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LAND
STATE PARKS

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
POST OFFICE BOX 621
HONOLULU, HAWAII 96809

March 27, 2018

Mr. Scott Glenn
Director, Office of Environmental Quality Control
Department of Health, State of Hawai'i
235 S. Beretania Street, Room 702
Honolulu, Hawai'i 96813

Dear Mr. Glenn:

With this letter, the Hawaii Department of Land and Natural Resources hereby transmits the draft environmental assessment and finding of no significant impact (DEA-AFONSI) for the Commercial Aquarium Fishery in the Honolulu, Ewa, Wai'anae, Waialua, Ko'olauloa, and Ko'olaupoko Judicial Districts on the island of O'ahu for publication in the next available edition of the Environmental Notice.

This draft Environmental Assessment has been prepared by the applicant Pet Industry Joint Advisory Council on behalf of Hawai'i fishers. Though it proposes a FONSI, DLNR has identified several concerns in the DEA, and specifically requests public comment concerning:

(1) the effects of the Commercial Aquarium Fishery on Flame Wrasse (*Cirrhilabrus jordani*) and Yellow Tang (*Zebrasoma flavescens)* and the estimated rate of annual take;

(2) the adequacy of the analysis presented in this DEA, including but not limited to removal and replenishment rates for vulnerable species; specifically, how is the estimated sustainable range of 5% to 25% annual take of the estimated total population arrived at, and should the threshold be 5% or 25%;

(3) the interpretation of data presented in this DEA, including the analysis of NOAA NMFS Coral Reef Ecosystem Project (CREP) data versus DLNR Division of Aquatic Resources West Hawai'i Aquarium Project (WHAP) data; and

18-477

(4) conservation measures to minimize or avoid impacts to target species and specifically, whether other alternatives might be proposed to minimize or avoid impacts other than the two presented of no action, with no aquarium permits issued, and the preferred alternative of programmatic issuance of aquarium permits for the Island of O'ahu – such as consideration of specific management measures for Flame wrasse, Yellow tang and other species.

Through this letter DLNR also solicits new or additional scientific information concerning the effects of the Commercial Aquarium Fishery on the environment. DLNR will fully consider all public comments and information submitted prior to finalizing this analysis.

Simultaneous with this letter, we have submitted a completed OEQC Publication Form, two copies of the DEA-AFONSI, an Adobe Acrobat PDF file of the same, and an electronic copy of the publication form in MS Word. In addition, we have submitted the summary of the action in a text file by electronic mail to your office.

If there are any questions, please contact David Sakoda at 808-587-0104.

Sincerely,

Suzanne D. Case
Chair
Hawai'i Department of Land and Natural Resources

Enclosures

Cc: Jim Lynch, KL Gates LLP

From: webmaster@hawaii.gov
To: HI Office of Environmental Quality Control
Subject: New online submission for The Environmental Notice
Date: Tuesday, March 13, 2018 10:13:52 AM

Action name

Issuance of Commercial Aquarium Permits for the Island of O'ahu

Type of document/determination

Draft environmental assessment and anticipated finding of no significant impact (DEA-AFNSI)

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

Statewide

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

N/A

Proponent type

Applicant

Permit(s)/approval(s)

- Other

Approving agency

Hawai'i Department of Land and Natural Resources

Agency contact name

David Sakoda

Agency contact email

david.sakoda@hawaii.gov

Agency contact phone

(808) 587-0104

Agency address

1151 Punchbowl Street, Room 330,
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United States
Map It

Applicant

Pet Industry Joint Advisory Council (PIJAC)

Applicant contact name

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Applicant address

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Alexandria, Virginia 22314
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Was this submittal prepared by a consultant?

Yes

Consultant

Stantec Consulting Services Inc.

Consultant contact name

Terry VanDeWalle

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terry.vandewalle@stantec.com

Consultant contact phone

(319) 334-3755

Consultant address

2300 Swan Lake Blvd., Suite 202
Independence, Iowa 50644
United States
Map It

Action summary

On September 6, 2017, the Supreme Court of Hawai'i ruled that aquarium collection using fine meshed traps or nets is subject to the environmental review procedures provided in the Hawai'i Environmental Protection Act (SCWC-13-0002125). This Draft Environmental Assessment (DEA) is prepared in response to the Court's ruling.

This DEA evaluates the impacts of issuance of Commercial Aquarium Permits on the island of O'ahu. The Applicant, with oversight from DLNR, has prepared this DEA to inform the public of the proposed action (i.e., issuance of Commercial Aquarium Permits), the impacts of the proposed action and its alternatives, and to seek information from the public in order to make better informed decisions concerning this DEA.

Reasons supporting determination

See Section 5.5 and related sections of DEA.

Searchable PDF(s)

- Draft-Environmental-Assessment_Oahu_03132018.pdf

Draft-Environmental-Assessment_Oahu_031320181.pdf
- Draft-Environmental-Assessment_Oahu_031320182.pdf
- Draft-Environmental-Assessment_Oahu_031320183.pdf
- Oahu-Transmittal-Letter-signed.pdf

Shapefile upload

- Action-Location-Map_Oahu.zip

Authorized individual

James Lynch

Proponent

PIJAC

Authorization

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

Draft Environmental Assessment

Issuance of Commercial Aquarium Permits for the Island of O’ahu

March 13, 2018

Applicant

Name: Pet Industry Joint Advisory Council (PIJAC)
Address: 1615 Duke St., #100 Alexandria, VA 22314
Phone: 202.452.1525

Approving Agency

Hawai'i Department of Land and Natural Resources
Division of Aquatic Resources
1151 Punchbowl Street, Room 330
Honolulu, HI 96813-3088

APPLICANT PUBLICATION FORM

Project Name:	Issuance of Commercial Aquarium Permits for the Island of O’ahu
Project Short Name:	DEA O’ahu Commercial Aquarium Permits
HRS §343-5 Trigger(s):	Trigger 1 (use of state lands) and Trigger 2 (use of conservation districts)
Island(s):	O’ahu
Judicial District(s):	Honolulu, Ewa, Waianae, Waialua, Koolauloa, Koolaupoko
TMK(s):	Fishing areas around O’ahu identified in Figure 1
Permit(s)/Approval(s):	Aquarium Fishing Permits issued pursuant to HRS §188-31, Commercial Marine License issued pursuant to HRS 189-2,3
Approving Agency:	Department of Land and Natural Resources
Contact Name, Email, Telephone, Address	David Sakoda, david.sakoda@hawaii.gov, 808-587-0104,1151 Punchbowl Street, Room 330, Honolulu, HI 96813
Applicant:	Pet Industry Joint Advisory Council (PIJAC) on behalf of fishers
Contact Name, Email, Telephone, Address	Jim Lynch; jim.lynch@klgates.com; 206.370-6587; 925 Fourth Ave., Suite 2900 Seattle, WA 98104
Consultant:	Stantec Consulting Services Inc
Contact Name, Email, Telephone, Address	Terry VanDeWalle; terry.vandewalle@stantec.com; (319) 334-3755; 2300 Swan Lake Blvd., Suite 202, Independence, IA 50644

Status (select one)	**Submittal Requirements**
_XX_ DEA-AFNSI	Submit 1) the approving agency notice of determination/transmittal letter on agency letterhead, 2) this completed OEQC publication form as a Word file, 3) a hard copy of the DEA, and 4) a searchable PDF of the DEA; a 30-day comment period follows from the date of publication in the Notice.
____ FEA-FONSI	Submit 1) the approving agency notice of determination/transmittal letter on agency letterhead, 2) this completed OEQC publication form as a Word file, 3) a hard copy of the FEA, and 4) a searchable PDF of the FEA; no comment period follows from publication in the Notice.
____ FEA-EISPN	Submit 1) the approving agency notice of determination/transmittal letter on agency letterhead, 2) this completed OEQC publication form as a Word file, 3) a hard copy of the FEA, and 4) a searchable PDF of the FEA; a 30-day comment period follows from the date of publication in the Notice.
____ Act 172-12 EISPN (“Direct to EIS”)	Submit 1) the approving agency notice of determination letter on agency letterhead and 2) this completed OEQC publication form as a Word file; no EA is required and a 30-day comment period follows from the date of publication in the Notice.
____ DEIS	Submit 1) a transmittal letter to the OEQC and to the approving agency, 2) this completed OEQC publication form as a Word file, 3) a hard copy of the DEIS, 4) a searchable PDF of the DEIS, and 5) a searchable PDF of the distribution list; a 45-day comment period follows from the date of publication in the Notice.
____ FEIS	Submit 1) a transmittal letter to the OEQC and to the approving agency, 2) this completed OEQC publication form as a Word file, 3) a hard copy of the FEIS, 4) a searchable PDF of the FEIS, and 5) a searchable PDF of the distribution list; no comment period follows from publication in the Notice.

___ FEIS Acceptance Determination	The approving agency simultaneously transmits to both the OEQC and the applicant a letter of its determination of acceptance or nonacceptance (pursuant to Section 11-200-23, HAR) of the FEIS; no comment period ensues upon publication in the Notice.
____ FEIS Statutory Acceptance	The approving agency simultaneously transmits to both the OEQC and the applicant a notice that it did not make a timely determination on the acceptance or nonacceptance of the applicant's FEIS under Section 343-5(c), HRS, and therefore the applicant's FEIS is deemed accepted as a matter of law.
____ Supplemental EIS Determination	The approving agency simultaneously transmits its notice to both the applicant and the OEQC that it has reviewed (pursuant to Section 11-200-27, HAR) the previously accepted FEIS and determines that a supplemental EIS is or is not required; no EA is required and no comment period ensues upon publication in the Notice.
____ Withdrawal	Identify the specific document(s) to withdraw and explain in the project summary section.
____ Other	Contact the OEQC if your action is not one of the above items.

Project Summary

The purpose of the Applicant's action is to ensure that commercial aquarium fish collection allows for the lawful, responsible, and sustainable commercial collection of various fish species from nearshore habitats. The objective of the proposed action is to create a program under the Department of Land and Natural Resources which helps to facilitate the permitting process for commercial aquarium collection permits for the island of O'ahu.

The need for the Applicant's action is to continue commercial aquarium fishers' livelihoods in compliance with all applicable laws, rules, and regulations pertaining to the industry.

Project Summary

Project Name: Issuance of Commercial Aquarium Permits for the Island of O'ahu

Proposed Action: Lawful, responsible, and sustainable commercial collection of various aquarium fish species from nearshore habitats pursuant to Aquarium Fishing Permits issued under HRS §188-31.

Applicant: Pet Industry Joint Advisory Council (PIJAC) on behalf of Hawai'i fishers

Applicant Contact: Jim Lynch, KL Gates LLP, 206-370-6587

Approving Agency: Department of Land and Natural Resources

Project Location: Throughout the nearshore region (to 3 nautical miles from shore) of the island of O'ahu except in those areas already designated as no collection areas such as Marine Life Conservation Districts.

Land Use Classification: N/A

Land Area: N/A NON-MLCDs

Tax Map Key: N/A

State Land District: N/A

Land Owner: State of Hawai'i

Permits Required: Aquarium Fishing Permits issued under HRS §188-31.

EA Trigger: Trigger 1 (use of state lands) and Trigger 2 (use of conservation districts)

Anticipated Determination: Finding of No Significant Impact

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Executive Summary

In October 2017, the circuit court ruled that, based upon the Supreme Court of Hawai'i's opinion, existing permits for use of fine mesh nets to catch aquatic life for aquarium purposes are illegal and invalid. The circuit court ordered the Department of Land and Natural Resources (DNLR) not to issue any new permits pending environmental review. The DLNR has not issued new or additional permits under HRS §188-31 since September of 2017.

This Draft Environmental Assessment (DEA) evaluates the impacts of issuance of Commercial Aquarium Permits on the island of O'ahu. The Applicant has prepared this DEA to inform the public of the proposed action (i.e., issuance of Aquarium Permits), the impacts of the proposed action and its alternatives, and to seek information from the public in order to make better informed decisions concerning this DEA. The purpose of the Applicant's action is to ensure that commercial aquarium fish collection allows for the lawful, responsible, and sustainable commercial collection of various fish species from nearshore habitats on the island of O'ahu. The objective of the proposed action is to create a program under the DLNR which helps to facilitate the permitting process for Aquarium Permits for the island of O'ahu.

The Applicant's action does not include any activities different from, or in addition to, those that have occurred in the past. There will be no construction of permanent or semi-permanent infrastructure, no discharges into coastal, surface or ground waters, no dredging, and no significant use of hazardous materials that could be released into the environment. The DLNR's issuance of Commercial Aquarium Permits is not anticipated to result in significant beneficial or adverse impacts to water and air quality, geology and soil resources, aesthetics, noise, vegetation, terrestrial wildlife and avian species, threatened and endangered species, land use, public health and safety, communications, historical resources, transportation, utilities, or population and demographics from their current condition.

The Applicant's action does not involve an irrevocable commitment or loss or destruction of any natural or cultural resource. If the average annual commercial aquarium fish collection were to occur over the 12-month analysis period, collection of 17 of the top 20 collected species would result in the loss of less than 1% of their respective overall island of O'ahu populations. For the remaining three species, an estimated 2.59% of the Potter's Angelfish population, 7% of the Yellow Tang population, and 28% of the Flame Wrasse population would be collected. However, the Flame Wrasse spends much of its time below the 98-foot depth limit of population estimate surveys, and therefore likely often goes undetected, leading to an underestimation of its overall population. Due to this underestimation, it is not possible to know the exact proportion of the Flame Wrasse population that would be collected, though it is assumed to be less than 28%. Research suggests collection of between 5%-25% is sustainable for various reef species similar to those found in O'ahu (e.g., tang, wrasse, butterflyfish, angelfish, triggerfish). Based on the low percentage of the overall populations collected annually by commercial aquarium fishers, which is spread throughout the year and across multiple areas, as well as the targeted take of smaller, less fecund individuals, commercial aquarium collection likely has minimal impacts on populations in general. Two studies have concluded that the aquarium fishery has no significant impact on coral or the reef ecosystem. In addition, herbivores taken by the aquarium fishery typically consist of the smaller size classes which are the least effective sizes for cropping algae. One study found there were no increases in the abundance of macroalgae where the abundance of herbivores was reduced by aquarium collecting.

The Applicant’s action does not substantially affect the economic welfare, social welfare, and cultural practices of the community or State, but plays an important role as a nearshore fishery in the state. The average annual value of the commercial aquarium fishery in O’ahu for the period 2000 to 2017 was $506,251. Under the Preferred Alternative, a portion of the income from this fishery would continue to be put back into O’ahu’s economy through re-investment efforts in terms of equipment, maintenance, supplies, and personnel. Funds from the licenses, other fees, and taxes associated with the fishery would continue to go to environmental conservation projects and research implemented by the DLNR and other agencies to monitor, manage, and regulate the fishery to ensure environmental impacts are avoided and minimized.

Abbreviations

CML	Commercial Marine License
CREP	Coral Reef Ecosystems Program
CWCS	Hawai'i's Comprehensive Wildlife Conservation Strategy
DAR	Division of Aquatic Resources
DLNR	Department of Land and Natural Resources
DOCARE	Division of Conservation and Resources Enforcement
DOH	Department of Health
EA	Environmental Assessment
EC	Environmental Council
EIS	Environmental Impact Statement
ENSO	El Niño Southern Oscillation
EQC	Environmental Quality Commission
ESA	Endangered Species Act
FMA	Fisheries Management Area
FONSI	Finding of No Significant Impact
FRA	Fish Replenishment Area

HEPA	Hawai'i Environmental Policy Act
HAR	Hawai'i Administrative Rule
HRS	Hawai'i Revised Statute
IUCN	International Union for the Conservation of Nature and Natural Resources
MHI	Main Hawaiian Islands
MLCD	Marine Life Conservation District
MPA	Marine Protected Area
NEPA	National Environmental Policy Act
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NWHI	Northwestern Hawaiian Islands
OEQC	Office of Environmental Quality Control
OHA	Office of Hawaiian Affairs
PIJAC	Pet Industry Joint Advisory Council
QUEST	Quantitative Underwater Ecological Survey Techniques
SAIA	Sustainable Aquarium Industry Association
SAWCS	Statewide Aquatic Wildlife Conservation Strategy

SCUBA	Self-contained Underwater Breathing Apparatus
SGCN	Species of Greatest Conservation Need
SWAP	State Wildlife Action Plan
TL	Total Length
UH	University of Hawai'i
USFWS	United States Fish and Wildlife Service
WHAP	West Hawai'i Aquarium Project
WHFC	West Hawai'i Fishery Council
WHRFMA	West Hawai'i Regional Fishery Management Area
WHRFWG	West Hawai'i Reef Fish Working Group

1.0 INTRODUCTION

This Draft Environmental Assessment (DEA) has been prepared by the Pet Industry Joint Advisory Council (PIJAC; the Applicant) pursuant to the Hawai'i Environmental Policy Act (HEPA). This DEA evaluates the impacts of issuance of commercial aquarium permits (Aquarium Permit) on the island of O'ahu, pursuant to Hawai'i Revised Statute (HRS) 188-31 (2013; Title 12 – Conservation and Resources; 188 – Fishing Rights and Regulations; 188-31 – Permits to take aquatic life for aquarium purposes). The Applicant has prepared this DEA to inform the public of the proposed action (i.e., issuance of Aquarium Permits), the impacts of the proposed action and its alternatives, and to seek information from the public in order to make better informed decisions concerning this DEA.

