandwichensis*);
- the Federally listed threatened **Newell's Shearwater** (*Puffinus newelli*); and
- the Federally listed endangered **Band-rumped Storm-Petrel** (*Oceanodroma castro*).

These species nest and breed in certain inland locations on the island but spend most of their lives at sea. They generally travel between land and sea during hours of darkness or near-darkness.

What are the legal implications?

There are significant legal implications if any of these birds are harmed, or the protected seabird protocols are not followed. Violations of the Federal ESA may include civil fines of up to $25,000 per incident, and criminal fines of up to $50,000, and up to one year imprisonment per incident. Violations of the state law include fines of up to $10,000 per species, up to one year imprisonment, or both.

Why do the seabirds fallout/What happens to them if they do?

- Nocturnally flying seabirds can be attracted to lights. This is particularly true of fledgling birds on their way to sea for the first time.
- The lights appear to confuse seabirds, leading them to collide with structures or simply circle until they land on the ground too tired to continue flying.
- Once on the ground they cannot take off again and will die from starvation, dehydration or be killed by predators if not rescued.

When is the seabird fallout season?

Adult seabirds arrive on the island as early as late March to find their mates and establish their nesting sites. These seabirds typically fly inland to their nests from sunset to about 3 hours after sunset and fly out to sea to forage for food during the 3 hours before sunrise. The potential for downings occurs during these flights. If downed, the seabirds will then attempt to seek places to hide at first light to escape from predators. Typical hiding places include under vegetation, in stairwells, under building materials, and under equipment including parked vehicles.

The vast majority of seabird fallout is by fledglings and occurs between September 15 and December 15 each year. However, adults and juveniles are typically present on Kaua‘i from mid-April onward.

Newell's Shearwater - ʻaʻo.

- Listed as a threatened species by both the U.S. and State of Hawaiʻi
- Ninety percent (90%) of the population nests on Kauaʻi. Also breeds on Maui, Hawaiʻi, and possibly Molokaʻi
- The Newell's Shearwater has an almost black head, upper wings and tail, and is white below. It has a thin narrow bill. Legs and feet are grey/black. Newell's are 12-14 inches long, and have a wingspan of 30 inches.

Hawaiian Petrel - ʻuʻau.

- Listed as an endangered species by both the U.S. and State of Hawaiʻi
- Breeding populations exist on Kauaʻi, Maui, Lanaʻi, and Hawaiʻi
- The Hawaiian Petrel has a dark gray head, wings, and tail, and a white forehead and belly. It has a stout grayish-black bill that is hooked at the tip. Its legs are pinkish with black and pink feet. This bird measures 16-17 inches in length and has a wing span of 35-37 inches.

Band-rumped Storm Petrel - ʻakeʻake.

- Listed as an endangered species by both the U.S. and State of Hawaiʻi
- Breeding populations exist on Kauaʻi, Lehua Island, Hawaiʻi and possibly on Maui.

The Band-rumped Storm-Petrel is an overall blackish-brown bird with an evenly-cut white rump band and slightly forked tail. It has a dark bill with a tube on top. This bird measures 8-9 inches in length and has a wing span of 17-18 inches.

Section 3

Seabird Recovery ReportingForm

ELECTRONIC SEABIRD RECOVERY REPORTINGFORM

As part of this year’s process improvements, the seabird recovery form can also be logged using our electronic form. Using Microsoft Forms and the below link, anyone can get to and submit a recovery form using a desktop computer, smart phone, or tablet.

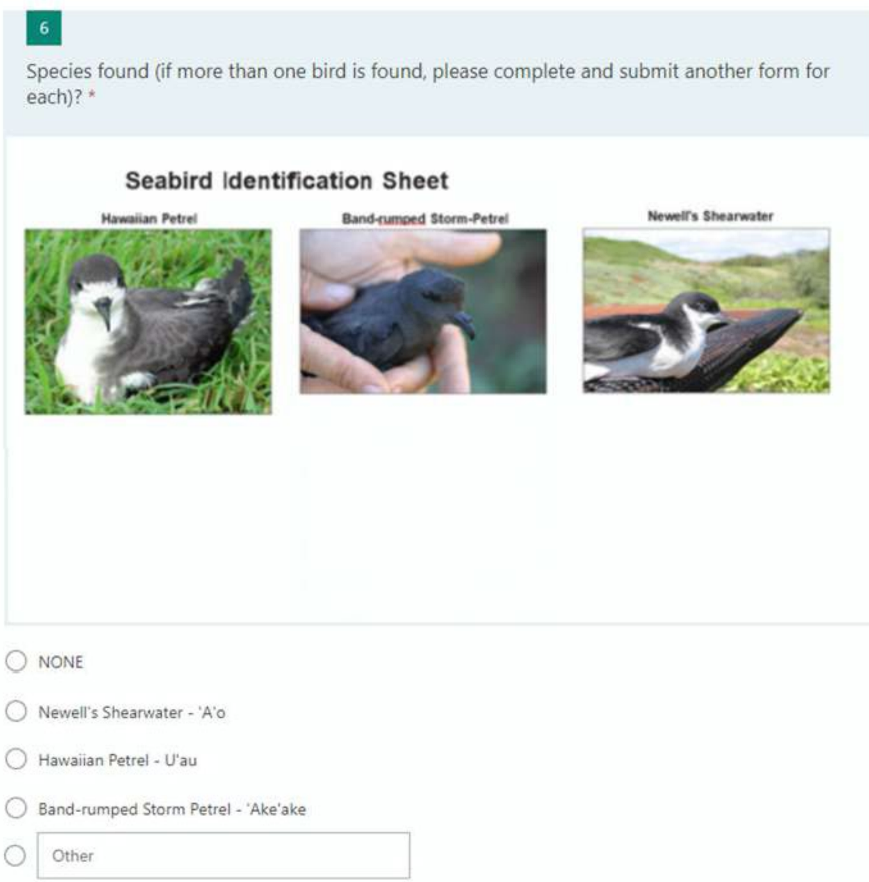
Link to the electronic seabird recovery form can be found using the SAME link to the seabird inspection log and found here:

KIUC Seabird Recovery Reporting Form

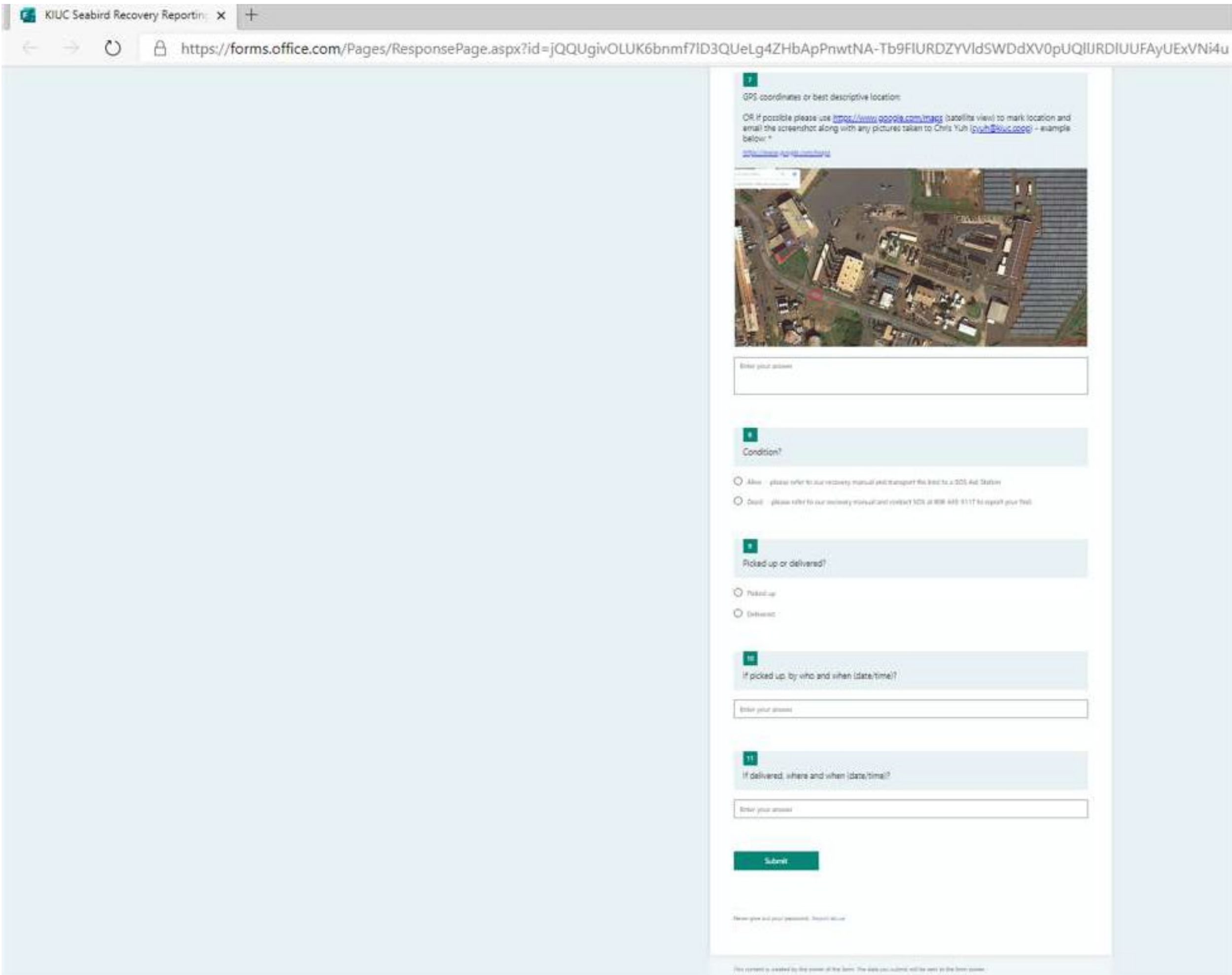
or by copy/paste the below into your browser:

https://forms.office.com/Pages/ResponsePage.aspx?id=jQQUgivOLUK6bnmf7lD3QUeLg4ZH
bApPnwtNA-Tb9FlURDZYVldSWDdXV0pUQllJRDlUUFAyUExVNi4u

If your answer to question 6 is anything other than “NONE,” then you will be prompted to fill out the electronic seabird recovery reporting form.



You will then be required to answer an additional set of questions regarding the endangered species you found.



As a last resort backup, the paper documents from previous seasons can be found in Section 6.

<u>If you encounter a living seabird:</u>

1. Before touching the downed seabird take at least one photograph of the scene showing the bird as it was found.
2. If possible please use https://www.google.com/maps (satellite view) to mark location the map and save the screenshot OR on the back side of the paper recovery reporting form, mark an "X" on the facility map to indicate where the seabird was found.
3. Deploy the KIUC Oppenheimer Seabird Recovery Kit.
4. Put on protective gloves.
5. Carefully wrap the bird in the clean towel from your kit and gently place it in the recovery box.
6. Transport the bird to the nearest SOS Aid Station.
7. Place the bird in the SOS Aid Station.
8. Call SOS at 635-5117 and report that seabird has been dropped off.
9. If seabird is dropped off after hours, leave a message with SOS providing all details and follow-up with a telephone call during business hours.
10. Fill in the Shearwater Aid Station log and provide Chris Yuh's contact information.
11. Contact Chris Yuh (cyuh@kiuc.coop, 808-246-8281 or 808-679-2388).
12. Completely fill out the *Electronic KIUC Seabird Recovery Reporting Form* OR manually fill out the paper version.