Hawai'i Revised Statute 188-31 states that, "Except as prohibited by law, the department (Department of Land and Natural Resources; DLNR), upon receipt of a written application, may issue an Aquarium Permit, not longer than one year in duration, to use fine meshed traps, or fine meshed nets other than throw nets, for the taking of marine or freshwater nongame fish and other aquatic life for aquarium purposes." As set down by the Supreme Court of Hawai'i (SCWC-13-0002125), issuance of an Aquarium Permit constitutes a discretionary state action by the DLNR and is thus subject to the HEPA, which requires that State agencies consider the impact of governmental actions on the environment by preparing an Environmental Assessment (EA) or an Environmental Impact Statement (EIS) to document the potential impacts of the State action. Accordingly, the Applicant has prepared this DEA to evaluate the potential impacts associated with issuance of Aquarium Permits on the island of O'ahu, and a No Action Alternative. The consequences of these alternatives on various resources are discussed in this DEA.

1.1 BACKGROUND

In 2017, the commercial aquarium fishery on the island of O'ahu reported landings greater than $513 thousand, down from a record $741,500 in 2015 (DAR 2018a). The fishery developed initially on O'ahu in the late 1940's, and then went through a period of expansion in the 1970's where it made up nearly 70% of the total commercial aquarium fish value from the state. Since then the total value of fish taken from O'ahu has decreased to approximately 30% of the total commercial aquarium fish value from the state (DAR 2018a).

Commercial aquarium fish collection in Hawai'i has long been a subject of controversy (DAR 2014a). As early as 1973, public concern over collecting activities prompted Hawai'i's DLNR, then Division of Fish and Game, to suspend the issuance of Aquarium Permits for a week while issues were considered and addressed (DAR 2014a). As a result, Aquarium Permit holders were required to submit monthly catch reports; however, no studies were conducted and no 'sanctuary' areas were created at that time. The first sanctuary areas were created through a gentleperson's agreement in 1987 and four of these sanctuaries were incorporated into the Kona Coast Fisheries Management Area (FMAs) off the coast of the island of Hawai'i in 1991 (DAR 2004).

On the island of O’ahu, three Marine Life Conservation Districts (MLCD) exist, where fishing activities of any kind are prohibited, including Hanauma Bay, Pūpūkea, and, Waikíkí (Figure 1). Hanauma Bay is located near Koko Head at the eastern end of Honolulu, which extends from the highwater mark seaward to a line across the bay’s mouth from Palea Point on the left to Pai’olu’olu Point on the right. Pūpūkea MLCD is located on the north shore of O’ahu near the town of Waimea, extending offshore from the highwater mark seaward 100 yards along a line extending due west of Kulalua Point, then south to the most seaward exposed rock of the Wananapaoa Islets. Waikíkí MLCD is located at the Diamond Head end of Waikíkí Beach, extending from the groin at the end of Kapahulu Avenue to the west wall of the Natatorium, from the highwater mark seaward a distance of 500 yards or to the edge of the fringing reef, whichever is greater.

In addition, there are 10 marine locations that have fishing restrictions: Waikíkí-Diamond Head Shoreline Fisheries Management Area (FMA), Ala Wai Canal, Kapalama Canal, Coconut Island – Hawai’i Marine Laboratory Refuge, He’eia Kea Wharf, Honolulu Harbor, Poka’i Bay, Waialua Bay, and the ‘Ewa Limu Management Area (Figure 1). Coconut Island does not allow any fishing of any kind within the boundaries of the refuge, while the other nine have specific permit restrictions on the number of fish allowed to be taken, type of equipment used, time of day, or time of year. None specifically prohibit collection under Aquarium Permits; however, the majority of the habitat would not be conducive to aquarium fish collection (e.g., canal, harbor, wharf).

1.1.1 Status of Aquarium Permits

In October 2012, Earthjustice filed a complaint under the HEPA in the First Circuit Court on behalf of four individuals and three non-governmental organizations. The complaint sought a court order to force the state to comply with the HEPA’s requirement to examine commercial aquarium fish collection’s effects on the environment before issuing collection permits. The complaint also asked the court to halt collection under existing commercial aquarium permits and to stop DLNR from issuing new permits until the environmental review is complete (Earthjustice 2012). On June 24, 2013, the Circuit Court of the First Circuit announced their findings on the case through an ‘Order Granting Department of Land and Natural Resources State of Hawai’i's, Motion for Summary Judgment filed February 4, 2013, and Denying Plaintiffs' Motion for Summary Judgment filed February 5, 2013 (Summary Judgment Order), and the Final Judgment in Favor of Defendant and Against Plaintiffs (Judgment), also filed on June 24, 2013. The Hawai’i Intermediate Court of Appeals upheld this decision in August of 2016. Permit issuance by DLNR’s Division of Aquatic Resources (DAR) continued. Through the appeals process, Earthjustice brought the case before the Supreme Court of Hawai’i. On September 6, 2017, the Supreme Court of Hawai‘i ruled that aquarium collection using fine meshed traps or nets is subject to the environmental review procedures provided in the HEPA (SCWC-13-0002125). The issue was remanded to the circuit court for further proceedings. In light of the ruling, DLNR discontinued issuance of new Aquarium Permits and renewal of existing Aquarium Permits (DAR 2017). On October 27, 2017, the circuit court ruled that, based upon the Supreme Court of Hawai’i’s opinion, existing permits for use of fine mesh nets to catch aquatic life for aquarium purposes are illegal and invalid. The circuit court ordered the DLNR not to issue any new Aquarium Permits pending environmental review. The DLNR has not issued new or additional permits under HRS §188-31 because of the Supreme Court's opinion issued in September of 2017 (DAR 2017).

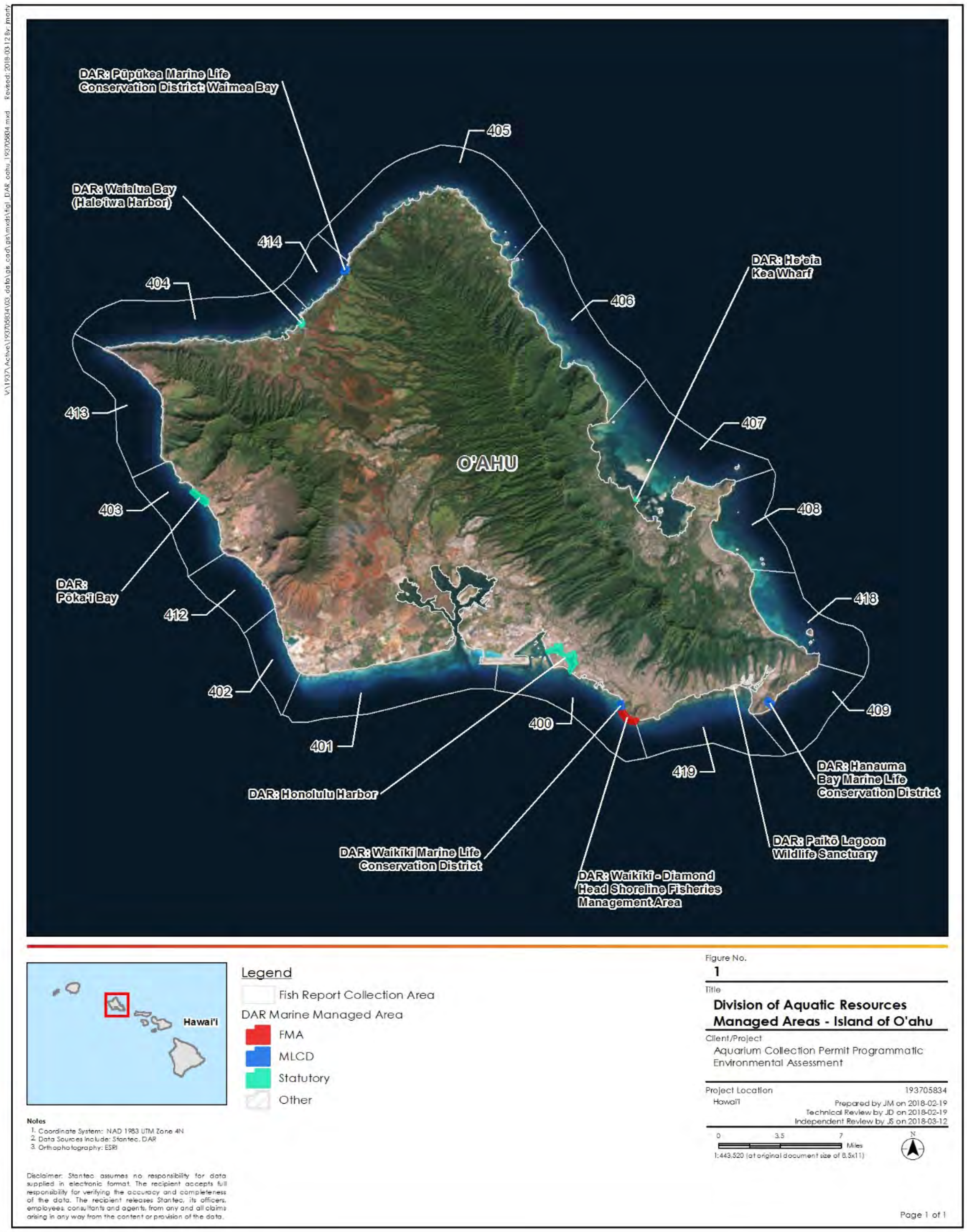


Figure 1. Division of Aquatic Resources Managed Areas – Island of O'ahu.

1.2 REGULATORY BACKGROUND

1.2.1 Hawai'i Revised Statute (HRS) 188-31

Hawai'i Revised Statute (HRS) §188-31 (2013; Title 12 – Conservation and Resources; 188 – Fishing Rights and Regulations; 188-31 – Permits to take aquatic life for aquarium purposes) states that:

> (a) *Except as prohibited by law, the department, upon receipt of a written application, may issue an aquarium fish permit, not longer than one year in duration, to use fine meshed traps, or fine meshed nets other than throw nets, for the taking of marine or freshwater nongame fish and other aquatic life for aquarium purposes.*
>
> (b) *Except as prohibited by law, the permits shall be issued only to persons who can satisfy the department that they possess facilities to and can maintain fish and other aquatic life alive and in reasonable health.*
>
> (c) *It shall be illegal to sell or offer for sale any fish and other aquatic life taken under an aquarium fish permit unless those fish and other aquatic life are sold alive for aquarium purposes. The department may adopt rules pursuant to HRS chapter 91 for the purpose of this section.*

1.2.2 Hawai'i Environmental Policy Act

The HEPA requires that State agencies consider the impact of governmental actions on the environment because humanity's activities have broad and profound effects upon the interrelations of all components of the environment, and an environmental review process would integrate the review of environmental concerns with existing planning processes of both the State and county governments. The HEPA includes the following statutes and administrative rules: a) HRS Chapter 343, Environmental Impact Statements; b) Hawai'i Administrative Rule (HAR) 11-200, Environmental Impact Statement Rules; c) HAR 11-201, Environmental Council Rules of Practice and Procedure (OEQC 2012).

The authorities governing the HEPA process include:

1. The text of the statute (Chapter 343, HRS) and its implementing administrative rules (Chapters 11-200, and 11-201, HAR, Department of Health;
2. The State Environmental Policy (Chapter 344, HRS);
3. The enumerated and written advisory opinions of the Attorney General of the State of Hawai'i;
4. The declaratory rulings of the Environmental Quality Commission (EQC) and the Environmental Council (EC); and,
5. The appellate rulings of the Intermediate Court of Appeals and the Supreme Court of the State of Hawai'i.

The HEPA process also alerts decision makers to significant environmental effects that may result from the implementation of certain actions (HRS 343-1). The specific instances when a proposing agency or an approving agency must prepare an EA (for an action not declared exempt under Section 11-200-8, HAR) derive from Section 343-5(a) HRS and are listed in Table 1.

Table 1. Statutory triggers for Hawai'i Environmental Policy Act (HEPA).

	Instances	Responsible Agency
1.	Use of State or County lands or use of State or County funds, other than funds to be used for feasibility or planning studies for possible future programs or projects that the agency has not approved, adopted, or funded, or funds to be used for the acquisition of unimproved real property; provided that the agency shall consider environmental factors and available alternatives in its feasibility or planning studies; provided further that an EA for proposed uses under Section 205-2(d)(11) or 205-4.5(a)(13) shall only be required pursuant to Section 205-5(b).	The agency with title to the land or is using funds.
2.	Use of any land classified as conservation district by the state land use commission under Chapter 205.	Office of Conservation and Coastal Lands of the DLNR.
3.	Use within a shoreline area as defined in Section 205A-41. The shoreline area in question is defined by county ordinance and consists of a predetermined distance going inland from the certified shoreline. In the City and County of Honolulu, this is forty-feet.	The respective county planning department.
4.	Use within any historic site as designated in the National Register or Hawai'i Register, as provided for in the Historic Preservation Act of 1966, Public Law 89-665, or Chapter 6E.	The respective county planning department.
5.	Use within the Waikiki area of O'ahu, the boundaries of which are delineated in the land use ordinance as amended, establishing the "Waikiki Special District".	The Department of Planning and Permitting of the City and County of Honolulu.
6.	Any amendments to existing county general plans where the amendment would result in designations other than agriculture, conservation or preservation, except actions proposing any new county general plan or amendments to any existing county general plan initiated by a county.	The respective county planning department.
7.	Any reclassification of any land classified as a conservation district by the state land use commission under Chapter 205.	The Land Use Commission, except in cases involving less than fifteen-acres (which cases are processed by the respective county planning department).
8.	Any construction of new or the expansion or modification of existing helicopter facilities within the State, that may affect: A. Any land classified as a conservation district by the state land use commission B. A shoreline area C. Any historic site as designated in the National Register or Hawai'i Register	The respective county planning department where the project is located processes the clearance of this trigger.
9.	Propose any:	The agencies of the State

	Instances	Responsible Agency
	A. Wastewater treatment unit, except an individual wastewater system or a wastewater treatment unit serving fewer than fifty single family dwellings or the equivalent B. Waste-to-energy facility C. Landfill D. Oil refinery E. Power-generating facility	or County government that issue discretionary approvals for the listed items.

The Supreme Court of Hawai'i ruled (SCWC-13-0002125) that an environmental review of the Aquarium Permit process is warranted based on the first (use of state lands) and second (use of conservation districts) statutory triggers identified in Table 1.

Actions that do not fall under one of the triggers are excluded by statute from the HEPA process. Any action that is not excluded by statute must undergo the HEPA environmental review process (OEQC 2012). The analysis within an EA is used to determine whether the impact on the environment will be significant enough to warrant the preparation of a full EIS or will be used to declare a Finding of No Significant Impact (FONSI) thus clearing the HEPA process.

In most cases, an agency determines that an action may have a significant impact on the environment and require an EIS if it meets any of the following criteria:

1. Involves an irrevocable commitment to loss or destruction of any natural or cultural resource;
2. Curtails the range of beneficial uses of the environment;
3. Conflicts with the state's long-term environmental policies or goals and guidelines as expressed in Chapter 344, HRS, and any revisions thereof and amendments thereto, court decisions, or executive orders;
4. Substantially affects the economic or social welfare of the community or State;
5. Substantially affects public health;
6. Involves substantial secondary impacts, such as population changes or effects on public facilities;
7. Involves a substantial degradation of environmental quality;
8. Is individually limited but cumulatively has considerable effect upon the environment or involves a commitment for larger actions;
9. Substantially affects a rare, threatened, or endangered species, or its habitat;
10. Detrimentally affects air or water quality or ambient noise levels;
11. Affects or is likely to suffer damage by being located in an environmentally sensitive area such as a flood plain, tsunami zone, beach, erosion-prone area, geologically hazardous land, estuary, fresh water or coastal waters;
12. Substantially affects scenic vistas and view planes identified in county or state plans or studies; or
13. Requires substantial energy consumption.

Since its inception, the HEPA process has bifurcated into two separate procedural tracks (OEQC 2012):

1. Agency actions (set forth in Section 343-5(b), HRS); refers to those proposed by a government agency; and

2. Applicant actions (set forth in Section 343-5(c), HRS); refers to those that are initiated by a private party and “triggers” an environmental review.

The need for this DEA is based on the Applicant’s actions.

The environmental review process described in the findings and purpose section of Chapter 343, HRS, necessitates integrating citizen concerns into the planning process and forewarning decision makers of potential significant environmental effects should implementation take place. The Hawai’i Office of Environmental Quality Control (OEQC) finds that the process of reviewing environmental effects is desirable because environmental consciousness is enhanced, cooperation and coordination are encouraged, and public participation during the review process benefits all parties involved and society as a whole (OEQC 2012).

1.2.3 Hawai’i Administrative Rule §13-77 - O’ahu Aquarium Life Management

The DAR proposed an Administrative Rule (HAR §13-77) for the management of the O’ahu aquarium fishery within 3 nautical miles from the shore of the O’ahu shoreline. The rule proposal was developed by commercial aquarium collectors from O’ahu and presented to DAR in August 2011. A Public Hearing on the proposed rule was held on December 5, 2012. The Administrative Rule was adopted on October 24, 2014, and applies to the collection of aquatic life for an aquarium purpose from the waters of O’ahu while using fine or small mesh traps or fine or small mesh nets, but not throw nets. While governing the taking of aquatic life intended for live aquarium displays, HAR §13-77 shall not apply to the use of nets to take aquatic life for food, bait, or other consumptive purposes.