13. Submit all pictures, screenshots, and/or the paper reporting form to Chris Yuh.

<u>If you encounter a dead seabird:</u>

1. Take at least one photograph of the scene showing the carcass as it was found.
2. If possible please use https://www.google.com/maps (satellite view) to mark location the map and save the screenshot OR on the back side of the paper recovery reporting form, mark an "X" on the facility map to indicate where the seabird was found.
3. Put on protective gloves.
4. Carefully place the carcass in two (2) Ziploc bags.
5. Place in refrigerator.
6. Contact SOS at 635-5117 and wait for further instructions (if after hours, leave a message with details and follow-up during business hours).
7. Contact Chris Yuh (cyuh@kiuc.coop, 808-246-8281 or 808-679-2388).
8. Completely fill out the *Electronic KIUC Seabird Recovery Reporting Form* OR manually fill out the paper version.
9. Submit all pictures, screenshots, and/or the paper reporting form to Chris Yuh.

Section 4

Contents of OppenheimerSeabird Recovery Kit

CONTENTS OF OPPENHEIMER SEABIRD RECOVERY KIT

To assist KIUC employees in fulfilling the conditions of its permits, it is equipping all KIUC vehicles and designated facilities with a package of materials which will help them deal with cases of downed, injured or dead protected species. Known as an *Oppenheimer Seabird Recovery Kit*, this kit is kept in their service vehicles and at selected KIUC facilities for use by employees as needed. As part of the Seabird Protection Training Program, all KIUC employees have been trained in how to use the contents of the kit to help them follow policies and procedures regarding the handling and reporting of downed, injured, or dead protected species they may encounter in the course of their duties.

Each *Oppenheimer Seabird Recovery Kit* includes the following five items:

***Folded Cardboard Carrier*.** This carrier is a collapsible cardboard box, approximately 18 inches long, 10 inches wide, and 12 inches deep. This is large enough to accommodate any of the Covered Species. It can be folded to allow for carrying in service vehicles and can be quickly deployed whenever necessary.

***Nitrile Gloves*.** A pair of Nitrile gloves, which are to be worn whenever a KIUC employee needs to handle a seabird. These gloves prevent contamination of the bird and protect the employee.

***Cloth Towel*.** A clean towel, such as a generic automotive cleanup towel, approximately 12 inches square. Once the employee has donned the Nitrile gloves, he/she may use this towel to gently wrap the bird and place it in the cardboard carrier described above. This helps prevent any further harm to the bird as it is transported to a recovery location.

***Seabird Recovery Reporting Form*.** This document is to be filled out by the KIUC employee(s) in the process of recovering a seabird. It contains fields for relevant information, such as the date, time, and location of the recovery, as well as GPS coordinates, species, status at time of recovery (i.e. living or dead), and the person/organization to which the bird was delivered. The form also summarizes the procedure which the employee is to follow at the time of recovery and reporting.

***Seabird Identification Photographs*.** Correctly identifying seabirds can be challenging, and KIUC employees are not expected to be able to do so with total accuracy. To assist them in the sometimes difficult process of accurately reporting species information, photographs of the three threatened or endangered covered species (i.e., Newell's Shearwater, Hawaiian Petrel, and Band-rumped Storm-Petrel) have been included on the back side of the *Seabird Recovery Reporting Form*. Detailed information is also located in this manual under the "Protected Seabird Species" section.

It is suggested that the items listed above are inserted into the collapsed carrier and then kept in a plastic trash bag for ease of storage in service vehicles and to keep them clean and free of any possible contaminants.

***Ziploc Bags*.** Two 2-gallon-sized Ziploc bags are to be used in the event a dead seabird is found at the facility. The double-bagged carcass should then be placed into a refrigerator until further instructions are received from SOS.

Section 5

SOS Aid Stations

SOS AID STATIONS

After initiating the proper recovery procedures, the downed seabird can be transported to one of the SOS Aid Stations located below:

North

- Hanalei Fire Station
- Hanalei Liquor Store
- North Shore Pharmacy Parking Lot *(formerly North Shore Medical Center)*

Central-East

- Kaiʻakea Fire Station
- Kapaʻa Fire Station
- Kauaʻi Humane Society
- Līhuʻe Fire Station

West

- Hanapēpē Fire Station
- Kalāheo Fire Station
- Port Allen Chevron
- Waimea Fire Station

South

- Koloa Fire Station

Contact Number for SOS: 635-5117

Photograph of SOS Aid Station

Section 6

Backup Paper Docs

2020 Seabird Fallout Season

KIUC Facility Site Monitoring - Weekly Inspection Log

Facility: **Week Starting:** ________________________ **Week Ending:** ______________________

		DATE	INSPECTION DONE BY	START TIME	BIRDS FOUND (Y/N)*	ALIVE / DEAD	IF YES, LOCATION
Monday	Sunrise-8AM						
	10PM-Midnight						
Tuesday	Sunrise-8AM						
	10PM-Midnight						
Wednesday	Sunrise-8AM						
	10PM-Midnight						
Thursday	Sunrise-8AM						
	10PM-Midnight						
Friday	Sunrise-8AM						
	10PM-Midnight						
Saturday	Sunrise-8AM						
	10PM-Midnight						
Sunday	Sunrise-8AM						
	10PM-Midnight						

* If a seabird is found, immediately follow established protocol specified on the *KIUC Seabird Recovery Reporting Form*.

IF A SCHEDULED SEARCH CANNOT BE CONDUCTED DUE TO AN OPERATIONAL EMERGENCY, PLEASE NOTE ON LOG.

KIUC SEABIRD RECOVERY REPORTING FORM

DATE:		**TIME:**		**RESPONDER:**	
LOCATION:					
GPS LOCATION:					
SPECIES:					**ALIVE / DEAD**
PHOTO REFERENCE #S:					
AGENCY PICKUP – WHO:					
PICK UP OR DELIVERY:					
IF DELIVERY WHERE:					
REMARKS:					

If you encounter a living seabird:

1. Before touching the downed seabird take at least one photograph of the scene showing the bird as it was found.
2. If possible please use https://www.google.com/maps (satellite view) to mark location the map and save the screenshot OR on the back side of the paper recovery reporting form, mark an "X" on the facility map to indicate where the seabird was found.
3. Deploy the KIUC Oppenheimer Seabird Recovery Kit.
4. Put on protective gloves.
5. Carefully wrap the bird in the clean towel from your kit and gently place it in the recovery box.
6. Transport the bird to the nearest SOS Aid Station.
7. Place the bird in the SOS Aid Station.
8. Call SOS at 635-5117 and report that seabird has been dropped off.
9. If seabird is dropped off after hours, leave a message with SOS providing all details and follow-up with a telephone call during business hours.
10. Fill in the Shearwater Aid Station log and provide Chris Yuh's contact information.
11. Contact Chris Yuh (cyuh@kiuc.coop, 808-246-8281 or 808-679-2388).
12. Completely fill out the *Electronic KIUC Seabird Recovery Reporting Form* OR manually fill out the paper version.
13. Submit all pictures, screenshots, and/or the paper reporting form to Chris Yuh.

If you encounter a dead seabird:

1. Take at least one photograph of the scene showing the carcass as it was found.
2. If possible please use https://www.google.com/maps (satellite view) to mark location the map and save the screenshot OR on the back side of the paper recovery reporting form, mark an "X" on the facility map to indicate where the seabird was found.
3. Put on protective gloves.
4. Carefully place the carcass in two (2) Ziploc bags.
5. Place in refrigerator (continued next page).

6. Contact SOS at 635-5117 and wait for further instructions (if after hours, leave a message with details and follow-up during business hours).
7. Contact Chris Yuh (cyuh@kiuc.coop, 808-246-8281 or 808-679-2388).
8. Completely fill out the *Electronic KIUC Seabird Recovery Reporting Form* OR manually fill out the paper version.
9. Submit all pictures, screenshots, and/or the paper reporting form to Chris Yuh.

Seabird Identification Sheet

Hawaiian Petrel

Band-rumped Storm-Petrel

Newell's Shearwater

North

Hanalei Fire Station
Hanalei Liquor Store
North Shore Pharmacy Parking Lot *(formerly N. Shore Medical Center)*

Central-East

Kaiʻakea Fire Station
Kapaʻa Fire Station
Kauaʻi Humane Society
Līhuʻe Fire Station

West

Hanapēpē Fire Station
Kalāheo Fire Station
Port Allen Chevron
Waimea Fire Station

South

Koloa Fire Station

SOS Aid Station Locations

Kauaʻi Island Utility Cooperative

Revised 11/2022

Appendix 7A

Cost Model

Kauaʻi Island Utility Cooperative Habitat Conservation Plan
Cost Model

Prepared by ICF

Introduction

This model estimates the cost of implementing the Kauaʻi Island Utility Cooperative (KIUC) Habitat Conservation Plan (HCP) in fulfillment of its terms and conditions. The goal of the cost model is to demonstrate that costs to KIUC over the 50-year HCP permit term have been reasonably and conservatively estimated in a manner that is transparent and reproducable. The table of contents, below, describes and links to each interconnected component of the model.

To briefly summarize the model design and function: The annual costs of the HCP are estimated within a series of distinct cost categories across the 50-year HCP permit term. Sources, assumptions, and calculations for estimating costs within each category are provided on the group of sheets listed under "HCP Implementation Cost Estimates," below. The model also recognizes costs incurred by KIUC for early implementation of certain conservation actions from 2020 through 2022, prior to issuance of the HCP permit, on the group of sheets listed under "Early Implementation Costs," below. Wherever possible, cost estimates are based on actual costs or detailed cost estimates for the same or similar activities that would be implemented for the HCP. Where this information was not available, cost were estimated based on reasonable assumptions and best professional judgement of the HCP preparation team. The sheets listed under "Assumptions and Parameters," below, identify global parameters and assumptions applied to the model. Certain fundamental assumptions and parameters can be updated dynamically throughout the model. Lastly, the sheets listed under "Summary Tables and Charts," below, draw from each individual cost category calculation sheet to present the aggregated costs of the HCP in tabular and graphic formats.

Chapter 7 of the HCP, "Plan Implementation," provides additional description of plan implementation and summary of HCP costs.

Cost Summary Table

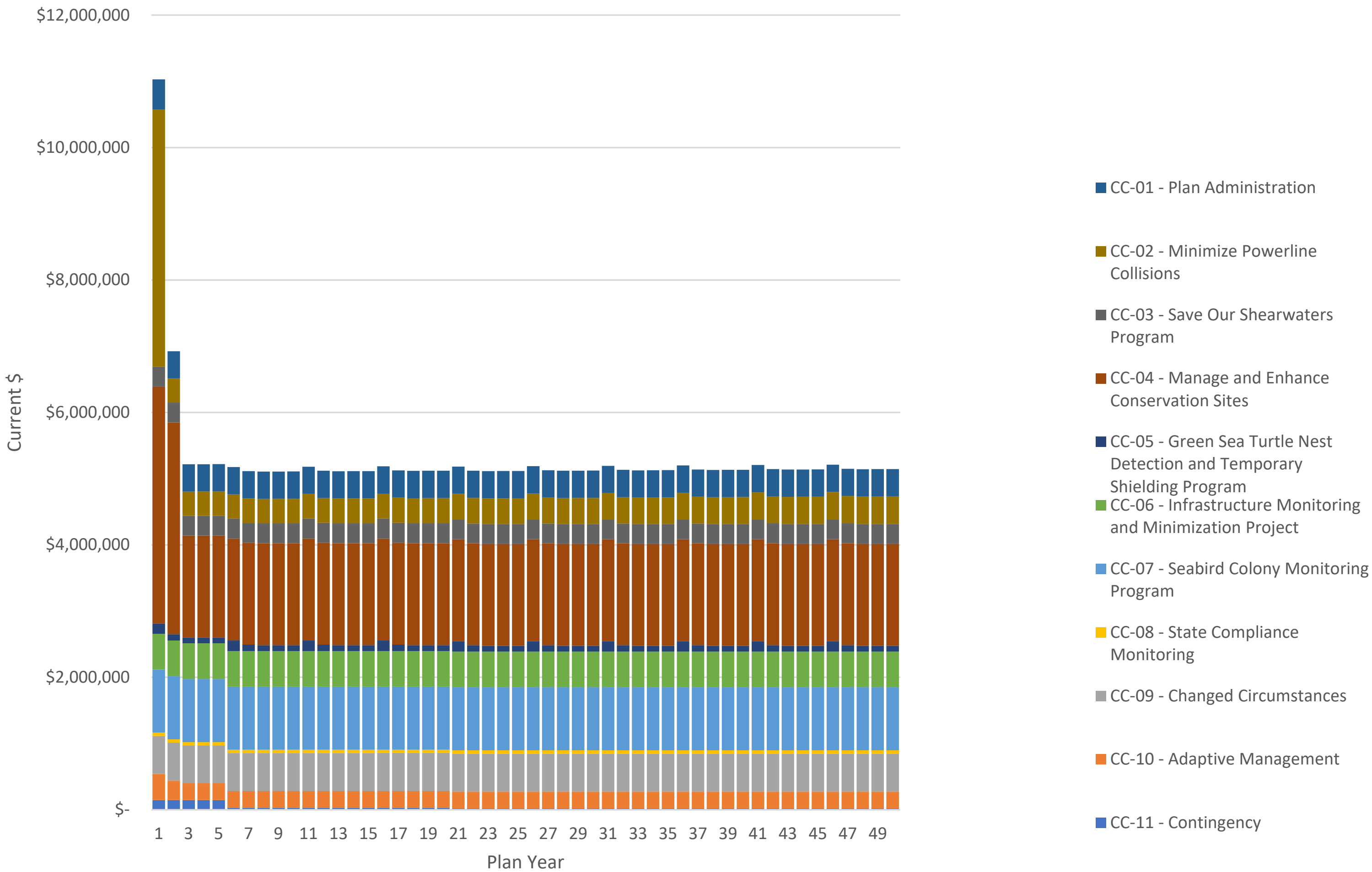
Table showing KIUC HCP implementation cost estimates by category and plan year

				Permit period (calendar years)																
Cost categories	**Avg. annual cost during permit period**	**Avg. annual cost: 2025-2072**	**Early implementation period: 2020–2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028–2032**	**2033–2037**	**2038–2042**	**2043–2047**	**2048–2052**	**2053–2057**	**2058–2062**	**2063–2067**	**2068–2072**	**Total: 2025-2072**	**50-year total**	**% of total cost by category**
Plan Administration	$413,300	$412,500	N/A	$452,500	$412,500	$412,500	$412,500	$412,500	$2,062,500	$2,062,500	$2,062,500	$2,062,500	$2,062,500	$2,062,500	$2,062,500	$2,062,500	$2,062,500	$19,800,000	$20,665,000	7.8%
Minimize Powerline Collisions	$460,133	$390,791	$19,757,870	$3,885,544	$363,141	$364,270	$365,399	$366,527	$1,849,564	$1,877,777	$1,905,991	$1,934,204	$1,962,418	$1,990,631	$2,018,845	$2,047,058	$2,075,272	$18,757,954	$23,006,640	8.7%
Save Our Shearwaters Program	$300,000	$300,000	$744,344	$300,000	$300,000	$300,000	$300,000	$300,000	$1,500,000	$1,500,000	$1,500,000	$1,500,000	$1,500,000	$1,500,000	$1,500,000	$1,500,000	$1,500,000	$14,400,000	$15,000,000	5.7%
Manage and Enhance Conservation Sites	$1,612,144	$1,538,202	$9,015,764	$3,576,627	$3,196,868	$1,538,202	$1,538,202	$1,538,202	$7,691,011	$7,691,011	$7,691,011	$7,691,011	$7,691,011	$7,691,011	$7,691,011	$7,691,011	$7,691,011	$73,833,709	$80,607,204	30.4%
Green Sea Turtle Nest Detection and Temporary Shielding Program	$104,100	$103,119	-	$158,900	$96,400	$88,400	$88,400	$88,400	$520,500	$520,500	$520,500	$520,500	$520,500	$520,500	$520,500	$520,500	$520,500	$4,949,700	$5,205,000	2.0%
Infrastructure Monitoring and Minimization Project	$539,911	$539,911	$2,746,125	$539,911	$539,911	$539,911	$539,911	$539,911	$2,699,554	$2,699,554	$2,699,554	$2,699,554	$2,699,554	$2,699,554	$2,699,554	$2,699,554	$2,699,554	$25,915,722	$26,995,544	10.2%
Seabird Colony Monitoring Program	$952,993	$952,993	$2,347,023	$952,993	$952,993	$952,993	$952,993	$952,993	$4,764,965	$4,764,965	$4,764,965	$4,764,965	$4,764,965	$4,764,965	$4,764,965	$4,764,965	$4,764,965	$45,743,662	$47,649,648	18.0%
State Compliance Monitoring	$50,000	$50,000	N/A	$50,000	$50,000	$50,000	$50,000	$50,000	$250,000	$250,000	$250,000	$250,000	$250,000	$250,000	$250,000	$250,000	$250,000	$2,400,000	$2,500,000	0.9%
Changed Circumstances	$572,934	$572,934	N/A	$572,934	$572,934	$572,934	$572,934	$572,934	$2,864,668	$2,864,668	$2,864,668	$2,864,668	$2,864,668	$2,864,668	$2,864,668	$2,864,668	$2,864,668	$27,500,812	$28,646,679	10.8%
Adaptive Management	$257,375	$253,744	N/A	$394,862	$294,183	$252,345	$252,373	$252,401	$1,266,354	$1,267,060	$1,267,765	$1,268,470	$1,269,176	$1,269,881	$1,270,586	$1,271,292	$1,271,997	$12,179,700	$12,868,745	4.9%
Contingency	$34,995	$30,378	N/A	$145,813	$145,813	$145,813	$145,813	$145,813	$145,813	$145,813	$145,813	$97,209	$97,209	$97,209	$97,209	$97,209	$97,209	$1,458,135	$1,749,762	0.6%
Total	**$5,297,884**	**$5,144,571**	**$34,611,125**	**$11,030,084**	**$6,924,744**	**$5,217,368**	**$5,218,525**	**$5,219,682**	**$25,614,930**	**$25,643,849**	**$25,672,768**	**$25,653,082**	**$25,682,001**	**$25,710,920**	**$25,739,838**	**$25,768,757**	**$25,797,676**	**$246,939,395**	**$264,894,222**	**100.0%**

Sources and notes: All costs are reported in current $ (year 2021). See individual cost category tabs for explanation of estimates. Average annual cost and total costs are reported separately for years 2025-2072 to omit high, one-time capital costs during years 2023 and 2024.

Cost Summary Chart

Chart showing KIUC HCP implementation cost estimates by category and plan year



Sources and notes: All costs are reported in current $ (year 2021). See individual cost category tabs for explanation of estimates.

General Assumptions

Assumptions for plan start year, permit term, cost base year, and future inflation

Source $: Cost expressed in dollar value from year it was paid
Current $: Cost expressed in dollars adjusted for purchasing power based on annual Consumer Price Index data
It is assumed that all cost components will increase over time due to inflation. To simplify the presentation, all costs are expressed in current $ (year 2021), allowing comparisons between costs today and costs later in the permit term. KIUC will pay all costs associated with HCP implementation, including inflation, even if those costs are above the costs estimated here.

Plan start year
2023

Plan end year
2072

Permit term (years)
50

Current $ Year
2021

Inflation

Plan year	Calendar year
	2021
	2022
1	2023
2	2024
3	2025
4	2026
5	2027
6	2028
7	2029
8	2030
9	2031
10	2032
11	2033
12	2034
13	2035
14	2036
15	2037
16	2038
17	2039
18	2040
19	2041
20	2042
21	2043
22	2044
23	2045
24	2046
25	2047
26	2048
27	2049
28	2050
29	2051
30	2052
31	2053
32	2054
33	2055
34	2056
35	2057
36	2058
37	2059
38	2060
39	2061
40	2062
41	2063
42	2064
43	2065
44	2066
45	2067
46	2068
47	2069
48	2070
49	2071
50	2072

Consumer Price Index Conversions

Historical consumer price index data used to convert costs to current dollars

CPI for All Urban Consumers (CPI-U)
Original Data Value

Series Id:	CUURS49FSA0,CUUSS49FSA0
Not Seasonally Adjusted	
Series Title:	All items in Urban Hawaii, all urban consumers, not seasonally adjusted
Area:	Urban Hawaii
Item:	All items
Base Period:	1982-84=100
Years:	2010 to 2020

Historical consumer price index (CPI) data used to convert costs from previous years (source $) to current $.

Source: U.S. Bureau of Labor Statistics. 2021. Accessed January 21, 2021.