From HAR §13-77:

1. It is unlawful for any person in or on the waters of O’ahu (3 nautical miles from the shore), possessing a small mesh net authorized under a commercial aquarium fish permit or recreational aquarium fish permit, to possess a small mesh net that is more than 30 feet long; provided that 2 or more permittees may join 2 nets, each no more than 30 feet long, for a total net length of no more than 60 feet long; or more than 6 feet in height. Restriction regarding net length and height took effect after July 1, 2015.

2. It is unlawful for any person, while possessing, using, or having used a small mesh net authorized under a commercial aquarium fish permit and in or on the waters of O’ahu, to possess a small mesh net and take or possess a daily bag limit of more than:

   - One hundred (100) Yellow Tang (*Zebrasoma flavescens*);
   - Seventy-five (75) Kole (= Goldring Surgeonfish; *Ctenochaetus strigosus*);
   - Fifty (50) Potter’s Angelfish (*Centropyge potteri*);
   - Fifty (50) Orangespine Unicornfish (= Naso Tang; Clown Tang; *Naso lituratus*);
   - Twenty-five (25) Moorish Idol (*Zanclus cornutus*); or
   - Ten (10) Achilles Tang (*Acanthurus achilles*).

A daily bag limit includes the cumulative number of regulated aquatic life taken or possessed by a person on any day.

3. It is unlawful for any person while possessing, using, or having used a small mesh net authorized under a commercial aquarium fish permit and in or on the waters of O'ahu, to possess a small mesh net and to take or possess more than six of any of the following per day:

    - Yellow Tang less than one and one-half inches in length;
    - Yellow Tang more than five inches in length;
    - Kole more than five inches in length; or
    - Cleaner Wrasse (*Labroides dimidiatus*) of any size.

4. It is unlawful for any person while possessing, using, or having used a small mesh net authorized under a commercial aquarium fish permit and in or on the waters of O'ahu, to take or possess more than two Bandit Angelfish (*Holacanthus arcuatus*) that are longer than five and a half inches in length, per day.

5. It is unlawful for any person while possessing, using, or having used a small mesh net authorized under a commercial aquarium fish permit, to operate a vessel on the waters of O'ahu with:

    - More than the daily bag limits as provided above, and for the number of permittees on board the vessel; or
    - More than three times the number of any daily bag limit, regardless of the number of permittees on board.

6. It is unlawful for any person, while possessing a small mesh net authorized under a commercial aquarium fish permit or recreational aquarium fish permit while in or on the waters of O'ahu, to take or possess any of the following species:

    - Ornate Butterflyfish (*Chaetodon ornatissimus*);
    - Oval Butterflyfish (*Chaetodon lunulatus*); and
    - Reticulated Butterflyfish (*Chaetodon reticulatus*).

1.2.4 Coral/Live Rock Damage

State law prohibits the breaking or damaging, with any implement, any stony coral from the waters of Hawai'i, including any reef or mushroom coral (HAR 13-95-70). It is unlawful to take, break or damage, any implement, any rock or coral to which marine life of any type is visibly attached or affixed (HAR 13-95-71). The taking of sand, coral rubble or other marine deposits is permitted in certain circumstances. The material may not exceed one gallon per person per day, and may be taken only for personal, noncommercial purposes (HRS §171-58.5, §205A-44).

Fines per specimen may be imposed for each damaged coral head or colony less than one square meter in surface area or for a colony greater than one square meter in surface area, each square meter of colony surface area and any fraction remaining constitutes an additional specimen. Penalties for damage to live rock are based on each individual rock or if the violation involves greater than one square meter of bottom area, then the penalty is based on each square meter of bottom area.

No liability shall be imposed for inadvertent breakage, damage, or displacement of an aggregate area of less than one half square meter of coral if caused by a vessel with a single anchor damage incident, in an area where anchoring is not otherwise prohibited, and not more frequently than once per year; or by accidental physical contact by an individual person.

2.0 PURPOSE AND NEED

2.1 PURPOSE FOR APPLICANT'S ACTION

The purpose of the Applicant's action is to ensure that commercial aquarium fish collection allows for the lawful, responsible, and sustainable commercial collection of various fish species from nearshore habitats on the island of O'ahu. The objective of the proposed action is to create a program under the DLNR which helps to facilitate the permitting process for Aquarium Permits for the island of O'ahu.

2.2 NEED FOR APPLICANT'S ACTION

The need for the Applicant's action is to continue commercial aquarium fishers' livelihoods in compliance with all applicable laws, rules, and regulations pertaining to the industry.

2.3 PURPOSE FOR APPROVING AGENCY'S (DLNR) ACTION

The purpose of an environmental review process under the HEPA is to provide the Approving Agency (DLNR) with the framework necessary for reviewing the Applicant's action and the environmental effects of issuing Aquarium Permits for O'ahu. The HEPA review also provides an opportunity for the public to be involved in the DLNR's decision-making process. The DLNR can also use a properly conducted HEPA analysis to review and improve plans, functions, programs, and resources under its jurisdiction. Furthermore, this DEA is the mechanism for recording the results of a comprehensive planning and decision-making process surrounding the Applicant's action.

The purpose of the DLNR's action is to determine the level of significance that issuing Aquarium Permits for O'ahu may have on the environment, based on the 13 criteria listed in Section 1.2.2. The final determination will result in either a FONSI, whereby the DLNR reinstates the Aquarium Permit program, or the development of an EIS to further evaluate environmental impacts and potentially additional alternatives.

2.4 NEED FOR APPROVING AGENCY'S (DLNR) ACTION

The need for DLNR's action is the Applicant's submittal of this DEA, to which the DLNR must respond.

2.5 SCOPE OF ANALYSIS

The scope of this DEA's analysis incorporates current methodologies, regulations, and historical data to determine past influences the commercial aquarium fishery and its management have had on O'ahu aquarium fisheries in order to estimate the direct, indirect, and cumulative impacts that issuance of Aquarium Permits would have for the island of O'ahu over a single annual permit period on various resources. Under HRS §188-31, the DLNR may issue an Aquarium Permit not longer than one year in duration; therefore, a temporal scope of one year is appropriate, because an EA with updated data and analysis will need to be completed on an annual basis. Any changes in resource data (e.g., increase or decrease in collection numbers, unforeseen circumstances, etc.) would be addressed by future EAs annually, allowing for the HEPA process to quickly recognize and address any potential issues (i.e., adaptive management).

2.5.1 Resources Evaluated and Dismissed from Further Consideration

This DEA evaluates the potential impacts of commercial aquarium fish collection on the nearshore habitat (3 nautical miles from shore) in which commercial aquarium fishing (or lack thereof) will take place, over a single year. During the evaluation process, it was determined that some resources typically evaluated in EA's will not be impacted by either alternative. The evaluation includes past use and potential impacts by the aquarium fish industry because it has been a part of the baseline condition of these resources since the late 1940s. Because a significant increase in commercial aquarium fishing is not anticipated during the 12-month period evaluated in this DEA, this DEA does not anticipate a significant change in the current baseline condition of these resources.

The Applicant's action does not include any activities different from or in addition to those that have occurred in the past. There will be no construction of permanent or semi-permanent infrastructure, no discharges into coastal, surface or ground waters, and no dredging, and no significant use of hazardous materials that could be released into the environment.

The DLNR's issuance of Aquarium Permits is not anticipated to result in significant beneficial or adverse impacts to water and air quality, geology and soil resources, aesthetics, noise, vegetation, terrestrial wildlife and avian species, threatened and endangered species, land use, public health and safety, communications, historical resources, transportation, utilities, or population and demographics from the current baseline condition; therefore, these resources will not be evaluated further.

2.5.2 Resources Retained for Further Analysis

The following resources could be impacted by either alternative. Current baseline conditions of these resources are presented in Section 4.0 and impacts to these resources are evaluated in Section 5.0 of this DEA:

- Socioeconomic Resources
- Cultural Resources
- Physical Resources
    - Climate

- Biological Resources
    - Top 20 O'ahu Collected Species
    - Hawai'i Species of Greatest Conservation Need
    - Reef Habitat

3.0 ALTERNATIVES

Reasonable alternatives include those that are practical or feasible from cultural, scientific, technical, and economic perspectives. The HEPA recommends that Applicants consider and objectively evaluate reasonable alternatives to the preferred alternative and briefly explain the basis for eliminating any alternatives that were not retained for detailed analysis.

The DLNR has been, and continues to work with stakeholders (e.g., public, various fishing and tourism industries, local governments) since the 1970's to ensure the commercial aquarium fishery is environmentally sustainable and prevents degradation of fish populations and the habitats in which they occur. As a result, many aspects of the fishery have changed over the past 40+ years due to the various alternatives recommended by stakeholders and implemented by the DLNR.

Any alternative that would include more, or less, restrictive Aquarium Permit requirements is not feasible for the purposes of this DEA because the Applicant has no legislative or regulatory authority and cannot create, eliminate, or alter conservation areas (e.g., Marine Protected Areas, Fishery Management Areas [FRAs], MLCDs; create, eliminate, or alter current regulations (e.g., bag and size limits, season length, permit term); or change reporting requirements.

Two alternatives were retained for detailed analysis:

- **Alternative 1:** No Action Alternative
    - Current court order would remain in place and no Aquarium Permits would be issued.
- **Alternative 2:** Issuance of Aquarium Permits for the island of O'ahu (Proposed Action and Preferred Alternative)
    - The DLNR would issue Aquarium Permits for the island of O'ahu under existing regulation set forth in HRS 188-31 (Section 1.2.1). These rules and regulations include restrictions on equipment, restrictions on access to various areas, bag limits on various collected fish species, and reporting requirements.

These alternatives were evaluated based on their capacity to meet the purpose and need of the Approving Agency's action (Section 2.3 and 2.4). The potential impacts on the environment of each alternative are described and analyzed in Section 5.0; Environmental Consequences.

3.1 NO ACTION ALTERNATIVE

Under the No Action Alternative, the court order would remain in place and no Aquarium Permits would be issued for the state of Hawai'i, including the island of O'ahu. The No Action Alternative meets the DLNR's objectives to ensure Applicant's Actions do not lead to degradation of fish populations and the habitats in which they occur in the context of aquarium collection alone (i.e., does not address impacts from other Hawaiian fisheries, and influences discussed in Sections 4.0 and 5.0). Under the No Action Alternative, Aquarium Permits would not be issued for the state of Hawai'i, which includes the island of O'ahu, and commercial collection of aquarium fish would stop. However, the No Action Alternative does not meet the Applicant's purpose and need to continue fishers' livelihoods participating in lawful, responsible, and sustainable commercial collection of fish species from nearshore habitats (3 nautical miles from shore).

3.2 PREFERRED ALTERNATIVE

The preferred alternative is based on the many years of public involvement, political involvement, and scientific research pertaining to the commercial aquarium fishery. Although this may be the first DEA written for the commercial aquarium fishery, various alternative approaches based on public, government, and scientific input have been implemented and studied since the 1970's (noted throughout this DEA).

Under the Preferred Alternative, the DLNR would begin issuing new Aquarium Permits, thereby allowing commercial aquarium fish collection in the State, including the island of O'ahu, to resume. Permittees would abide by all rules and regulations set forth in HRS-188-31 (Section 1.2.1), governing Commercial Aquarium Permit use. For the island of O'ahu, these rules and regulations include restrictions on equipment, restrictions on access to various areas, bag limits on various collected fish species, and reporting requirements (Section 1.2.3). The Preferred Alternative is based on the best available science, supports the DLNR purpose to ensure Applicant's Actions do not lead to degradation of fish populations and the habitats in which they occur in the context of aquarium collection, and supports the Applicant's purpose and need to continue fishers' livelihoods participating in the lawful, responsible, and sustainable commercial collection of various fish species from nearshore habitats.

4.0 AFFECTED ENVIRONMENT

The affected environment is the area and its resources (i.e., socioeconomic, cultural, physical, biological) potentially impacted by the Applicant's Action and selected Alternative. The purpose of describing the affected environment is to define the current baseline of conditions in which the impacts will occur. To make an informed decision about which alternative to select, it is necessary to first understand which resources will be affected and to what extent each alternative would result in changes from the baseline. This section attempts to provide the baseline for this understanding. Relative to the Applicant's action, the affected environment includes nearshore habitats along the island of O'ahu, from the shoreline out to 3 nautical miles.

Commercial aquarium fish collection has occurred in Hawaiian waters since the late 1940s. In 1953, the territorial government of Hawai'i enacted Act 154, which authorized the Board of Agriculture and Forestry to establish a permit system for the use of fine-mesh nets and traps for the taking of aquarium fish (DAR 2014a). Beginning in 1973, collectors were required to report their monthly catch on a detailed aquarium fish catch report. As of 2014, Aquarium Permit holders are required to keep daily trip reports and submit on a monthly basis. The number of permitted commercial aquarium fishers reporting statewide for the period 2000 to 2017 ranged from 61 - 99 (DAR 2018a); however, the number of commercial aquarium permits issued ranged from 113 – 226 (DAR 2018a). For the island of O'ahu, the number of permitted commercial aquarium fishers reporting catch ranged from 28-52 for the same time-period (DAR 2018a). Permitted commercial aquarium fishing has been a part of the socioeconomic, cultural, physical, and biological resources for decades and is considered a part of the baseline condition of the affected environment.

The DLNR's mission statement is to 'Enhance, protect, conserve and manage Hawai'i's unique and limited natural, cultural, and historic resources held in public trust for current and future generations of the people of Hawai'i nei, and its visitors, in partnership with others from the public and private sectors.' In pursuit of this mission, the DLNR has compiled, analyzed, and reported on the many facets of Hawai'i's socioeconomic, cultural, physical, and biological resources that make up the affected environment. The following sections rely heavily on the DLNR's *Hawai'i's Comprehensive Wildlife Conservation Strategy* (CWCS; Mitchell et al., 2005) and the DLNR's Hawai'i's State Wildlife Action Plan (SWAP; DLNR 2015), with numerous other sources cited as appropriate.

4.1 SOCIOECONOMIC RESOURCES

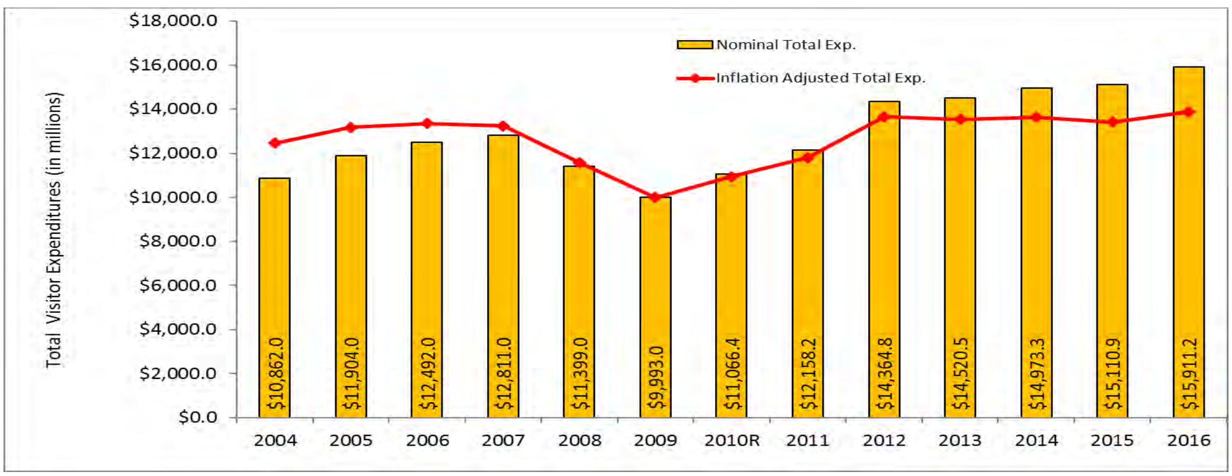
The state of Hawai‘i has four local governments: the City and County of Honolulu (island of O‘ahu and the Northwestern Hawaiian Islands), the County of Kaua‘i (islands of Kaua‘i and Ni‘ihau), the County of Maui (islands of Maui, Moloka‘i, Lāna‘I, and Kaho‘olawe), and the County of Hawai‘i (island of Hawai‘i). Hawai‘i also has a fifth county, Kalawao County, which does not have a separate government unit (Mitchell et al., 2005). Kalawao County covers the former Hansen's disease settlement at Kalaupapa (Moloka‘i) and is managed by the National Park Service (NPS) under a cooperative agreement with the State Department of Health (Mitchell et al. 2005).

The population of the State of Hawai‘i was estimated at 1,427,538 in 2017, with the majority (67%) found on O‘ahu, in the City and County of Honolulu (953,207) (HDBEDT 2017). The nearly nine million visitors in 2017 contributed an additional average of 26,000 people per day, mostly on O‘ahu and Maui (HDBEDT 2017).