■ = calculated by ICF
■ = add or replace with actual values when available

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	HALF1	HALF2	Annual Inflation Rate	Covert to current year cost
2010													234.869	233.822	235.916		126.376%
2011													243.622	241.902	245.342	3.727%	121.835%
2012													249.474	248.646	250.303	2.402%	118.978%
2013													253.924	253.202	254.646	1.784%	116.892%
2014													257.589	255.989	259.190	1.443%	115.229%
2015													260.165	257.848	262.482	1.000%	114.088%
2016													265.283	264.038	266.528	1.967%	111.887%
2017											274.346		272.014	270.738	273.290	2.537%	109.119%
2018	273.909		275.408		276.359		277.389		279.113		279.700		277.078	275.196	278.960	1.862%	107.124%
2019	279.005		280.263		282.271		281.928		282.106		282.248		281.585	280.666	282.503	1.627%	105.410%
2020	283.683		285.321		285.834		285.725		287.529		286.872		286.008	285.086	286.931	1.571%	103.780%
2021	287.634		290.361		296.559		298.820		301.891		302.332		296.818	292.475	301.161	3.780%	100.000%
2022	304.988		312.158		317.207		319.197		321.799				296.818	312.137		0.000%	100.000%
2023													296.818			0.000%	100.000%
2024													296.818			0.000%	100.000%
2025													296.818			0.000%	100.000%

Early Implementation Costs: Summary

Costs for early implementation of conservation measures and other actions from 2020 to 2022

Early Implementation Cost Summary (source $)

Category	2020	2021	2022	TOTAL
Minimize Powerline Collisions	**$5,250,352**	**$6,307,575**	**$8,001,500**	**$19,559,426**
Save Our Shearwaters Program	**$245,028**	**$245,028**	**$245,028**	**$735,083**
Manage and Enhance Conservation Sites	**$1,165,593**	**$1,441,853**	**$6,364,263**	**$8,971,709**
Site 10	*$26,869*	*$31,713*	*$2,364,609*	*$2,423,191*
Upper Limahuli Preserve	*$529,805*	*$465,235*	*$2,821,996*	*$3,817,036*
Pihea, Pōhākea, North Bog	*$608,919*	*$712,851*	-	*$1,321,770*
Hanakoa, Hanakāpīʻai	-	*$232,055*	-	*$232,055*
Pihea, Pōhākea, North Bog, Hanakoa, Hanakāpīʻai	-	-	*$1,151,099*	
Pōhākea PF	-	-	*$26,558*	*$26,558*
Infrastructure Monitoring and Minimization Project	**$595,145**	**$1,052,501**	**$1,075,985**	**$2,723,630**
Seabird Colony Monitoring Program	**$351,089**	**$976,918**	**$1,005,746**	**$2,333,753**
TOTAL	**$7,607,207**	**$10,023,874**	**$16,692,521**	**$34,323,602**

Early Implementation Cost Summary (current $)

Category	2020	2021	2022	TOTAL
Minimize Powerline Collisions	**$5,448,795**	**$6,307,575**	**$8,001,500**	**$19,757,870**
Save Our Shearwaters Program	**$254,289**	**$245,028**	**$245,028**	**$744,344**
Manage and Enhance Conservation Sites	**$1,209,648**	**$1,441,853**	**$6,364,263**	**$9,015,764**
Site 10	*$27,885*	*$31,713*	*$2,364,609*	*$2,424,207*
Upper Limahuli Preserve	*$549,830*	*$465,235*	*$2,821,996*	*$3,837,061*
Pihea, Pōhākea, North Bog	*$631,934*	*$712,851*	-	*$1,344,784*
Hanakoa, Hanakāpīʻai	-	*$232,055*	-	*$232,055*
Pihea, Pōhākea, North Bog, Hanakoa, Hanakāpīʻai	-	-	*$1,151,099*	*$1,151,099*
Pōhākea PF	-	-	*$26,558*	*$26,558*
Infrastructure Monitoring and Minimization Project	**$617,639**	**$1,052,501**	**$1,075,985**	**$2,746,125**
Seabird Colony Monitoring Program	**$364,359**	**$976,918**	**$1,005,746**	**$2,347,023**
TOTAL	**$7,894,730**	**$10,023,874**	**$16,692,521**	**$34,611,125**

Sources and notes

Minimize Powerline Collisions: See following page for cost estimation methods.

Save our Shearwaters: Save Our Shearwaters Program 2020

Manage and Enhance Conservation Sites: Hallux Ecosystem Restoration LLC 2020a, 2020b, 2021a, 2021b; National Tropical Botanical Garden 2020, 2021; Archipelago Research and Conservation 2021a; Conservation Fencing LLC 2021

Regional Feral and Free-Roaming Cat Management Program: Hallux Ecosystem Restoration LLC 2021b

Infrastructure Monitoring and Minimization Project: Kauaʻi Endangered Seabird Recovery Project 2020a; Archipelago Research and Conservation 2021b, 2021c

Seabird Colony Monitoring Program: Kauaʻi Endangered Seabird Recovery Project 2020b, 2020c, 2020d; Archipelago Research and Conservation 2021b, 2021c, 2021d

See the References tab for more detailed information about the cited sources.

Early Implementation Costs: Implement Powerline Collisions Minimization Projects

Costs for early implementation of powerline collisions minimization measures

Number of Spans with Powerline Collision Minimization Projects Completed or Planned (2020–2022)

Minimization type(s)	Number of spans minimized, 2020	Number of spans minimized, 2021	Number of spans minimized, 2022
69kV removal, Static wire removal	-	-	29
Diverter installation (LED)	-	49	62
Diverter installation (LED), Static wire removal	-	4	-
Diverter installation (Reflective)	24	333	474
Diverter installation (Reflective), Static wire removal	109	134	76
Reconfiguration, Static wire removal	45	-	-
Static wire removal	43	249	164
Underground	-	-	2
Total	**221**	**769**	**807**

Estimated Costs of Early Implementation Powerline Collision Minimization Projects (2020-2022)

Minimization type(s)	Estimated cost per span (current $)	Estimated total cost, 2020 (source $)	Estimated total cost, 2021 (source $)	Estimated total cost, 2022 (source $)
69kV removal, Static wire removal	$4,868	-	-	$146,508
Diverter installation (LED)	$30,210	-	$1,480,290	$1,943,813
Diverter installation (LED), Static wire removal	$32,644	-	$130,576	-
Diverter installation (Reflective)	$8,061	$200,776	$2,684,313	$3,965,330
Diverter installation (Reflective), Static wire removal	$10,495	$1,187,192	$1,406,330	$827,767
Reconfiguration, Static wire removal	$80,379	$3,753,766	-	-
Static wire removal	$2,434	$108,618	$606,066	$414,263
Underground	$339,093	-	-	$703,819
Total		**$5,250,352**	**$6,307,575**	**$8,001,500**

Sources and notes

Number of spans with powerline collisions minimization projects completed or planned: ICF 2022

Average cost per span for powerline collision minimization activities: Yuh 2021a, 2021b

See the References tab for more detailed information about the cited sources.

Implementation Costs: Plan Administration

Staffing, legal support, database administration, and annual reporting

Plan Adminsitration Costs

Type	Average annual cost (source $)	Source $ year	Average annual cost (current $)
Program Management	$385,000	2021	$385,000
Legal Support	$25,000	2021	$25,000
Database Administration and Software License Fees	$2,500	2021	$2,500
Additional Cost to Prepare 1st KIUC Annual Report	$40,000	2021	$40,000
Annual Total (Plan Year 1)			**$452,500**
Annual Total (Plan Years 2-50)			**$412,500**

Sources and notes

All plan administration cost assumptions developed through coordination between ICF and the Joule Group. Program management costs are based on current support provided by the Joule Group and additional tasks anticipated to implement the long-term HCP.

Implementation Costs: Implement Powerline Collision Minimization Projects (Conservation Measure 1)

Collision reduction through static wire removal, diverter installation, and reconfiguration

Estimated Costs of Planned Powerline Collision Minimization Projects for Existing Powerlines (Plan Year 1)

Minimization type	Number of spans minimized, 2023	Estimated cost per span (source $)	Estimated cost, plan year 1 (source $)	Source $ year	Estimated cost, plan year 1 (current $)
69kV removal, Static wire removal	-	$4,868	-	2021	-
Diverter installation (LED)	12	$30,210	$362,520	2021	$362,520
Diverter installation (LED), Static wire removal	-	$32,644	-	2021	-
Diverter installation (Reflective)	307	$8,061	$2,474,727	2021	$2,474,727
Diverter installation (Reflective), Static wire removal	64	$10,495	$671,680	2021	$671,680
Reconfiguration, Static wire removal	-	$80,379	-	2021	-
Static wire removal	6	$2,434	$14,604	2021	$14,604
Underground	-	$339,093	-	2021	-
Total	**389**		**$3,523,531**		**$3,523,531**

Estimated Costs of Reflective Diverter Installations on New Powerlines (Plan Years 1-50)

Year	Number of spans minimized per plan year	Estimated cost per span (source $)	Estimated cost per plan year (source $)	Source $ year	Estimated cost per plan year (current $)
Plan Years 1-50 (2023-2072)	7	$8,061	$56,427	2021	$56,427

Estimated Costs of Reflective Diverter Replacement (Plan Years 1-50)

Year	Number of spans minimized per plan year	Estimated cost per span (source $)	Estimated cost per plan year (source $)	Source $ year	Estimated cost per plan year (current $)
Plan Year 1 (2023)	28.4	$8,061	$228,932	2021	$228,932
Plan Years 2-50 (2024-2072)	0.14	$8,061	$1,129	2021	$1,129

Estimated Costs of LED Diverter Replacement (Plan Years 1-50)

Year	Number of spans replaced per plan year	Estimated cost per span (source $)	Estimated cost per plan year (source $)	Source $ year	Estimated cost per plan year (current $)
Plan Years 1-50 (2023-2072)	2.5	$30,210	$75,525	2021	$75,525

Sources and notes

Number of spans with powerline collision minimization projects planned: ICF 2022

Average cost per span for powerline collision minimization activities: Yuh 2021a, 2021b

New diverter installations per plan year: Assumes 7 new spans installed each year would be equipped with reflective diverters.

Reflective diverter replacements per plan year: There will be an estimated 1,419 spans with reflective diverters installed by Plan Year 1 (2023). Per previous note, an estimated 7 new spans would be equipped with reflective diverters each successive plan year. Cost estimate assumes reflective diverters would be replaced on 2% of all spans in system each year.

LED diverter replacements per plan year: There will be an estimated 127 spans with LED diverters installed by Plan Year 1 (2023). Cost estimate assumes LED diverters would be replaced on 2% of all spans in system each year.

See the References tab for more detailed information about the cited sources.

Implementation Costs: Fund the Save Our Shearwaters Program (Conservation Measure 3)

Ongoing contribution to fund a share of the Save our Shearwater Program's annual budget

SOS Program Costs and Contributions During Plan Implementation

Total SOS program annual costs	Funds contributed by KIUC annually	Proportion of annual SOS program costs funded by KIUC
$300,000	$300,000	100%

Sources and notes

Kauaʻi Island Utility Cooperative 2020

The $300,000 annual contribution will be held constant until issuance of the 50-year permit, at which time the annual contribution will increase with an inflation index.

See the References tab for more detailed information about the cited sources.