Much of the state's economy is based on the island's coastal and marine resources. Tourism accounts for the majority of the state's economy, with a significant portion of the tourist activities associated with beaches and marine wildlife (DLNR 2015). Coastal development and land values have both increased with the growth in tourism. In 2002, the Hawai‘i Coral Reef Initiative funded a study regarding the economic valuation of the coral reefs of Hawai‘i, where the value of coral reefs to the Hawai‘i economy was estimated to be about $380 million dollars per year (DLNR 2015). According to the 2012 National Oceanic and Atmospheric Administration (NOAA) Report on the Ocean and Great Lakes Economy of the

United States, Hawai‘i's ocean economy then accounted for 92,160 jobs and over $2.5 billion in wages. Commercial fish landings in Hawai‘i have increased annually since 2006 and NOAA reported total landings in 2013 were valued near $108 million dollars (DLNR 2015).

Hawai‘i's tourism industry achieved new records in total visitor spending and visitor arrivals in 2016, marking the fifth consecutive year of record growth in both categories. Total spending by visitors to the Hawaiian Islands increased 5.3% to a new high of $15.91 billion (HDBEDT 2017). When adjusted for inflation, total visitor spending was up 3.5% from 2015 (Figure 2). A total of 8,934,277 visitors came by air or by cruise ship to the state, up 2.9% from the previous record of 8,679,564 visitors in 2015. Total visitor days in 2016 rose 2% compared to 2015. The average spending per day by these visitors ($197 per person) was also higher than a year ago ($191 per person; HDBEDT 2017).



Note: Implicit price deflator (2009=100)
Source: 2016 State of Hawai‘i Data Book Table 7.35.

Figure 2. Total Visitor Spending: Nominal & Real 2004 – 2016 (HDBEDT 2017).

Arrivals by airlines in 2016 grew 3% compared to 2015, to 8,821,802 visitors. Additionally, there were 112,475 visitors who came to the islands by cruise ship, but this was down 3.5% from 2015 due to fewer out-of-state cruise ships that visited the islands (HDBEDT 2017).

Total Spending by Category (HDBEDT 2017):

- Lodging, the largest spending category by all visitors to Hawai‘i, increased 6.1% to $6.73 billion and made up 42.3% of total visitor spending in 2016.
- Food and beverage, the second largest category, rose 6.4% to $3.27 billion or 20.6% of total visitor spending.
- Shopping expenses of $2.24 billion was up 1.5% from 2015.
- Spending on transportation (+11.4% to $1.54 billion) and entertainment and recreation (+5.8% to $1.41 billion) also increased from the previous year.

- Supplemental business spending of $118.1 million was a decrease of 11.9% compared to 2015. These are additional business expenses spent locally on conventions and corporate meetings by out-of-state visitors (i.e., costs on space and equipment rentals, transportation, etc.) that were not included in personal spending.

The military has a significant presence in Hawaiʻi with large Naval installations located on estuarine and coastal areas such as Pearl Harbor and Kāneʻohe Bay on Oʻahu and the Pacific Missile Range Facility on the south shore of Kauaʻi (DLNR 2015).

Agriculture has always had a special place in Hawai'i history and continues to be an important industry, generating $2.9 billion to the state's annual economy, and directly and indirectly providing 42,000 jobs (HDA 2013). The plantation era witnessed the boom decades of the sugar and pineapple industries, expanding over thousands of acres of prime agricultural lands. Now, with the decline of the sugar and pineapple industries, these agricultural lands are returning to a new era of small farms growing diversified agricultural products (HDA 2013). Crops such as specialty exotic fruits, coffee, macadamia nuts, flowers and foliage not only provide fresh produce and flowers to Hawai'i's markets, but also have become major exports to destinations around the world. The early fishponds have evolved into high-tech aquaculture ventures, farming from the sea varieties of fish, shrimp, lobster, abalone, and seaweed (HDA 2013).

4.1.1 Socioeconomic Aspects of the Commercial Aquarium Fishery

Early aquarium collectors operated almost exclusively in the nearshore waters along the leeward coast of O'ahu, utilizing rudimentary equipment for collecting (Stevenson et al. 2011). Today, fishers on the island of O'ahu often perform day trips, or operate individually or with a partner, using more advanced equipment such as self-contained underwater breathing apparatus (SCUBA) and synthetic hand nets (nets used to exclude, contain, or direct fish) to capture fish (Stevenson et al. 2011). Most aquarium fishers are between the ages of 30 and 60 years, have remained active in the fishery for more than 20 years, and fish approximately 3–4 days per week (Stevenson et al. 2011). As throughout the state, O'ahu fishers are required to report their monthly catch on an aquarium fish catch report separate from, and more detailed than, the Commercial Marine License (CML). At present, there is no provision for the verification of submitted reports, so any catch numbers and dollar amounts should be regarded as minimum, not absolute values (DAR 2018a).

Since 2000, the commercial aquarium fishery has averaged annual total catch landings (fish and invertebrates) on the island of O'ahu valued at $506,251 (inflation-adjusted 2017 dollars), with a low of $201,210 (inflation-adjusted 2017 dollars) in 2003 and a high of $741,507 (inflation-adjusted 2017 dollars) in 2012 (Table 2; DAR 2018a). The economic value of fish collected has ranged from 67.2% to 91.1% of the total value, with an average of 79.4%, whereas the economic value of invertebrates has ranged from 6.8% to 31.3% of the total value, with an average of 16.7% (Table 2; DAR 2018a).

Table 2. Number of Aquarium Permit holders, reports, total catch (fish and invertebrates), and value by year on the island of O'ahu between 2000 and 2017 (DAR 2018a).

Fiscal Year[1]	Number of Commercial Aquarium Permits	Number of Permits Reporting	Fish Value (% of total)	Invertebrate Value (% of total)	Total Value[2]	Total Value Adjusted for Inflation[3]
2000	68	47	$186,592 (76.8%)	$40,220 (16.6%)	$242,856	$345,696
2001	75	39	$141,314 (69.3%)	$55,567 (27.2%)	$203,984	$282,489
2002	72	28	$117,055 (74.4%)	$32,915 (20.9%)	$157,387	$214,445
2003	66	30	$115,503 (76.5%)	$30,734 (20.3%)	$151,039	$201,210
2004	68	39	$233,937 (68.6%)	$103,608 (30.4%)	$341,049	$442,552
2005	76	39	$241,628 (67.2%)	$112,463 (31.3%)	$359,424	$451,112
2006	102	46	$372,229 (76.4%)	$102,273 (21.0%)	$487,187	$437,014
2007	106	50	$344,658 (71.8%)	$129,251 (26.9%)	$480,341	$567,860
2008	85	52	$445,274 (84.7%)	$73,949 (14.1%)	$525,791	$598,607
2009	100	46	$422,842 (83.3%)	$54,249 (10.7%)	$507,860	$580,257
2010	81	45	$475,564 (86.3%)	$54,463 (9.9%)	$550,940	$619,320
2011	81	39	$516,577 (81.8%)	$70,086 (11.1%)	$631,632	$688,300
2012	84	41	$578,042 (83.2%)	$76,836 (11.1%)	$694,539	$741,507
2013	71	32	$406,585 (80.0%)	$73,652 (14.5%)	$508,251	$534,787
2014	78	32	$488,314 (82.7%)	$63,785 (10.8%)	$590,659	$611,577
2015	93	42	$622,529 (91.1%)	$46,357 (6.8%)	$683,282	$706,641
2016	92	39	$500,152 (88.8%)	$44,865 (8.0%)	$563,418	$575,421
2017	126	41	$448,258 (87.3%)	$46,669 (9.1%)	$513,723	$513,723
Average	**85**	**40**	**$369,836 (79.4%)**	**$67,330 (16.7%)**	**$455,187**	**$506,251**
Total	**NA**	**NA**	**$6,657,053 (81.2%)**	**$1,211,943 (14.8%)**	**$8,193,363**	**$9,112,520**

[1]Fiscal year runs from July 1 through June 30

[2]Total value includes non-disclosure data (Section 5.1) and collection that was not identified to the finfish or invertebrate categories (i.e., unknown or miscellaneous species)

[3] http://www.usinflationcalculator.com/, adjusted for 2017 values

It should be noted that the dollar value of these fisheries represents only the *ex-vessel* value, what the fishers are paid for their catch, and does not include the value which would be generated by additional dealer and retail sales. The actual economic value of the catch is thus substantially greater than the *ex-vessel* values. A study done in 1994 found that the DAR reported total average value for FY 1993/FY 1994 saw only $819,957 (Miyasaka 1994), while analysis in 1993 by an aquarium trade group (Hawai'i Tropical Fish Association) estimated the total sales of Hawaiian aquarium fish (including freight and packaging) to be nearly 5 times this, at $4.9 million (Walsh et al., 2003). Although specific export data do not exist for the aquarium fishery, it is clear that most of the aquarium catch is shipped out of the state to dealers on the mainland United States, Europe, and Asia (Dierking 2002). This is neither surprising nor atypical for commercial fisheries in Hawai'i (DAR 2014a). For example, seafood exports of various Hawaiian species exceed 3.7 million pounds annually (Loke et al. 2012).

From 2000-2017, the total catch value (fish and invertebrates) of the commercial aquarium collection in O'ahu is $9,112,520 (inflation-adjusted 2017 dollars) (Table 2). Of the 304 species collected in O'ahu since 2000, 238 have been fish species and 66 have been invertebrates. Six species (5 fish and 1 invertebrate) compose over 52% of the total economic value of the catch (DAR 2018a):

- Yellow Tang - 15.0%
- Potter's Angelfish - 10.3%
- Feather Duster Worms *(Sabellastarte spectabilis)* - 7.3%
- Bandit Angelfish – 7.3%
- Kole - 6.6%
- Flame Wrasse (*Cirrhilabrus jordani)* - 6.4%

4.2 CULTURAL RESOURCES

Native species in Hawai'i play a significant role in Native Hawaiian culture. Historically, feathers from forest birds were used to make elaborate capes, leis, and helmets for the ali'i (royalty). Whale ivory, shells, and shark's teeth were used for necklaces and other adornments (Mitchell et al. 2005). Fish and sea turtle bones were used as kitchen implements, tools, and fishhooks, while sea turtle shells and scutes were used as containers. Koa (*Acacia koa*) trees were used for the ocean-voyaging canoes (Mitchell et al. 2005). Numerous other examples of the use of native plants and animals in both daily life and ritual exist. In present day Hawai'i, the link between Native Hawaiian culture and native species has not been lost and continues to be practiced in belief systems, as well as in traditional practices such as gathering of native plants for hula, traditional medicines, carving, weaving, and ceremonies (Mitchell et al. 2005).

The belief system of the Native Hawaiians links people with all living and non-living things (Mitchell et al. 2005). Because all components of ecosystems were descended from Wākea (sky father) and Papahanau-moku (earth mother) and their offspring, kini akua (multitude of gods), both living and non-living elements possess spiritual qualities and mana (spiritual power). As such, Native Hawaiians, as kanaka maoli (native people), are guardians of these ecosystems and their well-being is directly related to the well-being of these ecosystems. For example, areas such as wao akua (upland forests) are sacred places, the realm of the gods (Mitchell et al. 2005). Native Hawaiian land ownership and resource management were often based on a unit called the ahupua'a, which typically corresponded with what we today call watershed areas. This understanding of the link from uplands to the ocean was ahead of its time (Mitchell et al. 2005). Kapu (taboo) systems that limited certain classes or sexes from eating certain animals or fishing in certain places or at certain times may have aided in the conservation of some species (e.g., only men were allowed to eat honu (green sea turtle) and only royalty could eat certain fishes) (Mitchell et al. 2005).

Native wildlife also play an important role in Native Hawaiian culture as many species such as the pueo (*Asio flammeus sandwichensis* [Hawaiian short-eared owl]), ʻio (*Buteo solitarius* [Hawaiian hawk]), ʻelepaio (*Chasiempis sandwichensis* [Hawaiian elepaio]), ʻalalā (*Corvus hawaiiensis* [Hawaiian crow]), sea turtles (e.g., *Caretta* spp., *Chelonia* spp., *Dermochelys* spp., *Eretmochelys*, and *Lepidochelys* spp.), and sharks (*Hexanchus* spp.) are believed to be ʻaumakua (ancestors or guardians) of certain Hawaiian families (Mitchell et al., 2005). Hawaiian names have been given to many of the native wildlife and they have been incorporated into oli (chants) and moʻolelo (legends). Today, Native Hawaiian teachings play an increasing role in natural resource management, especially in areas of cultural significance like Kahoʻolawe or Wao Kele o Puna (island of Hawaiʻi). The CWCS recognizes that the State and its agencies are obligated to protect the reasonable exercise of customarily and traditionally exercised rights of Native Hawaiians to the extent feasible, in accordance with Public Access Shoreline Hawai'i versus Hawai'i County Planning Commission and subsequent case law (Mitchell et al., 2005).

4.2.1 Cultural Aspects of the Commercial Aquarium Fishery

From Jokiel et al. (2011):

For the past century Hawaiʻi has been dominated by a "Western" model of marine environmental management. Recently, however, there has been a renewed interest in the traditional management practices of ancient Hawaiians. Throughout Hawaiʻi, a growing cultural, sociological, and scientific movement is working to investigate and revive some of these traditional management tools and to integrate them with modern scientific methodology. The native islanders had devised and implemented every basic form of what are now considered modern marine fisheries conservation measures centuries ago, long before the need for marine conservation was even recognized in Western nations (Johannes 1982). Traditional restrictions on fishing in Hawaiʻi were achieved by the use of closed seasons, closed areas, size restrictions, gear restrictions, and restricted entry. Additional social, cultural, and spiritual controls strengthened the conservation ethic under the old system. Ancient Hawaiians used a holistic approach that we might now recognize and strive for as integrated coastal management. Bridging the gap between traditional management and Western science represents a challenge to researchers, government agencies, resource managers, cultural practitioners and organizations, and to the people of Hawaiʻi.

Commercial aquarium fish collection has been a part of Hawaiian culture since the late 1940's, with most fishers active in the fishery for more than 20 years. Hawai'i is their home and the fish are their livelihood. Protecting and preserving the reef, the fish, and the cultural heritage of both Hawai'i and the fishery, is in their best personal and business interest. Commercial aquarium fish collection is not a part of native Hawaiian culture; however, Native Hawaiians do participate in the fishery and Hawaiian culture has been a significant aspect of the fishery's management since the 1970's. For example, significant review and incorporation of Hawaiian culture was incorporated Act 306 SLH – West Hawai'i Regional Fishery

Management Area. Although Act 306 initiatives do not directly pertain to O’ahu, it does demonstrate the overall management strategy and public involvement with the aquarium fishery in the state.

4.3 PHYSICAL RESOURCES

The Hawaiian archipelago is composed of 8 main islands and approximately 124 smaller islands, reefs, and shoals spanning over 1,500 miles that vary in size from fractions of acres to thousands of square miles (Mitchell et al. 2005). The archipelago was formed over the last 70 million years through volcanic eruptions from a relatively stationary hotspot beneath the slowly moving seafloor. The island of O’ahu was created by two large shield volcanoes (Ko’olau and Wai’anae; Mitchell et al. 2005). O’ahu has a number of large estuaries and bays and one of only two barrier reef complexes in the State. Millions of years of erosion, subsidence, and reef building resulted in the formation of the atolls which form the Northwestern Hawaiian Islands (NWHI) and the submersion under the sea surface of the seamounts which used to be islands (Mitchell et al. 2005).

Located over 2,000 miles from the nearest continent, Hawai‘i is the most remote island chain in the world (Mitchell et al. 2005). Despite its relatively small area (less than 4.1 million acres), an elevation range from sea level to 13,796 feet results in Hawai‘i containing all the major known ecological zones. With a wide temperature range due to the elevational gradient and with average annual rainfall ranging from less than 15 inches to over 480 inches per year, Hawai‘i displays most of the earth’s variation in climatic conditions. Finally, Hawai‘i possesses many natural wonders: the most active volcano in the world, the wettest place on earth, the tallest seacliffs, and extensive coral reefs (Mitchell et al. 2005).

Due to the large number and the varied geology of the islands, Hawai‘i has diverse marine habitats, which range from estuaries, tidepools, sandy beaches, and seagrass beds to nearshore deep waters, extensive fringing and atoll reef systems, and smaller barrier reef systems (DLNR 2015). However, introduced mangroves have altered native coastal habitats in a number of places. The distribution of marine ecosystems in Hawai‘i is a result of island age, reef growth, water depth, exposure to wave action, geography, and latitude. The marine habitats found on each island depend on the type of island: large and young, mature, or drowned islands and seamounts (DLNR 2015). Large and young islands such as the island of Hawai‘i have recent lava flows and few, living structural coral reefs. Beaches are rocky except around bays, and drowned reefs may be found in deep waters or off parts of the east coast of Maui. Mature islands, such as O‘ahu and Kaua‘i in the MHI and Nihoa and Necker in the NWHI are the most diverse, with habitat types ranging from estuaries and sandy beaches to rocky beaches and fringing and barrier reefs to lagoons with patch or pinnacle reefs. Drowned islands, such as atolls in the rest of the NWHI, are the remains of volcanic islands with habitats ranging from coral islets and benches to caves and terraces along the slope of the atoll (DLNR 2015).

4.3.1 Climate

Features of Hawai’i's climate include mild temperatures throughout the year, moderate humidity, persistence of northeasterly trade winds, significant differences in rainfall within short distances, and infrequent severe storms (Price 1983). For most of Hawai’i, there are only two seasons: "summer," between May and October, and "winter," between October and April. Hawai’i’s length of day and temperature are relatively uniform throughout the year. Hawai'i's longest and shortest days are about 13.5 hours and 11 hours, respectively, compared with 14.5 and 10 hours for Southern California and 15.5 hours and 8.5 hours for Maine (Price 1983). Uniform day lengths result in small seasonal variations in incoming solar radiation and, therefore, temperature. On a clear winter day, level ground in Hawai'i receives at least 67%as much solar energy between sunrise and sunset as it does on a clear summer day. By comparison the percentages are only 33 and 20 at latitudes 40 and 50 degrees respectively (Price 1983).

Over the ocean near Hawai'i, rainfall averages between 25 and 30 inches per year. The islands receive as much as 15 times that amount in some places and less than one third of it in others. This is caused mainly by orographic or mountain rains, which form within the moist trade wind air as it moves from the sea over the steep and high terrain of the islands (Price 1983). Over the lower islands, the average rainfall distribution resembles closely the topographic contours. Amounts are greatest over upper slopes and crests and least in the leeward lowlands. On the higher mountains, the belt of maximum rainfall lies between 2,000 to 3,000 feet and amounts decrease rapidly with further elevation. As a result, the highest slopes are relatively dry (Price 1983). Another source of rainfall is the towering cumulus clouds that build up over the mountains and interiors on sunny calm afternoons. Although such convective showers may be intense, they are usually brief and localized. Hawai'i's heaviest rains are come from winter storms between October and April. On O'ahu, the Wai'anae and Ko'olau mountain ranges combine to produce distinctive windward and leeward climates, with average rainfalls exceeding 250 inches per year on the crest of the Ko'olau Range. The leeward coast of the Ko'olau Range receives less than 20 inches per year.

While the effects of terrain on storm rainfall are not as great as on trade wind showers, large differences over small distances do occur, because of topography and location of the rain clouds. Differences vary with each storm. Frequently, the heaviest storm rains do not occur in areas with the greatest average rainfall. Relatively dry areas may receive, within a day or a few hours, totals exceeding half of their average annual rainfall (Price 1983). The leeward and other dry areas obtain their rainfall mainly from a few winter storms. Therefore, their rainfall is usually seasonal and, their summers are dry. In the wetter regions, where rainfall comes from both winter storms and trade wind showers, seasonal differences are much smaller (Price 1983).

At the opposite extreme, drought is not unknown in Hawai'i, although it rarely affects an entire island at one time. Drought may occur when there are either no winter storms or no trade winds (Price 1983). If there are no winter storms, the normally dry leeward areas are hardest hit. A dry winter, followed by a normally dry summer and another dry winter, can have serious effects. The absence of trade winds affects mostly the windward and upland regions, which receive a smaller proportion of their rain from winter storms (Price 1983).

The waters surrounding Hawai'i are affected by seasonal variations in climate and ocean circulation. The surface temperature of the oceans around Hawai'i follow a north-south gradient and range from 75˚F in the MHI to 68˚F to 72˚F in the NWHI in winter and spring to 79˚F to 81˚F throughout all the islands in the late summer and fall (DLNR 2015). The depth of the thermocline, where water temperature reaches 50˚F, is 1,500 feet northwest of the islands and 1,000 feet off the island of O'ahu. Surface currents generally move east to west and increase in strength moving southward (DLNR 2015). The seas are rougher between islands than in the open ocean, because wind and water are funneled through the channels. Waves generated by north Pacific low-pressure systems are larger in the winter months than in the spring and are generally bigger on the northern shores of the islands than the southern shores. Marine organisms have adapted to these general climatological and oceanographic conditions (DLNR 2015).

Climate and oceanographic indicators highlight long-term trends and recent anomalous conditions in Hawaiʻi's natural environment. The El Niño Southern Oscillation (ENSO), an irregular, large-scale climate phenomenon that drives changes in regional oceanic and atmospheric conditions, has shifted over the last four decades towards increased frequency and severity in El Niño conditions, with the recent 2015 El Niño as one of the strongest on record (Gove et al., 2016). Rainfall, which can influence salinity, temperature, sediment load, and nutrient concentrations in the marine environment, has been at or below the long-term average over the past 15 years while the intensity of short-term events has increased over the same time period. Long-term sea level, an important indicator for coastal erosion and flooding, is rising by an estimated 0.15 inch per year and is expected to reach 1.6 feet higher than present day levels by 2100. Sea surface temperature, an indicator of regional and climatic forcing that is highly influential to a myriad of ecological processes, was anomalously warm in recent years and reached a record level of thermal stress in September 2015, resulting in widespread and severe coral reef bleaching in West Hawaiʻi (Gove et al., 2016).

4.3.2 Physical Aspects of the Commercial Aquarium Fishery

O'ahu's tropical fish collectors typically leave from one of four ports of entry: Hawai'i Kai, Sand Island, Waianae, or Haleiwa. Most collectors go out with partners and have boats that range in size between 17 to 26 feet. These boats are equipped with dive gear, scuba tanks, collecting buckets, nets, and containers to hold the fish. Before leaving the harbor, the collector is given instructions by their supplier on which fish to target for that particular day.

Most collectors leave in the morning and travel to their collecting sites, which range from 1-5 miles away. Although divers average 3-4 scuba bottles/day, typically, most collection sites are rotated every dive. Average dives are conducted in the 30-50 foot range, although some rarer fish are collected in the 150 foot range. A typical collector has between 150-250 dive sites on the island from which to choose, depending on surf, wind, and currents.

Collection is done primarily with the use of two hand nets, a fence net, and a collecting bucket, from which the targeted fish are placed upon capture. Most collectors chase the fish into the fence net, where they are corralled long enough so that the collector can use their hand nets to capture the fish. Fence nets range in length between 12-30 feet and are 4-6 feet tall. At the end of the dive, the fish in the collection bucket are brought back to the boat and placed between 20-25 feet on a decompression line hung from the boat. At this level, most fish can be safety decompressed within 30-40 minutes. If a fish cannot be decompressed correctly, they are released. Most experienced collectors can collect 10-40 fish per dive.

Once the dives are completed, the collector returns to the harbor and takes their catch to the wholesaler's facility.

4.4 BIOLOGICAL RESOURCES

Because of Hawai'i's geographical isolation, many of its coastal and marine species are endemic (i.e., native or restricted to a certain country or area). Approximately 15 to 25% of Hawai'i's marine species are endemic to the Hawaiian Archipelago (including Johnston Atoll), one of the largest proportions of marine endemism for any island chain in the world (DLNR 2015). Of the 612 known nearshore fishes in Hawai'i, 25% are endemic to the Hawaiian Archipelago (including Johnston Atoll) (Randall 2007). Yet because of the isolation, Hawai'i has relatively low marine species richness (i.e., diversity), with approximately 580 shallow reef fish species in contrast to areas of the Pacific further west with thousands of species. In total though, Hawai'i still has over 6,000 marine species (DLNR 2015).

4.4.1 Wildlife Species

Marine species in Hawai'i include over 1,200 species of fishes, with around 500 species adapted to live on coral reefs, and the rest adapted to the pelagic open surface waters, mesopelagic or bathypelagic zones (middle or deep waters), estuaries, or sandy bottoms (DLNR 2015). At the top of the food chain are the apex predators such as sharks and large predatory reef and pelagic fishes. Approximately 4,100 marine invertebrates are known from Hawai'i and include over 100 species of hard, soft, and precious corals as well as hundreds of types of snails, crabs, shrimps and small numbers of worms, jellyfish, sponges, starfish, and tunicates (DLNR 2015). Five marine turtles occur in Hawai'i: two are common residents that nest on Hawai'i's beaches and three are more occasional visitors. All sea turtles are listed as threatened or endangered under the federal Endangered Species Act (ESA) of 1973, as amended. Approximately 26 species of marine mammals, mostly cetaceans, are considered resident or occasional visitors to Hawai'i. These include the Humpback Whale or koholā (*Megaptera noveangliae*), False Killer Whale (*Pseudorca crassidens*), Spinner Dolphin (*Stenella longirostris*), and Bottlenose Dolphin (*Tursiops truncatus*). Humpback Whales and Hawaiian Monk Seals (*Monachus schauinslandi*) are common marine mammals in Hawai'i and are listed as endangered under the ESA (DLNR 2015). All marine mammals are protected by the Marine Mammal Protection Act. Many of the resident whales and dolphins feed on fishes and squids that occur in the moderately deep waters off Hawai'i's coasts.

4.4.2 Hawai'i Species of Greatest Conservation Need

Species of Greatest Conservation Need (SGCN) are identified in Hawai'i's State Wildlife Action Plan (SWAP) and are not threatened, endangered, or otherwise legislatively protected species. However, recognizing the need to take action to protect endemic species, the DLNR identified Hawai'i's indigenous SGCN in Exhibit 1 of Hawai'i Administrative Rules Chapter 124. This list includes terrestrial mammals, marine mammals, and marine reptiles only. Additional native species were identified and added based on their presence on the following lists (DLNR 2018):

- The Federal list of threatened, endangered, candidate and concern species;
- Species protected by the U.S. Marine Mammal Protection Act;
- The State list of threatened and endangered species;

- The Checklist of the Birds of Hawai'i; and
- Species identified as present in Hawai'i by groups or organizations with significant experience or expertise (e.g., Audubon Watch List; national and regional Bird Plans, such as the U.S. Shorebird Conservation Plan, Waterbird Conservation for the Americas; Regional Seabird Conservation Plan).

For any terrestrial indigenous species not represented by any of the lists, their status as indigenous automatically included them as Hawai'i's SGCN. For aquatic fishes and invertebrates only endemic species were added to the list (DLNR 2018). In addition, the DAR also included native species on the International Union for the Conservation of Nature and Natural Resources' (IUCN) Threatened Red List, and the Convention on International Trade in Endangered Species (CITES) list. A Statewide Aquatic Wildlife Conservation Strategy (SAWCS) Advisory Council was developed to advise on additional species that were at risk due to specific threats. The SAWCS Advisory Council is a panel with representatives from federal and state agencies, resource user groups, and non-profit organizations that helps the DAR develop its CWCS (DLNR 2018).

Additional species considered must meet one or more of the following biological criteria (DLNR 2018):

- Species with low or declining populations;
- Species indicative of the diversity and health of the state's wildlife;
- Species with small, localized "at-risk" populations;
- Keystone species;
- Indicator species;
- Species with limited dispersal;
- Disjunct species;
- Vulnerable species;
- Species of conservation concern;
- "Responsibility" species, (i.e., species that have their center of range within a state); and,
- Species with fragmented or isolated populations.

Currently nearly 25% of fish, 20% of mollusks, 18% of algae, and 20% of the corals are considered endemic to Hawai'i and listed as SGCN species (Randall 2007, DLNR 2015).

Three SGCN fish species have been reported as being collected by commercial aquarium collectors on O'ahu:

1. Psychedelic Wrasse (*Anampses chrysocephalus*)
2. Fisher's Angelfish (*Centropyge fisheri*)
3. Tinker's Butterflyfish (*Chaetodon tinkeri*)

The SWAP (2015) addresses these species and identifies the following actions to ensure the species conservation and sustainability:

1. Conservation Actions: The goals of conservation actions are to not only protect current populations, but to also establish further populations to reduce the risk of extinction. Commercial

licenses are required for aquarium collectors. In addition to common statewide and island conservation actions, specific actions include:

- Restoration of habitat; and,
- Maintaining healthy populations with appropriate fishing regulations and education.

2. Monitoring:

   - Continue to survey for populations and distribution in known and likely habitats.

3. Research Priorities:

   - Improve understanding of factors affecting the species population size and distribution; and,
   - Support aquaculture research to develop captive breeding for species used in the aquarium trade.

4.4.3 Aquarium Fish

4.4.3.1 Coral Reef Ecosystems Program (CREP) Surveys

The NOAA has been involved in a large-scale monitoring program that surveys coral reef fish assemblages and habitats, encompassing the bulk of the US-affiliated tropical Pacific. This effort, known as the Coral Reef Ecosystem Program (CREP), has included over 5,500 surveys around 39 islands, including the island of O’ahu. The dataset was developed as a resource that could be used to understand how human, environmental, and oceanographic conditions influence coral reef fish community structure, providing a basis for research to support effective management outcomes (CREP 2018).

In 2010, the Pacific Reef Assessment and Monitoring Program (RAMP) developed and implemented a standardized survey methodology focusing on reef fish and paired benthic habitat-monitoring using monitoring methods specified in the National Coral Reef Monitoring Plan (NCRMP). The aim of the current systematic sampling design is to maximize survey site replication, while the overarching goal was to generate data representative of coral reef hard-bottom substrate at the islands-scale (Heenan et. al 2017).

Surveys were conducted on the island of O’ahu in 2010, 2012–2013, and 2015–2016. Surveys were conducted at 228 stationary point count locations with a randomized depth-stratified design, at depths 0-98 feet (Figure 3). At each point count location divers conducted fish counts, estimated benthic cover, and habitat structural complexity. Typically, 3–5 days were spent at each island during each visit (generally once every 3 years), conducting 30–50 fish surveys during that time. Detailed explanations of the study sites and survey methods are found in Heenan et al. 2017. For each point count, a pair of divers conducted simultaneous counts in adjacent, visually estimated 49.2-foot cylindrical plots extending from the substrate to the limits of vertical visibility (Heenan et al. 2017).

Each fish count consists of two parts, a 5-minute species enumeration in which divers generates a list of taxa observed within their cylinder to species when possible; and, a tally portion in which divers systematically work through their species list recording the number and estimated size of fish present within the cylinder. Tallying is done by conducting a series of rapid visual sweeps of the plot with one species-group (e.g., mid-water, surgeonfish, benthic butterflyfish) counted per sweep. At the end of the sweeps, divers carefully search for small, site-attached, and semi-cryptic species. Surveys were not conducted if horizontal visibility was <25 feet (Heenan et al. 2017).

The estimated population size for the island of O'ahu was calculated for each species using CREP data by averaging the mean abundance per 100 square meters for all point count locations, converting to mean abundance per square meter, multiplying by the estimated area of hardbottom habitat available <30m (98 feet) (16,840 ha; CREP 2018), and multiplying by square meters per hectare (i.e. population size = mean survey density * area of habitat).

Due to the large spatial coverage and range of depths surveyed by the CREP, CREP data were considered to be the best estimator of island-wide fish population size, and therefore serve as the primary basis for the impact analysis found in Section 5. Estimated population size for each of the top 20 collected species on the island of O'ahu is included in the brief overview of each species in the following sections and is summarized in Table 4 in Section 4.4.4.

Although CREP data are the most comprehensive data publicly available for the island of O'ahu, certain limitations of the surveys may lead to an underestimate of some populations of aquarium fish. Specifically, surveys are concentrated into a short period of survey effort (about one month each year) located in different locations from one year to the next, allowing for a larger coverage of the entire island, but over five years during a seven-year period. Also, population estimates may be an underestimate for certain species as surveys were only conducted at depths <98 feet, in areas of hardbottom habitat. No data were collected from soft-bottom habitat, as these tend to not be important habitats for most aquarium species, but certain species may utilize these areas, and therefore are not represented in the population estimate. No data were collected from depths greater than 98 feet, but certain species may utilize these areas as well, and are therefore not represented in the population estimate. In addition, divers are trained in the identification of aquarium fish; however, certain species may be cryptic, skittish, or difficult to identify in the field, which may lead to underestimates of the population of those species.

4.4.4 Top 20 Collected Aquarium Fish Species

Since 2000, approximately 238 fish species have been collected under Aquarium Permits in O'ahu waters; however, some of these included those species reported as a general group (e.g., squirrelfishes, soldierfishes, damselfishes) (DAR 2018a). Only 161 species were reported by enough permits (>2 permits reporting from each collection area (Figure 1) during each year of collection) to determine total number of individuals collected (Table 3). Collection areas with less than three permits reporting fall under the DAR confidentiality statute, in which totals are not released publicly (Section 5.1).

A total of 1,295,700 individual fish have been collected from O'ahu under Aquarium Permits since 2000. The total number of aquarium fish collected in O'ahu since 2000 has ranged from 35,811 in 2003 to 100,662 in 2012, averaging 71,983 annually for the period (Table 3; DAR 2018a).

The top 20 fish species collected in O'ahu from 2000-2017 made up 80.0% (1,035,272 fish) of the total number of fish collected (Table 4; DAR 2018a). The top three collected species (Yellow Tang [273,356], Kole [175,425], and Potter's Angelfish [138,669]) from O'ahu make up 45.3% of the overall fish collection total. No other individual species had more than 60,000 individuals collected during that time. Approximately 75% of the top 20 collected species on O'ahu from 2000-2017 were collected in numbers below 30,000 individuals (DAR 2018a). Two SGCN species, the Psychedelic Wrasse and Fisher's Angelfish, made up 2.4% (30,036 individuals) of the total fish catch since 2000.

Table 3. Total number of fish collected under Aquarium Permits from 2000-2017 on the island of O'ahu (DAR 2018a).