Implementation Costs: Manage and Enhance Seabird Breeding Habitat and Colonies at Conservation Sites (Conservation Measure 4)

Perform various combinations of predator and weed controls at conservation sites

Summary of Estimated Annual Costs by Conservation Site

Conservation Sites	Annual Cost Plan Year 1 (current $)	Annual Cost Plan Year 2 (current $)	Annual Cost Plan Year 3 (current $)	Annual Cost Plan Year 4 (current $)	Annual Cost Plan Years 5-50 (current $)
Site 10	$864,485	$801,400	$29,267	$29,267	$29,267
Upper Limahuli Preserve	$1,285,160	$1,011,103	$124,570	$124,570	$124,570
Pihea, Pōhākea, North Bog, Hanakoa, Hanakāpīʻai (Hono O Nā Pali Natural Area Reserve)	$1,148,276	$1,148,276	$1,148,276	$1,148,276	$1,148,276
Pōhākea PF	$21,884	$21,884	$21,884	$21,884	$21,884
Honopū	$166,357	$166,357	$166,357	$166,357	$166,357
Honopū PF	$90,465	$47,848	$47,848	$47,848	$47,848
Total	**$3,576,627**	**$3,196,868**	**$1,538,202**	**$1,538,202**	**$1,538,202**

Site 10

Site 10 - Estimated Annual Predator Control Costs

Item	Units	Estimated unit cost (source $)	Source $ year	Estimated unit cost (current $)	Total cost (current $)
Personnel Subtotal					**$10,800**
Predator control staff labor	*1*	*$10,800*	*2022*	*$10,800*	*$10,800*
Materials and Supplies Subtotal					**$6,432**
Trapping Supplies	*1*	*$2,000*	*2022*	*$2,000*	*$2,000*
Ammunition	*1*	*$100*	*2022*	*$100*	*$100*
CO2 Cannisters	*66*	*$3*	*2022*	*$3*	*$197*
Automatic Lure Pumps	*90*	*$9*	*2022*	*$9*	*$810*
AA Batteries (Game Cameras)	*200*	*$1*	*2022*	*$1*	*$260*
AA Batteries (Owl hunting gear)	*50*	*$1*	*2022*	*$1*	*$65*
Assumed Annual Cost for Miscellaneous Items, Repairs, Replacements (one-time purchases)	*1*	*$3,000*	*2022*	*$3,000*	*$3,000*
Direct Procurement, Communications, Services, etc. Subtotal					**$16,052**
Transmitting Cameras Verizon Data	*9*	*$240*	*2022*	*$240*	*$2,160*
Camera Repair	*3*	*$30*	*2022*	*$30*	*$90*
MBTA Permit Application	*1*	*$100*	*2022*	*$100*	*$100*
Helicopter Services	*13*	*$1,054*	*2022*	*$1,054*	*$13,702*
Direct Contractor Costs					**$33,284**
General Excise Tax (4.7120%)					**$1,568**
Annual Total (Plan Year 1 (2023))					**$34,853**
Annual Total (Plan Years 3-30 (2025-2072)-cost reduced to 25% of plan year 1 cost after predator fencing and predator eradication					**$8,713**

Sources and notes

Hallux Ecosystem Restoration LLC 2021b. Plan year 2 (2024) is limited to predator eradication, which is costed out seperately, below.

See the References tab for more detailed information about the cited sources.

Site 10 - Estimated Annual Weed Control Costs

Annual Total (Plan Years 1-30 (2023-2072))	**$20,000**

Sources and notes

Koke'e Resource Conservation Program 2021

See the References tab for more detailed information about the cited sources.

Site 10 - Estimated Predator Fence Installation and Maintenance Costs

Total fence length (meters) = 182

Item	Unit	Estimated cost per unit (source $)	Source $ year	Estimated cost per unit (current $)	Total cost (current $)
Fence Installation					
Labor	*1*	*49,001*	*2014*	*56,463*	$56,463
Helicopter/Ground Transportation	*1*	*1,000,000*	*2022*	*1,000,000*	$1,000,000
Predator Eradication	*1*	*$500,000*	*2022*	*$500,000*	$500,000
Infrastructure at Site	*1*	*$30,000*	*2014*	*$34,569*	$34,569
Annual Total (Plan Year 1 (2023))					*$809,632*
Annual Total (Plan Year 2 (2024))					*$781,400*
Fence Maintenance (Plan Years 3-30 (2025-2072)					
Annual Fence Maintenance (cost per meter)	182	$2.64	2014	$3.04	$554

Sources and notes

Young and VanderWerf 2014, 2016. Fence materials assumed to be purchased in 2022; material costs included in early implementation costs. Fence labor cost from source reduced to 3.4% of original value due to decision to decrease fence length from 5,300 meters to 182 meters in 2022.

See the References tab for more detailed information about the cited sources.

Upper Limahuli Preserve

Upper Limahuli Preserve - Estimated Annual Predator and Weed Control Costs

Item	Units	Estimated unit cost (source $)	Source $ year	Estimated unit cost (current $)	Total cost (current $)
Salaries and Fringe Subtotal					**$317,874**
Salaries and Fringe	*1*	*$317,874*	*2022*	*$317,874*	*$317,874*
Helicopter Subtotal					**$59,285**
Helicopter Rental: Basic four-passenger trip (round t rip)	*1*	*$59,285*	*2022*	*$59,285*	*$59,285*
Equipment, Supplies, and Safety Subtotal					**$81,219**
Communications and monitoring equipment	*1*	*$26,420*	*2022*	*$26,420*	*$26,420*
Fence and shelter maintenance	*1*	*$4,000*	*2022*	*$4,000*	*$4,000*
Field and safety equipment (traps, firearms, camping gear, PPE)	*1*	*$20,305*	*2022*	*$20,305*	*$20,305*
Training (safety, preadator and weed control techniques)	*1*	*$10,494*	*2022*	*$10,494*	*$10,494*
Food and other expendables	*1*	*$20,000*	*2022*	*$20,000*	*$20,000*
Direct Contractor Cost					**$458,378**
NTGB Administrative fee of 5%					**$22,919**
Base Contract Total					**$481,297**
Assumed Cost for Miscellaneous Items (one-time purchases)					**$15,000**
Annual Total (Plan Year 1 (2023))					**$496,297**
Annual Total (Plan Year 2 (2024) - cost reduced by 50% of plan year 1 cost to account for weed control only while predator eradication is implemented)					**$248,148**
Annual Total (Plan Years 3-30 (2025-2072) - cost reduced to 25% of plan year 1 cost after predator fencing and predator eradication					**$124,074**

Sources and notes

Archipelago Research and Conservation 2021e.

See the References tab for more detailed information about the cited sources.

Upper Limahuli Preserve - Estimated Predator Fence Installation and Maintenance Costs

Total fence length (meters) = 163

Item	Unit	Estimated cost per unit (source $)	Source $ year	Estimated cost per unit (current $)	Total cost (current $)
Fence Installation					
Labor	*1*	*44,969*	*2014*	$51,817.42	$51,817
Helicopter/Ground Transportation	*1*	*1,000,000*	*2022*	$1,000,000.00	$1,000,000
Predator Eradication	*1*	*$500,000*	*2022*	$500,000.00	$500,000
Annual Total (Plan Year 1 (2023))					*$788,863*
Annual Total (Plan Year 2 (2024))					*$762,954*
Fence Maintenance (Plan Years 3-30 (2025-2072))					
Annual Fence Maintenance (cost per meter)	163	$2.64	2014	$3.04	$496

Sources and notes

Young and VanderWerf 2014, 2016. Fence materials assumed to be purchased in 2022; material costs included in early implementation costs. Fence labor cost from source reduced to 2.8% of original value due to decision to decrease fence length from 5,800 meters to 163 meters in 2022.

See the References tab for more detailed information about the cited sources.

Pihea, Pōhākea, North Bog, Hanakoa, Hanakāpīʻai (Hono O Nā Pali Natural Area Reserve)

Pihea, Pōhākea, North Bog, Hanakoa, Hanakāpīʻai (Hono O Nā Pali Natural Area Reserve) - Estimated Annual Predator Control Costs

Item	Units	Estimated unit cost (source $)	Source $ year	Estimated unit cost (current $)	Total cost (current $)
Personnel Subtotal					**$509,000**
Personnel Salaries and Fringe	*1*	*$509,000*	*2022*	*$509,000*	*$509,000*
Training Subtotal					**$9,000**
First Aid Training	*10*	*$300*	*2022*	*$300*	*$3,000*
Firearms training	*10*	*$200*	*2022*	*$200*	*$2,000*
Off-island travel	*8*	*$500*	*2022*	*$500*	*$4,000*
Materials and Supplies Subtotal					**$104,430**
Automatic Rat and Mouse Traps	*100*	*$150*	*2022*	*$150*	*$15,000*
Automatic Lure Pumps	*2550*	*$9*	*2022*	*$9*	*$22,950*
CO2 Canisters	*1900*	*$4*	*2022*	*$4*	*$7,600*
Trapping Supplies	*1*	*$8,000*	*2022*	*$8,000*	*$8,000*
Ammunition	*2*	*$200*	*2022*	*$200*	*$400*
Firearm maintenance	*1*	*$1,000*	*2022*	*$1,000*	*$1,000*
Bait and Lures	*5*	*$500*	*2022*	*$500*	*$2,500*
Staff Field Gear Replacements	*10*	*$850*	*2022*	*$850*	*$8,500*
Propane Refills	*8*	*$35*	*2022*	*$35*	*$280*
Propane Tank Replacement	*2*	*$50*	*2022*	*$50*	*$100*
Office supplies	*1*	*$2,000*	*2022*	*$2,000*	*$2,000*
First-aid kit restocking	*8*	*$30*	*2022*	*$30*	*$240*
AA Batteries (Game Cameras and Headlamps)	*2040*	*$1*	*2022*	*$1*	*$2,652*
AA Batteries (Owl Hunting Gear)	*300*	*$1*	*2022*	*$1*	*$390*
Weatherport Consumables	*1*	*$2,550*	*2022*	*$2,550*	*$2,550*
Flight Helmet Repair/Replace	*1*	*$1,200*	*2022*	*$1,200*	*$1,200*
Camping Gear Replacement	*1*	*$3,568*	*2022*	*$3,568*	*$3,568*
Assumed Annual Cost for Miscellaneous Items, Repairs, Replacements (one-time purchases)	*1*	*$25,500*	*2022*	*$25,500*	*$25,500*
Direct Procurement, Communications, Services, etc. Subtotal					**$124,174**
Transmitting Cameras Verizon Data	*19*	*$240*	*2022*	*$240*	*$4,560*
Satellite Communication Services	*12*	*$72*	*2022*	*$72*	*$864*
Vehicle Repair & Maintenance	*1*	*$5,000*	*2022*	*$5,000*	*$5,000*
Gas	*1*	*$6,000*	*2022*	*$6,000*	*$6,000*
Miscellaneous Shipping	*1*	*$2,000*	*2022*	*$2,000*	*$2,000*
Camera Repair	*15*	*$50*	*2022*	*$50*	*$750*
Helicopter Services	*1*	*$105,000*	*2022*	*$105,000*	*$105,000*
Direct Contractor Cost					**$746,604**
Contractor Overhead Cost					**$350,000**
General Excise Tax (4.7120%)					**$51,672**
Annual Total (Plan Years 1-30 (2023-2072))					**$1,148,276**

Sources and notes

Hallux Ecosystem Restoration LLC 2021b. See the References tab for more detailed information about the cited sources.

Pōhākea PF

Pōhākea PF - Estimated Annual Predator Control Costs

Item	Units	Estimated unit cost (source $)	Source $ year	Estimated unit cost (current $)	Total cost (current $)
Personnel Subtotal					**$4,000**
Predator control staff labor	*1*	*$4,000*	*2022*	*$4,000*	*$4,000*
Materials and Supplies Subtotal					**$12,240**
Automatic Rat and Mouse Traps	*15*	*$150*	*2022*	*$150*	*$2,250*
Automatic Lure Pumps	*15*	*$9*	*2022*	*$9*	*$135*
CO2 Canisters	*15*	*$4*	*2022*	*$4*	*$60*
Victors (12 units)	*3*	*$35*	*2022*	*$35*	*$105*
Transmitting Game Camera Replacements	*5*	*$660*	*2022*	*$660*	*$3,300*
Transmitting Camera Plans	*60*	*$5*	*2022*	*$5*	*$300*
Track Tunnels and Ink Plates	*20*	*$10*	*2022*	*$10*	*$200*
Cage Traps	*10*	*$160*	*2022*	*$160*	*$1,600*
Gear Storage Box	*1*	*$500*	*2022*	*$500*	*$500*
AA Batteries	*120*	*$2*	*2022*	*$2*	*$240*
SD Cards	*10*	*$5*	*2022*	*$5*	*$50*
Misc. Trapping Gear and Supplies	*1*	*$1,000*	*2022*	*$1,000*	*$1,000*
Bait	*1*	*$500*	*2022*	*$500*	*$500*
Assumed Annual Cost for Miscellaneous Items, Repairs, Replacements (one-time purchases)	*1*	*$2,000*	*2022*	*$2,000*	*$2,000*
Direct Procurement, Communications, Services, etc. Subtotal					**$5,270**
Helicopter Hours	*5*	*$1,054*	*2022*	*$1,054*	*$5,270*
Direct Contractor Costs					**$21,510**
Contractor Overhead Costs (30%)					**$6,453**
General Excise Tax (4.7120%)					**$1,318**
Annual Total (2022 - included as early implementation cost)					**$29,281**
Annual Total (Plan Years 1-30 (2023-2072)- cost reduced to 25% of early implementation cost after predator fencing and predator eradication complete)					**$7,320**

Sources and notes
Hallux Ecosystem Restoration LLC. 2021b. Any additional costs associated with training and transportation for Pōhākea PF are assumed to be covered under Hono O Nā Pali NAR costs.
See the References tab for more detailed information about the cited sources.

Pōhākea PF - Estimated Annual Social Attraction Site Costs

Item	Units	Estimated unit cost (source $)	Source $ year	Estimated unit cost (current $)	Total cost (current $)
Social Attraction Equipment Subtotal					**$470**
Average annual social atttraction equipment replacement cost	*1*	*$470*	*2022*	*$470*	*$470*
Social Attraction Monitoring Subtotal					**$2,867**
Reconyx cameras (HP2X) replacement	*5*	*$437*	*2022*	*$437*	*$2,185*
Reconyx cameras thunderbolt mounting block replacement	*5*	*$19*	*2022*	*$19*	*$95*
Reconyx cameras (HP2X) replacement shipping	*1*	*$347*	*2022*	*$347*	*$347*
2 Reconyx SD cards per camera 32 GB	*10*	*$12*	*2022*	*$12*	*$120*
Batteries (lithium)	*120*	*$1*	*2022*	*$1*	*$120*
Transportation Subtotal					**$4,100**
Helicopter (sling loads of boxes and sand)	*1.6*	*$1,025*	*2022*	*$1,025*	*$1,640*
Helcopter (transport digging crew - 6 pax)	*2.4*	*$1,025*	*2022*	*$1,025*	*$2,460*
Direct Contractor Costs					**$7,437**
Contractor Overhead Costs (30%)					**$2,231**
General Excise Tax (4.7120%)					**$456**
Annual Total (Plan Years 1-30 (2023-2072))					**$10,124**

Sources and notes
Archipelago Research and Conservation. 2021f. All costs associated with staff time for social attraction at Pōhākea PF are assumed to be covered in other existing budgets. All costs associated with predator eradication and social attraction equipment installation are assumed to be complete (and funded by other entities) and are not included in this cost estimate.

See the References tab for more detailed information about the cited sources.

Pōhākea PF - Estimated Annual Weed Control Costs	
Annual Total (Plan Years 1-30 (2023-2072))	**$4,000**

Sources and notes
Costs for Pōhākea PF were estimated based on a proportion of Site 10 costs. Other weed control equipment and materials purchased for use at Site 10 are assumed to be reusable at Pōhākea PF.

See the References tab for more detailed information about the cited sources.

Pōhākea PF - Estimated Predator Fence Maintenance Costs

Total fence length (meters) = 145

Item	Meters	Estimated cost per meter (source $)	Source $ year	Estimated cost per meter (current $)	Total cost (current $)
Annual Fence Maintenance Cost (Plan Years 1-30 (2023-2072))	145	$2.64	2014	$3.04	$440

Sources and notes
Young and VanderWerf 2014. KIUC is not responsible for predator fence installation at Pōhākea PF.

See the References tab for more detailed information about the cited sources.

Honopū

Honopū - Estimated Annual Predator Control Costs

Item	Units	Estimated unit cost (source $)	Source $ year	Estimated unit cost (current $)	Total cost (current $)
Personnel Subtotal					**$117,450**
Personnel Salaries and Fringe	*1*	*$117,450*	*2021*	*$117,450*	*$117,450*
Training Subtotal					**$1,000**
First Aid Training	*1*	*$300*	*2021*	*$300*	*$300*
Firearms training	*1*	*$200*	*2021*	*$200*	*$200*
Off-island travel	*1*	*$500*	*2021*	*$500*	*$500*
Materials and Supplies Subtotal					**$8,380**
Automatic Lure Pumps	*375*	*$9*	*2021*	*$9*	*$3,375*
CO2 Canisters	*300*	*$4*	*2021*	*$4*	*$1,200*
Trapping Supplies	*1*	*$2,000*	*2021*	*$2,000*	*$2,000*
Ammunition	*1*	*$100*	*2021*	*$100*	*$100*
Firearm maintenance	*1*	*$500*	*2021*	*$500*	*$500*
Bait	*1*	*$500*	*2021*	*$500*	*$500*
Propane refills	*2*	*$35*	*2021*	*$35*	*$70*
First-aid kit restocking	*1*	*$50*	*2021*	*$50*	*$50*
AA Batteries (Game Cameras)	*450*	*$1*	*2021*	*$1*	*$585*
AA Batteries (Owl Hunting Gear)	*60*	*$1*	*2021*	*$1*	*$78*
Direct Procurement, Communications, Services, etc. Subtotal					**$23,680**
Transmitting Cameras Verizon Data	*4*	*$240*	*2021*	*$240*	*$960*
Vehicle Repair & Maintenance	*1*	*$1,000*	*2021*	*$1,000*	*$1,000*
Gas	*1*	*$300*	*2021*	*$300*	*$300*
Miscellaneous Shipping	*1*	*$300*	*2021*	*$300*	*$300*
Camera Repair	*4*	*$30*	*2021*	*$30*	*$120*
Helicopter Services	*1*	*$20,000*	*2021*	*$20,000*	*$20,000*
Assumed Cost for Miscellaneous Items (one-time purchases)	*1*	*$1,000*	*2021*	*$1,000*	*$1,000*
Direct Contractor Cost					**$150,510**
General Excise Tax (4.7120%)					**$7,092**
Annual Total (Plan Years 1-50 (2023-2072))					**$157,602**

Sources and notes
Archipelago Research and Conservation 2021a

See the References tab for more detailed information about the cited sources.

Honopū - Estimated Ungulate Fence Maintenance Costs

Total fence length (meters) = 5,065

Item	Meters	Estimated cost per meter (source $)	Source $ year	Estimated cost per meter (current $)	Total cost (current $)
Annual Fence Maintenance Cost (Plan Years 1-50 (2023-2072))	5,065	$1.50	2014	$1.73	$8,755

Sources and notes
Costs to maintain the existing ungulate fence at Honopū. Assumed $1.50 per meter (in 2014 $), less than maintenance costs for predator fence.

See the References tab for more detailed information about the cited sources.

Honopū PF

Honopū PF - Estimated Annual Predator Control Costs

Item	Units	Estimated unit cost (source $)	Source $ year	Estimated unit cost (current $)	Total cost (current $)
Personnel Subtotal					**$500**
Predator control staff labor	*1*	*$500*	*2022*	*$500*	*$500*
Materials and Supplies Subtotal					**$552**
Trapping Supplies	*1*	*$500*	*2022*	*$500*	*$500*
Ammunition	*1*	*$20*	*2022*	*$20*	*$20*
CO2 Canisters	*2*	*$3*	*2022*	*$3*	*$6*
Automatic Lure Pumps	*2*	*$9*	*2022*	*$9*	*$18*
AA Batteries (Game Cameras)	*4*	*$1*	*2022*	*$1*	*$5*
AA Batteries (Owl Hunting Gear)	*2*	*$1*	*2022*	*$1*	*$3*
Direct Procurement, Communications, Services, etc. Subtotal					**$510**
Transmitting Cameras Verizon Data	*2*	*$240*	*2022*	*$240*	*$480*
Camera Repair	*1*	*$30*	*2022*	*$30*	*$30*
Direct Contractor Costs					**$1,562**
General Excise Tax (4.7120%)					**$74**
Annual Total (Plan Years 2-50 (2024-2072))					**$1,635**

Predator Eradication (Plan Year 1 (2023) - assumed to be 50 times greater than annual predator control cost) **$81,769**

Sources and notes
Costs for Honopū PF were estimated based on a proportion of Honopū costs. All costs associated with training and transportation for Honopū PF are assumed to be covered under Honopū costs.

See the References tab for more detailed information about the cited sources.

Honopū PF - Estimated Annual Social Attraction Site Costs

Item	Units	Estimated unit cost (source $)	Source $ year	Estimated unit cost (current $)	Total cost (current $)
Personnel Subtotal					**$25,367**
Personnel Labor	*1*	*$25,367*	*2022*	*$25,367*	*$25,367*
Social Attraction Monitoring					**$7,204**
Speaker System Repairs	*1*	*$500*	*2022*	*$500*	*$500*
Artificial Burrow Repairs	*1*	*$500*	*2022*	*$500*	*$500*
Reconyx cameras (HP2X) replacements	*3*	*$414*	*2022*	*$414*	*$1,380*
Reconyx cameras thunderbolt mounting block replacements	*3*	*$20*	*2022*	*$20*	*$67*
Reconyx cameras (HP2X) shipping	*1*	*$250*	*2022*	*$250*	*$250*
Reconyx camera repairs	*1*	*$250*	*2022*	*$250*	*$250*
2 Reconyx SD cards per camera 32 GB	*6*	*$13*	*2022*	*$13*	*$75*
Lithium AA batteries (3 sets per camera)	*27*	*$15*	*2022*	*$15*	*$396*
Song meters SM4 replacements	*1*	*$805*	*2022*	*$805*	*$1,073*
Song Meter - D batteries	*10*	*$1*	*2022*	*$1*	*$9*
32GB SD cards for SM2/4	*4*	*$13*	*2022*	*$13*	*$50*
Miscellaneous Field Equipment	*1*	*$500*	*2022*	*$500*	*$500*
Song Meter analysis - Contracted to Conservation Metrics	*1*	*$2,154*	*2022*	*$2,154*	*$2,154*
Direct Contractor Costs					**$32,571**
Contractor Overhead Costs (10%)					**$3,257**
General Excise Tax (4.7120%)					**$1,688**
Annual Total (Plan Years 2-50 (2024-2072))					**$37,516**

Sources and notes

Archipelago Research and Conservation 2021g. All costs associated with training and transportation for Honopū PF are assumed to be covered under Honopū costs.