Fiscal Year[1]	Number of Permits Reporting	Number Individuals Kept
2000	47	66,896
2001	39	43,687
2002	28	37,470
2003	30	35,811
2004	39	73,911
2005	39	70,073
2006	46	99,143
2007	50	81,959
2008	52	76,304
2009	46	75,902
2010	45	81,464
2011	39	81,173
2012	41	100,662
2013	32	65,751
2014	32	77,016
2015	42	91,196
2016	39	71,223
2017	41	66,059
Average	**40**	**71,983**
Total	**1,524**	**1,295,700**

[1]Fiscal year runs from July 1 through June 30

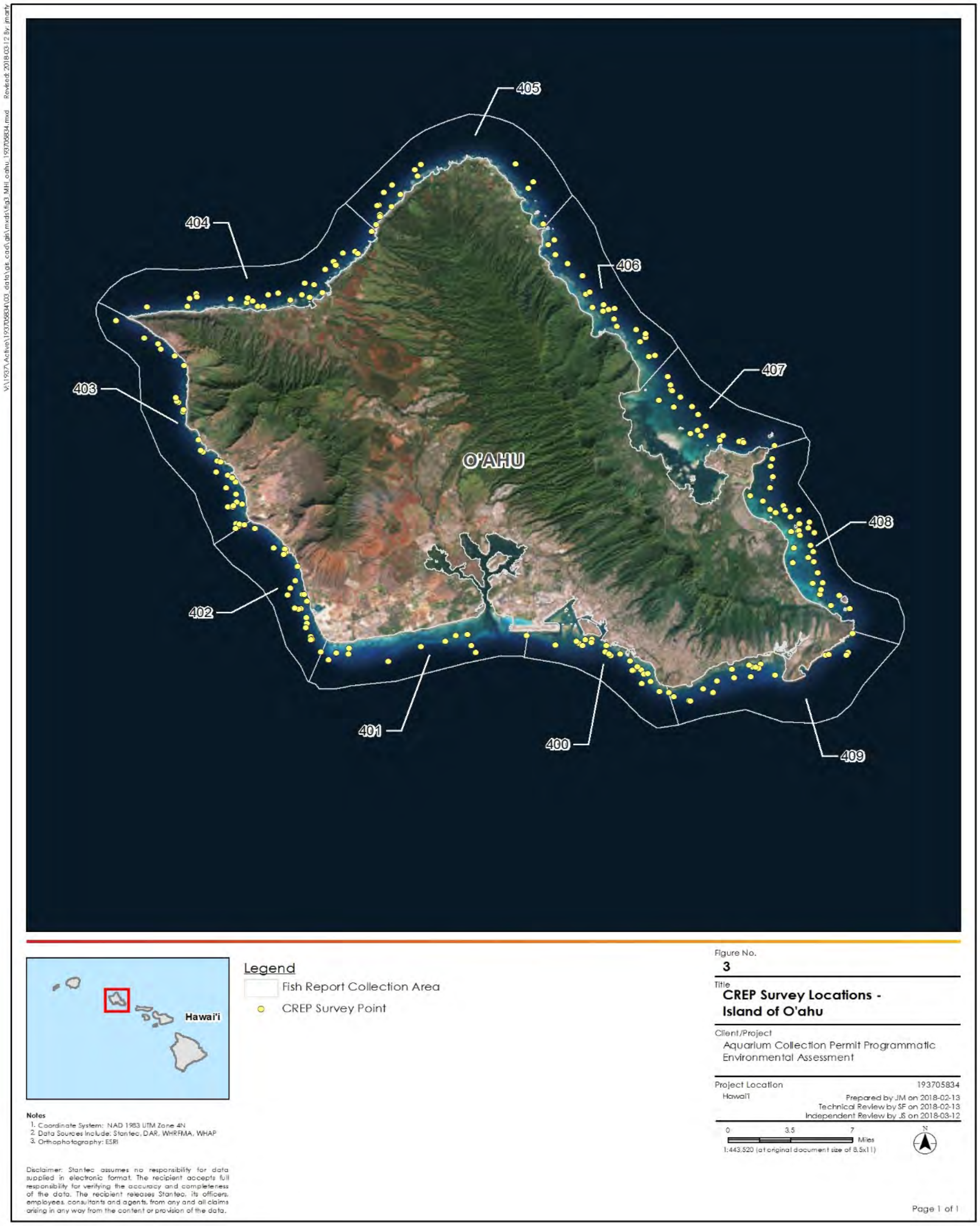


Figure 3. CREP survey locations - Island of O’ahu.

Table 4. Top 20 fish species collected under Aquarium Permits on the island of O'ahu from 2000-2017 (DAR 2018a).

Common Name	Scientific Name	Number Collected	Percentage of Total Collected[1]	Average # Collected per Year
Yellow Tang[2]	*Zebrasoma flavescens*	273,356	21.1%	15,186
Kole (= Goldring Surgeonfish, Yelloweye)[2]	*Ctenochaetus strigosus*	175,425	13.5%	9,746
Potter's Angelfish[2]	*Centropyge potteri*	138,669	10.7%	7,704
Orangespine Unicornfish (= Clown Tang)[2]	*Naso lituratus*	59,133	4.6%	3,285
Ornate Wrasse (= Pinkface)	*Halichoeres ornatissimus*	46,113	3.6%	2,562
Flame Wrasse	*Cirrhilabrus jordani*	28,894	2.2%	1,605
Fourline Wrasse	*Pseudocheilinus tetrataenia*	28,882	2.2%	1,604
Hawaiian Whitespotted Toby (= Puffer)	*Canthigaster jactator*	28,619	2.2%	1,590
Forcepsfish	*Forcipiger flavissimus*	28,502	2.2%	1,583
Milletseed Butterflyfish (= Lemon)	*Chaetodon miliaris*	25,293	2.0%	1,405
Shortnose Wrasse (= Geoffroy's)	*Macropharyngodon geoffroy*	24,381	1.9%	1,355
Bicolor Anthias	*Pseudanthias bicolor*	24,188	1.9%	1,343
Orangeband Surgeonfish (= Orange shoulder)	*Acanthurus olivaceus*	24,175	1.9%	1,343
Moorish Idol[2]	*Zanclus cornutus*	23,449	1.8%	1,303
Multiband Butterflyfish (= Pebbled)	*Chaetodon multicinctus*	18,118	1.4%	1,006
Psychedelic Wrasse (= Redtail)[3]	*Anampses chrysocephalus*	16,426	1.3%	913
Eightline Wrasse	*Pseudocheilinus octotaenia*	16,053	1.2%	892
Crowned Puffer (= Saddleback Puffer)	*Canthigaster coronata*	14,558	1.1%	809
Saddle Wrasse	*Thalassoma duperrey*	14,470	1.1%	804
Fisher's Angelfish[3]	*Centropyge fisheri*	13,610	1.1%	756
Total		**1,035,272**	**80.0%**	**2,615**

[1]Percentage calculated based on total individuals reported collected in O'ahu and do not include any non-disclosure data.
[2] Regulated species (e.g., bag and/or size limits) on the island of O'ahu.
[3]Hawai'i SGCN.

The following sections provide a brief overview of the ecology of the top 20 collected fish species in O'ahu since 2000.

4.4.4.1 Yellow Tang (*Zebrasoma flavescens*)

The Yellow Tang is one of the most popular aquarium species, growing to 8 inches, oval in shape and laterally compressed, with a small mouth and eyes set high on the head. Adults are bright yellow and have modified scales along the base of the tail which can be exposed when the fish flexes its tail. These modified scales or spines are used for defense from predators and competition for feeding areas. At night, the yellow color darkens, and a white band appears along the lateral line (University of Hawai'i 2016).

The Yellow Tang is the only solid yellow fish common throughout Hawai'i. This species is found in subtropical waters and is rare on the western extremes of its range. Flexible comb-like teeth are used to pick algae and seaweed that grow along the reefs. Young Yellow Tang are associated with finger coral (*Porites compressa*) which is abundant in the coastal waters of the island of Hawai'i, but less so on O'ahu (Dr. Bruce Carlson, pers. comm.). They spend a large amount of time feeding and aggressively protect prime feeding territories (University of Hawai'i 2016). Yellow Tang are found from shallow surge zones to a depth of 130 feet. They occur in the Pacific Ocean: Ryukyu, Mariana, Marshall, Marcus, Wake, and Hawaiian Islands. (fishbase.org 2018).

Yellow Tang are broadcast spawners. Many broadcast spawners migrate to the edge of the reef drop off to spawn at dusk or dawn (Thresher 1984). Males and females simultaneously release eggs and sperm into the water column where the eggs are fertilized before floating to the surface until they hatch 20-30 hours later (Thresher 1984).

CREP (2018) data indicate that the island of O'ahu population of Yellow Tang at the 0-98 foot depth is approximately 216,524 individuals.

4.4.4.2 Kole (Goldring Surgeonfish, Yelloweye) (*Ctenochaetus strigosus*)

The Kole is endemic to the Hawaiian Islands (Randall and Clements 2001) and Johnston Atoll (Lobel 2003). It is brown with light blue to yellow horizontal stripes over its body which change into spots towards the face. It also has a yellow ring surrounding the eye.

Individuals are usually solitary and mainly found in shallow water, although it has been recorded at depths of 370 feet. This species is herbivorous, grazing on diatoms and algae from the sand or reef (Randall and Clements 2001), and has also been commonly observed to clean algal growths from the shells of sea turtles (Work and Aeby 2014).

Kole are broadcast spawners. Many broadcast spawners migrate to the edge of the reef drop off to spawn at dusk or dawn (Thresher 1984). Males and females simultaneously release eggs and sperm into the water column where the eggs are fertilized before floating to the surface until they hatch 20-30 hours later (Thresher 1984).

CREP (2018) data indicate that the island of Oa'hu population of Kole at the 0-98 foot depth is approximately 1,144,130 individuals.

4.4.4.3 Potter's Angelfish (*Centropyge potteri*)

The bright orange and blue Potter's Angelfish is an endemic species found along Hawaiian reefs and Johnston Atoll (Lobel 2003). Like other angelfishes, this species is recognized by a heavy, curved spine on its "cheek" near the edge of the gill cover. However, because it generally only reaches approximately 5 inches, it is considered a 'pygmy' angelfish. Its slender, disc-shaped body is well-suited to life on a coral reef.

Individuals limit their movements to a well-defined area close to the shelter of finger coral branches, usually at depths of at least 15 feet. Active by day, it feeds on algae and detritus on dead coral surfaces. At night, it remains alert but inactive, protected within the coral. Angelfishes are very dependent upon the protection of coral caves and crevices, and are rarely seen over sandy stretches or other areas that offer little cover. They are often territorial and spend most of their time near the bottom in search of food. They have small mouths and many flexible, comb-like teeth used for plucking or scraping food from the rocks (University of Hawai'i 2016).

Potter's Angelfish are broadcast spawners, with males and females simultaneously releasing eggs and sperm into the water column where the eggs are fertilized before floating to the surface until they hatch 20-30 hours later (Thresher 1984).

CREP (2018) data indicate that the island of O'ahu population of Potter's Angelfish at the 0-98 foot depth is approximately 297,372 individuals.

4.4.4.4 Orangespine Unicornfish (Clown Tang) (*Naso lituratus*)

The Orangespine Unicornfish has a black dorsal fin, with the black continuing onto the back as a pointed projection, with a pale blue line at base. The anal fin is mainly orange while the caudal fin is yellow. The caudal peduncle bears two forward-directed spines (Randall and Clements 2001). Orangespine Unicornfish are found at depths of 16 to 100 feet along coral, rock, and rubble of seaward reefs. They feed mostly on leafy brown algae and sometimes in groups (Randall and Clements 2001). Distinct pairs are formed during breeding.

The species is found throughout the Indo-Pacific from the Red Sea (except the Gulf of Oman and Persian Gulf) south to Natal and east to Hawai'i and French Polynesia. In the western Pacific from Suruga Bay to the southern Great Barrier Reef (Randall and Clements 2001).

Orangespine Unicornfish are broadcast spawners. Many broadcast spawners migrate to the edge of the reef drop off to spawn at dusk or dawn (Thresher 1984). Males and females simultaneously release eggs and sperm into the water column where the eggs are fertilized before floating to the surface until they hatch 20-30 hours later (Thresher 1984).

CREP (2018) data indicate that the island of O'ahu population of Orangespine Unicornfish at the 0-98 foot depth is approximately 950,505 individuals.

4.4.4.5 Ornate Wrasse (Pinkface) (*Halichoeres ornatissimus*)

This small wrasse has a pinkish head that is marked with horizontal green lines. The throat and belly are blue; scales on the sides are marked by a vertical, crescent-shaped stripe followed by blue. The dorsal fin is dark red with green spots and is traced by green and blue lines. A large dark spot on the dorsal fin and one just behind the eye are common identifiers. Males usually have more intense coloration than females (University of Hawai'i 2016).

The Ornate Wrasse has an elongate soft body that is tapered and spindle-shaped. The dorsal fin is continuous, rounded, and soft. The pectoral fins are used extensively for swimming with up and down motions. The snout has a pointed mouth, fleshy lips, and canine teeth used in plucking small crustaceans and mollusks from the reef. Special bones in the gill area called pharyngeal bones help the wrasse crush the shells of their prey. The Ornate Wrasse is diurnal, feeding during the day, and sheltering in reef crevices or burying in sand patches at night. The Ornate Wrasse, like others within this family (Labridae) undergo sex changes as they develop (University of Hawai'i 2016).

Ornate Wrasse are broadcast spawners, with males and females simultaneously releasing eggs and sperm into the water column where the eggs are fertilized before floating to the surface until they hatch 20-30 hours later (Thresher 1984).

CREP (2018) data indicate that the island of O'ahu population of Ornate Wrasse at the 0-98 foot depth is approximately 668,852 individuals.

4.4.4.6 Flame Wrasse (*Cirrhilabrus jordani*)

The Flame Wrasse is endemic to the Hawaiian Islands and Johnston Atoll (Lobel 2003, Lieske and Myers 1994). Females are bright red on the dorsal part of the body fading to a light pink on the ventral side. The fins are opaque with some yellow features on the face. Females grow to about 3 inches before they begin to transform into a male. As the male matures the dorsal remains bright red fading into a vibrant yellow orange.

The Flame Wrasse utilizes seaward reefs and forms groups above large drop-offs at a depth of 15 to 600 feet, where it feeds exclusively on zooplankton along the ocean floor (Lieske and Myers 1994). During breeding males and females form pairs for mating (Breder and Rosen 1966).

Flame Wrasse are broadcast spawners, with males and females simultaneously releasing eggs and sperm into the water column where the eggs are fertilized before floating to the surface until they hatch 20-30 hours later (Thresher 1984).

CREP (2018) data indicate that the island of O'ahu population of Flame Wrasse at the 0-98 foot depth is approximately 5,683 individuals. However, this is a low estimate because most of the Flame Wrasse population occurs below the 98-foot depth surveyed by the CREP and is not observable by the methods of the survey.

4.4.4.7 Fourlined Wrasse (*Pseudocheilinus tetrataenia*)

The Fourlined Wrasse is found in the tropical waters of the north and south Pacific. This species has a green body with blue and purple fins and four horizontal stripes that run across the upper half of the body. Each stripe is made up of three smaller stripes: one black, one blue and one red stripe. The eye is red with two white lines on it.

This species is secretive and inhabits seaward reefs, among coral or rubble at depths of 20 to 144 feet. This species uses the small heads of live coral to hide from predators (Myers 1991) and is thought to mainly feed on demersal eggs, copepods, amphipods, alpheid shrimp, crabs, larval shrimp, and gastropods (Myers 1999). The Fourlined Wrasse forms distinct pairing during breeding (Breder and Rosen 1966).

Fourlined Wrasse are broadcast spawners, with males and females simultaneously releasing eggs and sperm into the water column where the eggs are fertilized before floating to the surface until they hatch 20-30 hours later (Thresher 1984).

CREP (2018) data indicate that the island of O’ahu population of Fourlined Wrasse at the 0-98 foot depth is approximately 177,710 individuals, but due to its secretive behavior, visual counts usually underestimate its numbers.

4.4.4.8 Hawai’i Whitespotted Toby (Puffer) (*Canthigaster jactator*)

The Hawaiian Whitespotted Toby is endemic to Hawai’i and Johnston Atoll (Lobel 2003). This species belongs to the pufferfish family (Tetraodontidae) and reaches lengths of 4 inches. The body is brown with white spots, the eye is green.

Hawaiian Whitespotted Toby are common in lagoon and seaward reefs at depth of 3 to 290 feet (Mundy 2005). This species has also been found to utilize man-made structures (Brock 1981) and has been shown to feed on sponges, algae, detritus, tunicates, polychaetas, bryozoans, sea urchins, brittle stars, crabs, peanut worms, shrimps, zoanthids, fishes, amphipods, and foraminiferans (Randall 1985). It often is afflicted with parasitic worms (nematodes) and causing it to become inflated (Deardorff and Stanton 1983),

Breeding behavior has not been documented for the Hawaiian Whitespotted Toby; however, the Eastern Pacific Whitespotted Toby (*Canthigaster punctatissima*) has been found to be sexually dimorphic. It is likely that the toby’s breeding behavior is similar. Males and females guard their territories against others of the same sex. Male areas include the smaller territories of multiple females. Males mate with a female from their harem one at a time.

CREP (2018) data indicate that the island of O’ahu population of Hawaiian Whitespotted Toby at the 0-98 foot depth is approximately 1,888,605 individuals.