See the References tab for more detailed information about the cited sources.

Honopū PF - Estimated Annual Weed Control Costs

Annual Total (Plan Years 1-50 (2023-2072))	**$6,500**

Sources and notes

Costs for Pōhākea PF were estimated based on a proportion of Site 10 costs. Other weed control equipment and materials purchased for use at Site 10 are assumed to be reusable at Pōhākea PF.

See the References tab for more detailed information about the cited sources.

Honopū PF - Estimated Predator Fence Maintenance Costs

Total fence length (meters) = 722

Item	Meters	Estimated cost per meter (source $)	Source $ year	Estimated cost per meter (current $)	Total cost (current $)
Annual Fence Maintenance Cost (Plan Years 1-50 (2023-2072))	722	$2.64	2014	$3.04	$2,197

Sources and notes

Young and VanderWerf 2014. KIUC is not responsible for predator fence installation at Honopū PF.

See the References tab for more detailed information about the cited sources.

Implementation Costs: Implement a Green Sea Turtle Nest Detection and Temporary Shielding Program (Conservation Measure 5)

Implement a nest detection and shielding program for green sea turtle

Nest Detection and Shielding Program Costs by Plan Year

					Note: Sequence repeats through plan year 50		
Item	**Quantity**	**Estimated unit cost (source $)**	**Source $ year**	**Estimated unit cost (current $)**	**Annual cost, plan year 1 (current $)**	**Annual cost, plan year 2 (current $)**	**Annual cost, plan year 3-5 (current $)**
Personnel Subtotal					**$86,400**	**$82,400**	**$74,400**
Personnel Salaries and Fringe	*1*	*$82,400*	*2021*	*$82,400*	*$86,400*	*$82,400*	*$74,400*
Materials and Supplies Subtotal					**$63,500**	**$5,000**	**$5,000**
Drone (Mavic Pro 2 or similar)	*1*	*$4,000*	*2021*	*$4,000*	*$4,000*		
Drone Materials (iPad, chargers, software, laptop, storage)	*1*	*$7,500*	*2021*	*$7,500*	*$7,500*		
Light Mitigation Structure Materials	*1*	*$2,000*	*2021*	*$2,000*	*$2,000*		
Vehicle (Ford F-150 base model)	*1*	*$50,000*	*2021*	*$50,000*	*$50,000*		
Miscellaneous annual material and repair costs.	*1*	*$5,000*	*2022*	*$5,000*		*$5,000*	*$5,000*
Travel Subtotal					**$9,000**	**$9,000**	**$9,000**
Project Coordinator (fuel cost/reimbursement)	*1*	*$4,000*	*2021*	*$4,000*	*$4,000*	*$4,000*	*$4,000*
Volunteer Network (fuel cost/reimbursement)	*1*	*$5,000*	*2021*	*$5,000*	*$5,000*	*$5,000*	*$5,000*
GRAND TOTAL					**$158,900**	**$96,400**	**$88,400**

Sources and notes

Department of Land and Natural Resources, Division of Aquatic Resources 2020

See the References tab for more detailed information about the cited sources.

Implementation Costs: Implement Infrastructure Monitoring and Minimization Project

Monitor seabird and water bird collision rates at KIUC powerlines

Infrastructure Monitoring and Minimization Project Costs by Plan Year

Item	Quantity	Estimated unit cost (source $)	Source $ year	Estimated unit cost (current $)	Annual cost (current $)
Personnel Subtotal					**$288,192**
Personnel Salaries and Fringe	1	$288,192	2021	$288,192	$288,192
Equipment and Supplies Subtotal					**$150,349**
Estimated Annual Misc. Expenses	*1*	*$750*	*2022*	*$750*	*$750*
SONG METERS					
Song meters - SM4 (replacements every 5 years)	*8.5*	*$825*	*2021*	*$825*	*$7,013*
Song Meter - D batteries	*546*	*$1*	*2021*	*$1*	*$502*
Microphone for SM4 (replacements)	*19.2*	*$50*	*2021*	*$50*	*$960*
32GB SD cards for SM2/4 (replacements)	*38.4*	*$13*	*2021*	*$13*	*$482*
Song meters - shipping	*9.5*	*$42*	*2021*	*$42*	*$394*
Song meter repairs ($147 per unit, including postage - $22 out, $25 return post, repair cost $100)	*9.5*	*$147*	*2021*	*$147*	*$1,397*
Analysis of song meter data by Conservation Metrics - all UMP work	*1*	*$115,761*	*2021*	*$115,761*	*$115,761*
CAMERAS					
Reconyx HP2X - replacements	*0.6*	*$414*	*2021*	*$414*	*$248*
Reconyx Repair (avg cost per camera to repair, including shipping)	*0.6*	*$60*	*2021*	*$60*	*$36*
Lithium AA batteries (3 sets per camera)	*108*	*$1*	*2021*	*$1*	*$138*
T post camera mount - replacements	*0.6*	*$20*	*2021*	*$20*	*$12*
SanDisk 32GB SDHC Memory Card (replacements)	*2*	*$13*	*2021*	*$13*	*$25*
FIELD EQUIPMENT					
Garmin GPS Unit (replacements)	*1.5*	*$550*	*2021*	*$550*	*$825*
iPad (replacements)	*1*	*$300*	*2021*	*$300*	*$300*
Ipad Cases (replacements)	*1.5*	*$45*	*2021*	*$45*	*$68*
Handheld Camera	*2*	*$210*	*2021*	*$210*	*$420*
Handheld Camera (replacements)	*0.5*	*$210*	*2021*	*$210*	*$105*
Helicopter Helmet	*1.5*	*$1,660*	*2021*	*$1,660*	*$2,490*
Helicopter Helmet (replacemets)	*1*	*$1,660*	*2021*	*$1,660*	*$1,660*
CWU-27/P Flight Suit	*1.5*	*$238*	*2021*	*$238*	*$357*
CWU-27/P Flight Suit (replacements)	*1*	*$238*	*2021*	*$238*	*$238*
USNV PVS-7 GEN III Auto-Gated Nightvision Goggles (replacements)	*1*	*$3,695*	*2021*	*$3,695*	*$3,695*
MSR Hubba NX 1 Tent & footprint	*1*	*$410*	*2021*	*$410*	*$410*
MSR Hubba NX 1 Tent & footprint (replacements)	*1*	*$410*	*2021*	*$410*	*$410*
Field Equipment (new gear for each new staff member, includes first aid training NOLS)	*1*	*$3,300*	*2021*	*$3,300*	*$3,300*

Field Equipment (replacement gear for existing staff members)	*2*	*$825*	*2021*	*$825*	*$1,650*
Field Equipment (annual group gear purchases)	*1*	*$750*	*2021*	*$750*	*$750*
IMMP-SPECIFIC MONITORING EQUIPMENT					
Near Infrared Lights (replacements)	*0.6*	*$3,200*	*2021*	*$3,200*	*$1,920*
Near Infrared Lights (annual small repairs)	*1*	*$250*	*2021*	*$250*	*$250*
Honda Generator (replacements)	*0.6*	*$1,000*	*2021*	*$1,000*	*$600*
Light shields, mallets , cables, locks (annual)	*1*	*$100*	*2021*	*$100*	*$100*
NV portable Cameras (replacements)	*0.75*	*$500*	*2021*	*$500*	*$375*
Weather station	*0.5*	*$2,000*	*2021*	*$2,000*	*$1,000*
Weather station (replacements)	*0.2*	*$2,000*	*2021*	*$2,000*	*$333*
Heli sling gear (Replacements)	*0.13*	*$1,000*	*2021*	*$1,000*	*$125*
Miscelanious supplies- pegs, ropes, tapes, wood, rain guards, etc	*1*	*$1,250*	*2021*	*$1,250*	*$1,250*
Transportation Subtotal					**$30,200**
Helicopter	*10*	*$1,040*	*2021*	*$1,040*	*$10,400*
Equipment (3 vehicles) Charge	*18*	*$1,100*	*2021*	*$1,100*	*$19,800*
Subtotal					*$468,741*
Contractor Overhead (10%)					*$46,874*
General Excise Tax (4.712%)					*$24,296*
GRAND TOTAL					**$539,911**

Sources and notes
Archipelago Research and Conservation 2021c

See the References tab for more detailed information about the cited sources.

Implementation Costs: Implement Seabird Colony Monitoring Program
Monitor seabird breeding colonies at ten sites

Seabird Colony Monitoring Program Costs by Plan Year (Detail)

Conservation Sites

Item	Quantity	Estimated unit cost (source $)	Source $ year	Estimated unit cost (current $)	Annual cost (current $)
Personnel Subtotal					**$536,891**
Personnel Salaries and Fringe	*1*	*$536,891*	*2022*	*$536,891*	*$536,891*
Equipment and Supplies Subtotal					**$230,933**
Estimated Annual Misc. Expenses	*1*	*$15,000*	*2022*	*$15,000*	*$15,000*
SONG METERS					
Song meters - SM4 - replacements every 5 years, 75 units	*15*	*$805*	*2022*	*$805*	*$12,075*
Microphone for SM4 (replacements every 5 years, 2 mics per unit, 75 units)	*30*	*$50*	*2022*	*$50*	*$1,500*
32GB SD cards for SM2/4 (replacements every 3 years, 4 SD cards per unit, 75 units)	*100*	*$13*	*2022*	*$13*	*$1,254*
Wildlife Acoustics - shipping	*1*	*$400*	*2022*	*$400*	*$400*
*Song Meter - D batteries (5 sites - 10 units*4*3)*	*600*	*$1*	*2022*	*$1*	*$554*
*Song Meter - D batteries (ULP - 14 units*4*3)*	*168*	*$1*	*2022*	*$1*	*$155*
*Song Meter - D batteries (UMV - 8 units*4*3)*	*96*	*$1*	*2022*	*$1*	*$105*
Song meter repairs ($147 per unit, including postage - $22 out, $25 return post, repair cost $100)	*14.4*	*$147*	*2022*	*$147*	*$2,117*
Analysis of song meter data by Conservation Metrics - all 7 sites NESH/HAPE/BAOW	*1*	*$127,014*	*2022*	*$127,014*	*$127,014*
RECONYX CAMERAS					
Reconyx HP2X - replace each unit (n=210) every 5 years	*42*	*$414*	*2022*	*$414*	*$17,388*
T post camera mount (replacements)	*42*	*$20*	*2022*	*$20*	*$840*
Reconyx - shipping	*1*	*$850*	*2022*	*$850*	*$850*
Lithium AA batteries (3 sets per camera)	*630*	*$15*	*2022*	*$15*	*$9,233*
SanDisk 32GB SDHC Memory Card (replacements)	*140*	*$13*	*2022*	*$13*	*$1,756*
Reconyx Repair (avg cost per camera to repair, including shipping)	*82*	*$60*	*2022*	*$60*	*$4,920*
MISC. FIELD GEAR					
Garmin Inreach Explorer +	*2*	*$450*	*2022*	*$450*	*$900*
Garmin Inreach Explorer + (replacements)	*1*	*$450*	*2022*	*$450*	*$450*
Garmin GPS Unit (replacements)	*4*	*$550*	*2022*	*$550*	*$2,200*
iPad (replacements)	*2.7*	*$300*	*2022*	*$300*	*$800*
Handheld Camera (replacements)	*4*	*$210*	*2022*	*$210*	*$840*
Helicopter Helmet	*2*	*$1,660*	*2022*	*$1,660*	*$3,320*

Helicopter Helmet (replacemets)	*1.2*	*$1,660*	*2022*	*$1,660*	*$1,992*
CWU-27/P Flight Suit	*2*	*$238*	*2022*	*$238*	*$476*
CWU-27/P Flight Suit (replacements)	*1.6*	*$238*	*2022*	*$238*	*$381*
USNV PVS-7 GEN III Auto-Gated Nightvision Goggles	*1*	*$3,695*	*2022*	*$3,695*	*$3,695*
USNV PVS-7 GEN III Auto-Gated Nightvision Goggles (replacements)	*1.3*	*$3,695*	*2022*	*$3,695*	*$4,927*
Tent & footprint (replacements)	*2.7*	*$410*	*2022*	*$410*	*$1,093*
Field Equipment (new field gear for each new staff member, includes first aid training NOLS)	*3*	*$3,300*	*2022*	*$3,300*	*$9,900*
Field Equipment (replacement gear for existing staff members)	*4*	*$825*	*2022*	*$825*	*$3,300*
Field Equipment (annual group gear purchases)	*1*	*$1,500*	*2022*	*$1,500*	*$1,500*
WEATHERPORT MAINTENANCE					
Buckets	*4*	*$7*	*2022*	*$7*	*$28*
Wood Shavings	*4*	*$20*	*2022*	*$20*	*$80*
Water filter Repair	*4*	*$40*	*2022*	*$40*	*$160*
Water Filter Replacement	*3.0*	*$317*	*2022*	*$317*	*$951*
Transportation Subtotal					**$26,400**
Equipment (3 vehicles) Charge	*24*	*$1,100*	*2022*	*$1,100*	*$26,400*
Subtotal					*$794,224*
Contractor Overhead (10%)					*$79,422*
General Excise Tax (4.712%)					*$41,166*
GRAND TOTAL (for 7 conservation sites)[1]					**$914,813**

Nā Pali Coast Sites

Item	Quantity	Estimated unit cost (source $)	Source $ year	Estimated unit cost (current $)	Annual cost (current $)
Personnel Subtotal					**-**
Covered under conservation site monitoring budget, above.	*0*	*-*	*2022*	*-*	*-*
Equipment and Supplies Subtotal					**$33,147**
Song meters - SM4 - replacements every 5 years, 20 units	*4*	*$805*	*2022*	*$805*	*$3,220*
32GB SD cards for SM2/4 (replacements, 2 per unit)	*40*	*$21*	*2022*	*$21*	*$828*
*Song Meter - D batteries (20 units*4)*	*80*	*$1*	*2022*	*$1*	*$74*
Supplies for building new deployment boxes	*1*	*$500*	*2022*	*$500*	*$500*
Analysis of song meter data by Conservation Metrics - 20 units, 3 species (NESH, BANP, BAOW), 3 months per unit	*1*	*$22,376*	*2022*	*$22,376*	*$22,376*
Helicopter - (3 hrs to deploy song meters, 3 hrs to receover song meters)	*6*	*$1,025*	*2022*	*$1,025*	*$6,150*
Subtotal					*$33,147*
Contractor Overhead (10%)					*$3,315*
General Excise Tax (4.712%)					*$1,718*
GRAND TOTAL					**$38,180**

Sources and notes

Archipelago Research and Conservation 2021c. Seabird costs for Pōhākea PF and Honopū PF costs are accounted for in social attraction monitoring. Helicopter costs are covered under management and enhancement of conservation sites.

See the References tab for more detailed information about the cited sources.

Implementation Costs: Fund State Compliance Monitoring

Funds monitoring of endangered species by the State of Hawaii

State Compliance Monitoring Costs by Plan Year			
Type	**Average annual cost (source $)**	**Source $ year**	**Average annual cost (current $)**
Program Management	$50,000	2022	$50,000

Sources and notes

ICF 2022. KIUC has included a total of $50,000 annually to fund endangered species monitoring by the State of Hawaii.

See the References tab for more detailed information about the cited sources.

Implementation Costs: Changed Circumstances, Adaptive Management, and Contingency

Funds to address changed circumstances, adaptive management, and contingencies with plan implementation

Estimated Costs to Account for Changed Circumstances

Funding for changed circumstances is calculated as a percentage of the annual cost to manage and enhance conservation sites, using parameters below. These funds will accrue throughout the permit term.

Changed circumstance	Cost assumption	2023	2024	2025	2026	2027	2028–2032	2033–2037	2038–2042	2043–2047	2048–2052	2053–2057	2058–2062	2063–2067	2068–2072	50-year total
Severe Weather	Total cost of $15,275,229, divided equally across the 50-year permit term, of replacing all reflective ($8,061 × 1,419 spans) and LED ($30,210 × 127 spans) diverters once due to severe weather.	$305,505	$305,505	$305,505	$305,505	$305,505	$1,527,523	$1,527,523	$1,527,523	$1,527,523	$1,527,523	$1,527,523	$1,527,523	$1,527,523	$1,527,523	$15,275,229
Severe Weather	Annual cost of $200,000 to cover replacement of two predator fences during permit term.	$200,000	$200,000	$200,000	$200,000	$200,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$10,000,000
Loss of Accessibility To or Destruction of Conservation Sites/Escape of Domesticated Animals	Annual cost of $60,000 (approximately 1% of Plan Year 1 cost to manage conservation sites) to compensate for termporary loss of accessibility to or temporary or permanent destruction of conservation sites, as well as escape of domesticated animals.	$60,000	$60,000	$60,000	$60,000	$60,000	$300,000	$300,000	$300,000	$300,000	$300,000	$300,000	$300,000	$300,000	$300,000	$3,000,000
Invasive Species	Annual cost of $3,500 to purchase additional predator control equipment.	$3,500	$3,500	$3,500	$3,500	$3,500	$17,500	$17,500	$17,500	$17,500	$17,500	$17,500	$17,500	$17,500	$17,500	$175,000
Vandalism	Annual cost to repair vandalism to predator fencing ($100) plus vandalism to turtle nesting light mitigation structures ($2,240).	$2,340	$2,340	$2,340	$2,340	$2,340	$11,700	$11,700	$11,700	$11,700	$11,700	$11,700	$11,700	$11,700	$11,700	$117,000
Destruction of Green Sea Turtle Nests	Annual cost of $1,589 (approximately 1% of Plan Year 1 cost to detect and shield nests) to compensate for destruction of green sea turtle nests.	$1,589	$1,589	$1,589	$1,589	$1,589	$7,945	$7,945	$7,945	$7,945	$7,945	$7,945	$7,945	$7,945	$7,945	$79,450
Changed Circumstances Total		**$572,934**	**$572,934**	**$572,934**	**$572,934**	**$572,934**	**$2,864,668**	**$2,864,668**	**$2,864,668**	**$2,864,668**	**$2,864,668**	**$2,864,668**	**$2,864,668**	**$2,864,668**	**$2,864,668**	**$28,646,679**

Estimated Adaptive Management and Contingency Costs

Funding for adaptive management is calculated as a percentage of the annual costs for each cost category, as listed below. Percentages vary based on the degree of uncertainty within each cost category. Contingencies are based on a percentage of the average annual total cost for plan implementation from years 2025-2072. Plan years 2023 and 2024 are omitted from the annual average due to their high, one-time capital costs. Contingencies are assessed each year but do not accrue.

		Cost by Category During Permit period (calendar years)														
Cost categories	**Percentage of annual and 5-year total costs allocated to contingency**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028–2032**	**2033–2037**	**2038–2042**	**2043–2047**	**2048–2052**	**2053–2057**	**2058–2062**	**2063–2067**	**2068–2072**	**50-year total**
Plan Administration	**0.0%**	$452,500	$412,500	$412,500	$412,500	$412,500	$2,062,500	$2,062,500	$2,062,500	$2,062,500	$2,062,500	$2,062,500	$2,062,500	$2,062,500	$2,062,500	$20,665,000
Minimize Powerline Collisions	**2.5%**	$3,885,544	$363,141	$364,270	$365,399	$366,527	$1,849,564	$1,877,777	$1,905,991	$1,934,204	$1,962,418	$1,990,631	$2,018,845	$2,047,058	$2,075,272	$23,006,640
Save Our Shearwaters Program	**2.5%**	$300,000	$300,000	$300,000	$300,000	$300,000	$1,500,000	$1,500,000	$1,500,000	$1,500,000	$1,500,000	$1,500,000	$1,500,000	$1,500,000	$1,500,000	$15,000,000
Manage and Enhance Conservation Sites	**2.5%**	$3,576,627	$3,196,868	$1,538,202	$1,538,202	$1,538,202	$7,691,011	$7,691,011	$7,691,011	$7,691,011	$7,691,011	$7,691,011	$7,691,011	$7,691,011	$7,691,011	$80,607,204
Green Sea Turtle Nest Detection and Temporary Shielding Program	**5.0%**	$158,900	$96,400	$88,400	$88,400	$88,400	$520,500	$520,500	$520,500	$520,500	$520,500	$520,500	$520,500	$520,500	$520,500	$5,205,000
Infrastructure Monitoring and Minimization Project	**12.5%**	$539,911	$539,911	$539,911	$539,911	$539,911	$2,699,554	$2,699,554	$2,699,554	$2,699,554	$2,699,554	$2,699,554	$2,699,554	$2,699,554	$2,699,554	$26,995,544
Seabird Colony Monitoring Program	**12.5%**	$952,993	$952,993	$952,993	$952,993	$952,993	$4,764,965	$4,764,965	$4,764,965	$4,764,965	$4,764,965	$4,764,965	$4,764,965	$4,764,965	$4,764,965	$47,649,648
State Compliance Monitoring	**12.5%**	$50,000	$50,000	$50,000	$50,000	$50,000	$250,000	$250,000	$250,000	$250,000	$250,000	$250,000	$250,000	$250,000	$250,000	$2,500,000
Changed Circumstances	**0.0%**	$572,934	$572,934	$572,934	$572,934	$572,934	$2,864,668	$2,864,668	$2,864,668	$2,864,668	$2,864,668	$2,864,668	$2,864,668	$2,864,668	$2,864,668	$28,646,679
Adaptive Management Total		**$394,862**	**$294,183**	**$252,345**	**$252,373**	**$252,401**	**$1,266,354**	**$1,267,060**	**$1,267,765**	**$1,268,470**	**$1,269,176**	**$1,269,881**	**$1,270,586**	**$1,271,292**	**$1,271,997**	**$12,868,745**
Contingency % of Average Cost Years 2025-2072		**3%**	**3%**	**3%**	**3%**	**3%**	**3%**	**3%**	**3%**	**2%**	**2%**	**2%**	**2%**	**2%**	**2%**	
Contingency Total		**$145,813**	**$145,813**	**$145,813**	**$145,813**	**$145,813**	**$145,813**	**$145,813**	**$145,813**	**$97,209**	**$97,209**	**$97,209**	**$97,209**	**$97,209**	**$97,209**	**$1,749,762**