4.4.4.9 Forcepsfish (*Forcipiger flavissimus*)

The Forcepsfish has a long black snout, and the head is dark brown to black above and white below. The body is yellow with a black spot on the anal fin. Adults can grow up to 8 inches. This species is widespread throughout the Hawaiian Islands and the tropical waters of the Indo-Pacific area (University of Hawai'i 2016).

The Forcepsfish typically lives along exposed outer reefs containing abundant coral growth, caves, and ledges, and occasionally within lagoon reefs. They are usually found in pairs, but may also be encountered as solitary animals or in small groups. It feeds on a variety of small animals including hydroids, fish eggs, and crustaceans, but prefers tube feet of echinoderms, pedicilaria of sea urchins, and polychaete tentacles (Myers 1991).

Forcepsfish are broadcast spawners. Many broadcast spawners migrate to the edge of the reef drop off to spawn at dusk or dawn (Thresher 1984). Males and females simultaneously release eggs and sperm into the water column where the eggs are fertilized before floating to the surface until they hatch 20-30 hours later (Thresher 1984).

CREP (2018) data indicate that the island of O'ahu population of Forcepsfish is at the 0-98 foot depth approximately 192,505 individuals.

4.4.4.10 Milletseed (Lemon) Butterflyfish (*Chaetodon miliaris*)

The Milletseed Butterfly fish is endemic to Hawai'i and the most common species of butterflyfish in Hawai'i including Johnston Atoll (Lobel 2003). The species is named for the seed-sized black specks that are distributed in vertical rows on its lemon-yellow body. Other distinctive features are a black mask through the eye and a black spot near the tail. Adults reach lengths of 6.5 inches (University of Hawai'i 2016).

Habitat for this species includes coastal fringing reefs, lagoons, and outer reefs, with juveniles found on shallow inner reefs from April to June (IUCN 2017). The Milletseed Butterflyfish feeds primarily on zooplankton above the reef, but sometimes cleans other fishes and is also known to feed on nests of damselfish eggs if left unprotected.

Milletseed Butterflyfish are broadcast spawners. Many broadcast spawners migrate to the edge of the reef drop off to spawn at dusk or dawn (Thresher 1984). Males and females simultaneously release eggs and sperm into the water column where the eggs are fertilized before floating to the surface until they hatch 20-30 hours later (Thresher 1984).

CREP (2018) data indicate that the island of O'ahu population of Milletseed Butterfly fish at the 0-98 foot depth is approximately 603,563 individuals. However, much of the milletseed butterflyfish population occurs below the 98-foot depth surveyed by the CREP, and therefore the population is underestimated by the survey.

4.4.4.11 Shortnose (Geoffroy's) Wrasse (*Macropharyngodon geoffroy*)

The Shortnose Wrasse is endemic throughout the Hawaiian Islands and Johnston Atoll (Lobel 2003) and is found at depths between 20 and 100 feet. It has dark blue spots on a yellow to orange background. Research suggests that the Shortnose Wrasse is common throughout its range (Craig 2010). This species inhabits mixed sand, rubble patches, and coral reefs where it feeds on mollusks (Lieske and Myers 1994). Distinct pairs are formed during breeding (Breder and Rosen 1966).

Shortnose Wrasse are broadcast spawners, with males and females simultaneously releasing eggs and sperm into the water column where the eggs are fertilized before floating to the surface until they hatch 20-30 hours later (Thresher 1984).

CREP (2018) data indicate that the island of O'ahu population of Shortnose Wrasse at the 0-98 foot depth is approximately 746,227 individuals.

4.4.4.12 Bicolor Anthias (*Pseudanthias bicolor*)

The Bicolor Anthias is a small (5 inch) Indo-Pacific Ocean fish found from Maldives to the Hawaiian Islands and south to northeastern Australia, typically at water depths between 30–210 feet. The upper half is a yellow orange color while the lower half is a lavender pink. They typically inhabit lagoon patch reef slopes and can be found in deep coastal to outer reef slopes in current prone areas. Small groups are found above coral outcrops or near crevices or ledges (Mundy 2005).

Bicolor Anthias are broadcast spawners, with males and females simultaneously releasing eggs and sperm into the water column where the eggs are fertilized before floating to the surface until they hatch 20-30 hours later (Thresher 1984).

CREP (2018) data indicate that the island of O'ahu population of Bicolor Anthias at the 0-98 foot depth is approximately 300,208 individuals.

4.4.4.13 Orangeband (Shoulder) Surgeonfish (*Acanthurus olivaceus*)

The Orangeband Surgeonfish occurs in tropic waters of the Indo-west Pacific. The head and anterior half of the Orangeband Surgeonfish are distinctly paler than that of the dark grayish brown posterior. Juveniles are bright yellow. Orangeband Surgeonfish are commonly found in small groups near reefs at depths of 30 to 150 feet (Randall and Clements 2001) where they feed on detritus, diatoms, and algae (Myers 1991).

Orangeband Surgeonfish are broadcast spawners. Many broadcast spawners migrate to the edge of the reef drop off to spawn at dusk or dawn (Thresher 1984). Males and females simultaneously release eggs and sperm into the water column where the eggs are fertilized before floating to the surface until they hatch 20-30 hours later (Thresher 1984).

CREP (2018) data indicate that the island of O'ahu population of Orangeband Surgeonfish at the 0-98 foot depth is approximately 1,380,451 individuals.

4.4.4.14 Moorish Idol (*Zanclus cornutus*)

The Moorish Idol is a small (8 inch) fish that are vertically flattened, with black, yellow, and white vertical stripes, and a very long white sickle-shaped extension off the dorsal fin. It has a protruding, tubular snout with a yellow saddle across the top, and long, bristle-like teeth.

It has a long pelagic larval stage, which is the dispersal mechanism used in the widely-found species. They are found throughout the tropical pacific, from the coast of East Africa and the Indian Ocean to Mexico and the Galapagos Island. It inhabits mostly reefs in shallow waters where it feed on corals, sponges, and other small invertebrates. They mate for life, found individually, in pairs, or sometimes groups of up to 100, especially as juveniles (Randall 2005).

CREP (2018) data indicate that the island of O'ahu population of Moorish Idol at the 0-98 foot depth is approximately 285,667 individuals.

4.4.4.15 Multiband (Pebbled) Butterflyfish (*Chaetodon multicinctus*)

The Multiband Butterflyfish is endemic to the Hawaiian Islands and Johnston Atoll (Lobel 2003). The body is white with five or six brown vertical bands. A dark vertical bar runs along the eye and a black band along the tail fin. The distinguishing feature is an overall covering of small spots which create a pattern of horizontal and vertical lines along the body.

The Multiband Butterflyfish inhabits heavy coral areas of lagoon and seaward reefs at depths of 15 to 100 feet. This species mainly feeds on the polyps of small corals but also supplement their diet with worms, shrimps, hydroids, and algae fragments. This species is often seen in monogamous pairs and defending an established territory (Breder and Rosen 1966).

Multiband Butterflyfish are broadcast spawners. Many broadcast spawners migrate to the edge of the reef drop off to spawn at dusk or dawn (Thresher 1984). Males and females simultaneously release eggs and sperm into the water column where the eggs are fertilized before floating to the surface until they hatch 20-30 hours later (Thresher 1984).

CREP (2018) data indicate that the island of O'ahu population of Multiband Butterflyfish at the 0-98 foot depth is approximately 806,937 individuals.

4.4.4.16 Psychedelic Wrasse (Redtail Wrasse) (*Anampses chrysocephalus*)

The Psychedelic Wrasse is endemic to the Hawaiian Islands and is found among seaweed coral reefs at depths from 40 to 450 feet (Lieske and Myers 1994). This species is dark brown with white spots and a red tail. However, like others in the wrasse family, as the females mature they undergo a color and sexual transition to the "terminal phase" male. These males have a bright orange head covered in blue spots and radiating lines. Psychedelic Wrasse terminal phase males are usually only found in depths greater than 50 feet (DLNR 2015). The main prey for the Psychedelic Wrasse are macro-invertebrates found among the rocks and corals it inhabits. Females usually form small groups with a single male (Lieske and Myers 1994).

Psychedelic Wrasse are broadcast spawners, with males and females simultaneously releasing eggs and sperm into the water column where the eggs are fertilized before floating to the surface until they hatch 20-30 hours later (Thresher 1984).

CREP (2018) data indicate that the island of O’ahu population of Psychedelic Wrasse at the 0-98 foot depth is approximately 146,521 individuals. However, the Psychedelic Wrasse occupies habitat below the 98 foot depth surveyed by the CREP study. As such, this is likely a low estimate, because much of the population is not observable by the methods of the study.

The Psychedelic Wrasse is a DLNR SGCN (Section 4.4.3), but is considered a species of ‘Least Concern’ by the IUCN (2017).

4.4.4.17 Eightline Wrasse (*Pseudocheilinus octotaenia*)

The Eightline Wrasse is widespread from east Africa to the Hawaiian Islands. This species has variable color patterns from yellowish/orange to a pink/reddish body. The distinguishing feature of this species are the eight horizontal stripes, ranging from orange to a maroon red. They have a pointed head and mouth which enable them to feed on coral reef invertebrates such as, mollusks, sea urchins, fish eggs, and crab larvae (Myers 1991, 1999).

The Eightline Wrasse inhabits corals and seaward reefs at depths of 6 to 164 feet (Myers 1991), and forms distinct mating pairs (Breder and Rosen 1966). This species is diurnal, feeding during the day and resting at night.

Eightline Wrasse are broadcast spawners, with males and females simultaneously releasing eggs and sperm into the water column where the eggs are fertilized before floating to the surface until they hatch 20-30 hours later (Thresher 1984).

CREP (2018) data indicate that the island of O’ahu population of Eightline Wrasse at the 0-98 foot depth is approximately 206,014 individuals.

4.4.4.18 Crowned (Saddleback) Puffer (*Canthigaster coronata*)

The Crowned Puffer is a small marine fish approximately 3–5 inches in length. It is light blue ventrally, and the darker dorsal portion is divided by light blue stripes. The head and body have many small pale spots, faint or absent on paler portions of the body, but very evident within the dark saddle like bars on the dorsal portion of the body (University of Hawai’i 2016).

It is endemic to Hawai’i including the Midway Islands and Johnston Atoll, inhabiting coral reefs about 15 to 450 feet deep, but mainly in depths below 70 feet. It is mostly found on sand or sand and rubble bottom or algal flats (University of Hawai’i 2016).

Crowned Puffers are broadcast spawners, with males and females simultaneously releasing eggs and sperm into the water column where the eggs are fertilized before floating to the surface until they hatch 20-30 hours later (Thresher 1984).

CREP (2018) data indicate that the island of O'ahu population of Crowned Puffer at the 0-98 foot depth is approximately 285,677 individuals. However, this is a low estimate because most of the Crowned Puffer population occurs below the 98-foot depth surveyed by the CREP and is not observable by the methods of the survey.

4.4.4.19 Saddle Wrasse (*Thalassoma duperrey*)

The Saddle Wrasse is a common and endemic reef fish of Hawai'i and Johnston Atoll (Lobel 2003). It is found at depths ranging from 16 to 98 feet. This species has a blue head, green body with a prominent red saddle and purple highlights around the edges of the fins (University of Hawai'i 2016).

This species is commonly observed alone, in pairs, or in small groups close to the reef where they forage for small crustaceans, mollusks, worms, urchins, and brittlestars. Canine teeth are used to pick these invertebrates from the reef. Most individuals begin life as females, when older they show the typical blue, red, and green pattern. Females that change to males, which is common in the wrasse family (Labridae), and have a white bar behind the red saddle. These sex-changed males are called “terminal phase” males, and become dominant territory holders that maintain a harem of females (University of Hawai'i 2016).

Saddle Wrasse are broadcast spawners, with males and females simultaneously releasing eggs and sperm into the water column where the eggs are fertilized before floating to the surface until they hatch 20-30 hours later (Thresher 1984).

CREP (2018) data indicate that the island of O'ahu population of Saddle Wrasse at the 0-98 foot depth is approximately 11,959,153 individuals.

4.4.4.20 Fisher's Angelfish (*Centropyge fisheri*)

The Fisher's Angelfish is mostly orange with a thin blue outline highlighting the belly and anal fin, the caudal fin is pale yellow. Adults attain a length of only 2 inches. This angelfish is found throughout Hawai'i and Johnston Atoll (Lobel 2003). Small groups have been observed feeding on algae and small shrimp associated with coral along outer reef slopes at depths between 10 and 200 feet (Pyle 2001). This species is hermaphroditic and changes sex as it matures.

Fisher's Angelfish are broadcast spawners, with males and females simultaneously releasing eggs and sperm into the water column where the eggs are fertilized before floating to the surface until they hatch 20-30 hours later (Thresher 1984).

CREP (2018) data indicate that the island of O'ahu population of Fisher's Angelfish at the 0-98 foot depth is approximately 192,591 individuals. However, this is a low estimate because much of the population occurs below the 98-foot depth surveyed by the CREP and is not observable by the methods of the survey.

The Fisher's Angelfish is a DLNR SGCN (Section 4.4.3), but is considered a species of ‘Least Concern’ by the IUCN (2017).

4.4.5 Other Regulated Species

The Achilles Tang, Bandit Angelfish, and Hawaiian Cleaner Wrasse are regulated by the DAR in terms of bag limits, size limits, or both (Section 1.2.3), but are not collected to the level of the top 20 collected fish species. Of the 1,295,700 individual fish collected from O'ahu under Aquarium Permits since 2000, the Hawaiian Cleaner Wrasse ranks as the 26th most collected fish making up 0.87% (11,243 individuals) of the total fish collected, averaging 625 collected each year. The Achilles Tang ranks as the 33rd most collected fish making up 0.62% (8,092 individuals) of the total fish collected, averaging 450 collected each year. The Bandit Angelfish ranks as the 47th most collected fish making up 0.38% (4,866 individuals) of the total fish collected, averaging 209 collected each year.

The following sections provide a brief overview of the ecology of the other regulated fish species collected in O'ahu since 2000.

4.4.5.1 Achilles Tang (*Acanthurus achilles*)

A member of the surgeonfish family, the Achilles Tang grows to 10 inches, is laterally compressed, and has a small mouth and eyes set high on the head. Adults are recognized by the bright orange patch at the base of the tail, where modified scales can be exposed when the fish flexes its tail. These modified scales or spines are used for defense from predators and competition for feeding areas (University of Hawai'i 2016).

The Achilles Tang is present throughout Hawai'i and found near exposed coral reefs and rocky shores. Flexible comb-like teeth are used to pick algae and seaweed that grow along the reefs. They spend a large amount of time foraging and aggressively protecting prime feeding territories (University of Hawai'i 2016). Juvenile typically range from 20 – 45 feet in depth, while the adults are found in the very shallow surge zone to 20 feet.

Spawning occurs in groups where females deposit eggs in open water, the males swim by, release sperm, and fertilize the eggs. Initially, larvae develop among plankton and then move to reefs for protection where juveniles develop to adults (University of Hawai'i 2016).

Achilles Tang are broadcast spawners. Many broadcast spawners migrate to the edge of the reef drop off to spawn at dusk or dawn (Thresher 1984). Males and females simultaneously release eggs and sperm into the water column where the eggs are fertilized before floating to the surface until they hatch 20-30 hours later (Thresher 1984).

CREP (2018) data indicate that the island of O'ahu population of Achilles Tang at the 0-98 foot depth is approximately 5,750 individuals.

4.4.5.2 Bandit Angelfish (*Apolemichthys arcuatus*)

The Bandit Angelfish is mostly pale with a broad black bar bordered by a narrow white band running across the upper side from the front of the eye to soft dorsal fin. A similar broad black band with white border runs submarginal on the caudal and anal fins.

It is endemic to the Hawaiian archipelago and Johnston Atoll. It is generally associated with reefs at a depth of 30 to 150 feet, seldom seen at depths less than 30 feet. Juveniles may occur more frequently in deeper habitats. They inhabit rocky reefs, in ledges and caves (Endoh 2007).

Bandit Angelfish are broadcast spawners, with males and females simultaneously releasing eggs and sperm into the water column where the eggs are fertilized before floating to the surface until they hatch 20-30 hours later (Thresher 1984).

Due to the deep-water habitats of the Bandit Angelfish, a reliable population estimate could not be derived for the species. However, also because of its deep-water habits, this species is collected at low numbers and is not among the top 20 most collected species averaging just 209 individuals per year since 2000.

4.4.5.3 Hawaiian Cleaner Wrasse (*Labroides phthirophagus*)

This brilliantly-colored wrasse is recognized by its habit of "cleaning" host fishes. The male and female phases of the cleaner wrasse appear identical in color, but dominant, terminal (sex-changed) males patrol a territory that may include several smaller females and their cleaning stations. If the male dies, it is believed that the dominant female changes sex and takes over the territory (Waikiki Aquarium 2018). Reproduction is year-round, and spawning occurs in pairs (Waikiki Aquarium 2018, Tinker 1978). Juveniles have a different color pattern than the adults, black with a broad blue stripe on the dorsal surface. Unlike nearly all small wrasses, this species does not bury in the sand at night. While inactive on the bottom at night, it accumulates a cocoon of mucus, similar to that observed in many parrotfishes (Waikiki Aquarium 2018, Tinker 1978). The Hawaiian Cleaner Wrasse is endemic, found only in the Hawaiian Islands, though related species occur throughout Indo-Pacific reefs (Waikiki Aquarium 2018, Tinker 1978).

Individuals establish "cleaning stations" at specific locations on the reef where a variety of "client" or host fishes assemble and await the Hawaiian Cleaner Wrasse's services. The Hawaiian Cleaner Wrasse's special mouth design enables it to remove crustacean ectoparasites from the host fishes, and in the process of cleaning, they also feed on mucus and some scales (Waikiki Aquarium 2018).

Hawaiian Cleaner Wrasse are broadcast spawners, with males and females simultaneously releasing eggs and sperm into the water column where the eggs are fertilized before floating to the surface until they hatch 20-30 hours later (Thresher 1984).

CREP (2018) data indicate that the island of O'ahu population of Hawaiian Cleaner Wrasse at the 0-98 foot depth is approximately 190,455 individuals.

4.4.6 Invertebrate Species

Approximately 4,100 species of marine invertebrates are known from the state of Hawai'i. A small portion (1.6%) of these marine invertebrate species are reported under Aquarium Permits, generally those species that are colorful or aesthetically pleasing. Between 2000 and 2017, approximately 66 invertebrate species were collected under Aquarium Permits in O'ahu waters; however, some of these included those species reported as a general group (e.g., hermits, stars, crabs) (DAR 2018a). Only 44 species were reported by enough permits (>2 permits reporting from each area of collection during each year of collection) to determine total number of individuals collected (Figure 1). Collection areas with less than three permits reporting fall under the DAR non-disclosure agreement, in which totals are not released publicly (Section 5.1). A total of 2,971,008 individual marine invertebrates have been reported as collected under Aquarium Permits since 2000. However, it is important to note that marine invertebrates can be collected using other methods not requiring the acquisition of an Aquarium Permit.

Of the invertebrates collected on O'ahu, 89.7% (2,664,728 individuals) reported represent just three species; hermit crabs (species not specified), Feather Duster Worms (*Sabellastarte spectabilis)*, and Zebra Hermit Crabs (*Calcinus laevimanus*; Table 5). An additional 41 species account for the other 10.3% of invertebrates reported collected (excluding non-disclosed data) (DAR 2018a).

Table 5. Top three marine invertebrate species collected under Aquarium Permits on the island of O'ahu from 2000-2017 DAR 2018a).

Common Name	Scientific Name	Number Collected	Percentage of Total Invertebrates Collected[1] (2,971,008)
Hermit Crab	Various species	1,505,061	50.7%
Zebra Hermit Crab	*Calcinus laevimanus*	694,565	23.4%
Feather Duster Worm	*Sabellastarte spectabilis*	465,102	15.7%
Total		**2,664,728**	**89.7%**

[1]Percentage calculated based on total number of invertebrate individuals collected (2,972,008) in O'ahu and does not include any non-disclosure totals.

The following sections provide a brief overview of the ecology of each of the top three aquarium invertebrate species collected.

4.4.6.1 Hermit Crab (various species)

Because specific species of hermit crabs are not reported on aquarium permit reporting forms, it is not possible to know which species are collected, with the exception of Zebra Hermit Crabs (Section 4.4.6.2). However, hermit crabs are one of the most common types of tide pool animals. They rely on empty snail shells for protection. Most species will scavenge the reefs consuming fish, other invertebrates, or algae. Some will display a variety of coloration and elaborate eye colors. Approximately 23 species of hermit crabs are known from Hawai'i shorelines. No population estimates are available for hermit crabs.

4.4.6.2 Zebra Hermit Crab (*Calcinus laevimanus*)

This species of hermit crab is found in a large area of the Indo-Pacific, extending from Africa to Australia and Japan to Hawai'i. The common name comes from the coloration, black and white pincers, and white bands on dark legs. They also have orange and sky-blue eyestalks. They prefer to inhabit gastropod shells in intertidal flats, reef flats, and rock platforms, and may also be found in mangrove areas on sand mud bottoms and on rocky shores (Rahayu 2000). No population estimates are available for Zebra Hermit Crabs.

4.4.6.3 Feather Duster Worm (*Sabellastarte spectabilis*)

Feather Duster Worms are native to the Indian Ocean and Red Sea, but are a widely introduced species inhabiting the Gulf of Mexico and Hawai'i, appearing sometime after World War II. It is approximately 3.1 inches in length, and 0.5 inch in width. It is buff in color with purple specks, living in a tough leathery tube covered with fine mud. Branched tentacles project from the tube and form a plum. This species can reproduce either asexually through fragmentation or sexually (Bailey-Brock 1976). They are found in holes and cracks among algae on reefs and rocky shores. It may sometimes be found growing in crevices of corals, under boulders in still water, tidal pools, or in channels exposed to heavy surf (Bailey-Brock 1976). No population estimates are available for Feather Duster Worms.

4.4.7 Threatened and Endangered Wildlife Species

A total of 8 federal, and 10 state-listed threatened or endangered marine species, consisting of 1 seal, 4 whales, and 5 sea turtles, occur in Hawai'i (Table 6). Federal endangered species are those species that the US Fish and Wildlife Service define as being in danger of becoming extinct, while threatened species are those likely to become endangered in the foreseeable future. State endangered species are those defined by the DLNR as in danger of becoming extinct at a state level, while threatened species are those likely to become endangered in the foreseeable future at the state level. No species collected by aquarium fishers occur on the state of federal list of threatened and endangered species.

Table 6. Threatened and endangered marine species of Hawai'i.

Common Name	Scientific Name	State Status	Federal Status
Mammals			
Hawaiian Monk Seal	*Neomonachus schauinslandi*	E	E
Fin Whale	*Balaenoptera physalus*	E	NA
Humpback Whale	*Megaptera novaeangliae*	E	E
Sperm Whale	*Physeter catodon*	E	E
False Killer Whale	*Pseudorca crassidens*	E	NA
Reptiles			
Pacific Leatherback Sea Turtle	*Dermochelys coriacea schlegelii*	E	E
Pacific Hawksbill Sea Turtle	*Eretmochelys imbricata bissa*	E	E
Loggerhead Sea Turtle	*Caretta caretta*	T	T
Green Sea Turtle	*Chelonia mydas*	T	T
Olive Ridley Sea Turtle	*Lepidochelys olivacea*	T	T

4.4.8 Reef Habitat

Stretching for more than 1,200 miles in the Central Pacific, Hawaiian coral reefs account for about 85% of all coral reefs in the United States. More than 500 species of algae also live in Hawai'i's coral reefs providing food for fish and oxygen for all marine life. The oceans' algae provide more oxygen than all land plants worldwide combined. There are 78 species of endemic marine algae, 24 species of endemic freshwater algae, and two aquatic plants included on Hawai'i's list of SGCN (DLNR 2015).

Hawai'i's reefs are unique among the world's reef ecosystems. Compared to coral reefs in the Indo-Pacific or Caribbean, Hawaiian reefs are relatively young. Hawai'i reefs are therefore dominated by hard corals (as opposed to sponges, tunicates, and soft corals) and are inhabited by distinctive reef fish and other marine life. Hawai'i hosts about 40 species of hard, reef building corals (MRC 2017). Due to Hawai'i's extreme isolation, an estimated 25% of the coral reef species are found nowhere else.

Stony corals are defined by Hawai'i Administrative Rule 13-95 as any species belonging to the Order Scleractinia (marine corals which generate a hard skeleton). All reef corals, including mushroom corals, belong to this order (DAR 2014b). The animals which form stony corals belong to the same major group as jellyfish and anemones. Most of them are colonial, and all secrete a hard skeleton made of calcium carbonate. The animals themselves, called polyps, form the outer living layer of a coral colony. Each polyp sits in a cup-like depression called a calyx. Some Hawaiian stony corals grow very slowly and can take hundreds of years to recover from damage. To differentiate from many west Pacific corals which can grow very rapidly, and from *Pocillopora* which rapidly recolonizes dead reefs and grows rather quickly (DAR 2014b).

The characteristic color of many living corals is due to the presence of single-celled algae, called zooxanthellae, which live inside the coral polyp. The coral and algae have a symbiotic relationship. Most stony corals produce colonial forms that are attached to the substrate, but a few are solitary and unattached (DAR 2104b).

Coral reefs surround the island of O'ahu, although active live coral growth is limited to the leeward sides of the island or in sheltered areas on the windward coasts. In 2014 and 2015, coral reefs in the main Hawaiian Islands suffered up to 90% bleaching and 50% mortality rates in some areas due to widespread prolonged warming events during each year (Rodgers et al 2017). These areas affected included portions of O'ahua.

4.4.8.1 Corals Common to Hawai'i (DAR 2014b)

4.4.8.1.1 Rose or Cauliflower Coral (*Pocillopora meandrina*)

The most common Pocillopora in Hawai'i, this coral prefers wave-agitated environments, and is found at depths to about 150 feet. Commonly called "rose coral" or "cauliflower coral," the colonies form cauliflower-shaped heads about 10 to 20 inches in diameter. Branches are heavy and leaf-like, and fork bluntly near the ends. All branches have wart-like projections called verrucae that are covered with calices. Color of living colonies ranges from brown to pink.

4.4.8.1.2 Lace Coral (*Pocillopora damicornis*)

This delicate and fragile coral forms small bushy clumps up to about 6 inches in diameter. Colonies consist of fine branches covered with calices. These branches range from long and slender in calm waters to more robust forms in areas of wave action. Sometimes the skeleton will create pocket formations around a crab that lives among the branches. Usually found in protected areas and inner portions of large reef flats, this species appears to strongly depend on sunlight, as it is rarely found below about 30 feet. Colonies range in color from light brown in shallow waters to dark brown in deeper waters.

4.4.8.1.3 Antler Coral (*Pocillopora eydouxi*)

Colonies consist of thick pipe-like branches that resemble moose antlers. This species also possesses verrucae and is usually found in depths of 35 to 150 feet. Live colonies are brown in color and usually darker than other Pocilloporid corals.

4.4.8.1.4 Lobe Coral (*Porites lobata*)

This coral produces many encrusting or massive forms on the reef from the intertidal zone to depths of over 180 feet. Long narrow cracks found on the coral heads are produced by a type of alpheid shrimp. Calices have a snowflake-like appearance and are shallow and flush to the surface. Living colonies range in color from yellowish-green to brown and sometimes blue.

4.4.8.1.5 Finger Coral (*Porites compressa*)

Distinguishing features are the finger-like branching and shallow snowflake-shaped calices. This species is most common in wave-protected areas like bays or deeper reef slopes to depths of about 150 feet. It has many growth forms, but all of them show some sort of fingerlike branching. Color of live colonies ranges from light brown to light yellowish-green.

4.4.8.1.6 Rice Coral (*Montipora capitata*)

The most obvious characteristic of this coral is the nipple-like projections (papillae) that cover the surface. These papillae are smooth with no calices on them. Calices are found on the upper surface of the coral between the papillae. The image of the calices and papillae create a "rice & pepper" appearance. This species is found at depths up to about 150 feet. It has a number of growth forms ranging from platelike to branchlike and encrusting types. Color of living colonies is usually brown. If the colony is growing in a plate form, the edges may be white.

4.4.8.1.7 Mushroom or Razor Coral (*Fungia scutaria*)

This solitary (single polyp), free-living (unattached) coral is most commonly found on reef flats, frequently between cracks and crevices. It has also been found at depths of over 75 feet. Its disk-like, elliptical shape resembles a mushroom cap and ranges from 1.5 to 7 inches in diameter. Some adults may form a high arch in the middle. Immature forms are attached to the substrate or an adult mushroom coral by a stalk. It grows into a disk and, when large enough, breaks off the stalk and becomes free-living. The color of live specimens ranges from pale brown in bright sunlight to dark brown in shady areas or deeper water.

4.4.8.1.8 Cup or Tube Coral (*Tubastraea coccinea*)

This is a common non-reef building coral found in shallow Hawaiian waters. This species forms large calices and occurs in clumps that are 2 to 4 inches in diameter. Living tissue is usually bright orange in color, but may also appear pink or even black. The bright coloration is not produced by zooxanthellae. This coral is usually found on steep ledges, in caves and in shady tidepools.

4.4.9 Invasive Species

From *A Guidebook of Introduced Marine Species in Hawai'i* (DeFelice et al. 2001):

> *Through the Hawai'i Biological Survey at Bishop Museum, a count of the total number of species in the Hawai'i Archipelago has been compiled. In 1999, there were 23,150 known species of terrestrial and aquatic algae, plants and animals, including 5,047 nonindigenous species (~ 20%). The total number of marine and brackish water alien species in the Hawaiian Islands was 343, including 287 invertebrates, 24 algae, 20 fish, and 12 flowering plants.*
>
> *The 287 alien marine invertebrate species make up about 7% of the known marine and brackish water invertebrate fauna in the Hawaiian Islands (4,099 species). Arthropods have been the most successful marine invaders, with 71 suspected alien crustacean species, while 53 alien mollusks have made it to Hawai'i. Limited information exists for these invasive species.*
>
> *The greatest number of introduced marine invertebrates have arrived to Hawai'i through hull fouling, but many have also arrived with solid ballast and in ballast water. DeFelice et al. (2001) considered 201 species (70%) to be introduced, and 86 species (30%) cryptogenic (not demonstratively native or introduced). Two hundred forty-eight (87%) have become established, 15 (5%) arrived but failed to become established, 6 (2%) were intercepted, and the population status of 18 species (6%) is unknown.*
>
> *The nonindigenous invertebrate species in the Hawaiian Islands are primarily of Indo-Pacific/Philippines Islands region origin. A surprising number of species from the tropical western Atlantic/Caribbean region have invaded Hawai'i as well.*

Invasive algae pose the largest threat to Hawai'i's reef ecosystem. The five most common algae species posing the largest threat include Smothering Seaweed (*Kappaphycus* and *Euchema* spp.), Gorilla Ogo (*Gracilaria salicornia*), Leather Mudweed (*Avrainvillea amadelpha*), Hook Weed (*Hypnea musciformis*), and Prickly Seaweed (*Acanthophora spicifera*). Marine debris arriving from other countries and regions and ballast water/biofouling are the primary threat for invasion in the Hawaiian Islands.

Introduced fish species of concern in Hawai'i include the Bluestripe Snapper (= Taape; *Lutjanus kasmira*) and Peacock Grouper (= Roi, bluespot peacock grouper; *Cephalopholis argus*). The Blacktail Snapper (*Lutjanus fulvus*) is less common, and restricted to the main Hawaiian Islands. All three species were introduced from 1956-1961, mostly as game fish (IUCN 2017). The introduction of the Bluestripe Snapper into Hawai'i included at least one non-native parasite that has spread to local fishes (Gaither et al. 2013).

The Bluestripe Snapper and Peacock Grouper are well established in Hawai'i. The Blacktail Snapper is not a common fish and occurs at low densities only in the lower Hawaiian Islands (Randall 1987, IUCN 2017). From 2008 through 2014, regional estimates of the density of Blacktail Snapper ranged from 1.8 to 14.1 individuals per 2.5 acres over hard bottoms to 98.5 feet depth in Pacific coral reef areas surveyed by NOAA (NOAA unpublished data as described in Heenan et al. 2014 *in* IUCN 2017). The highest recorded density was in the MHI region (0.3 to 45.1 individuals per 2.5 acres) as compared to the lowest in the Southern Mariana Islands region (0 to 4.3 individuals; IUCN 2017).

This peacock grouper prefers exposed reef front habitats with a water depth of 3 to 30 feet, while juveniles utilize thick pockets of coral (Myers 1999). Individuals use a variety of hunting techniques to capture prey. They may hover and wait, stalk prey, and follow larger predators such as eels and attack missed prey (Hoover 2008). Dierking et al. (2009) found reef fishes were the principal diet component (97.7% by % Index of Relative Importance [IRI]) of peacock grouper. Crustaceans were the only other higher taxonomic group in the diet, but were of minor importance (2.3% by %IRI) (Dierking et al. 2009).

5.0 ENVIRONMENTAL CONSEQUENCES

This section discusses the impacts of implementing the Preferred Alternative and No Action Alternative on resources retained for further analysis. Aspects of the environment that may be affected by the alternatives is discussed to the level of detail commensurate with the potential effect. Those aspects of the environment that would not be affected are discussed briefly. The content, intensity, and likelihood of the impact were taken into consideration in the making of these ratings.

Direct, indirect, and cumulative impacts are evaluated for each resource. The HEPA does not specifically define direct and indirect impacts. As such, for the purposes of this PDEA, the National Environmental Policy Act (NEPA) definitions are used. The NEPA defines direct effects as those effects that are caused by the action and occur at the same time and place (40 C.F.R. § 1508.8(a)). Indirect effects include effects later in time or farther removed in distance, but are still reasonably foreseeable (40 C.F.R. § 1508.8(b)). Indirect effects may include growth-inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems (40 C.F.R. § 1508.8).

The HEPA defines cumulative impacts as the impact on the environment, which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time (HAR Section 11-200-2).

Cumulative impacts were analyzed according to a tiered approach, which allows for a resource-specific analysis of regional and local actions, and narrows the focus to those effects with direct influence on the proposed action and agency decision-making. Following this approach, the cumulative impacts analysis focused on potential impacts to the top 20 aquarium fish collected in O'ahu, SGCN, and reef habitat, as these are the resources with the potential for on-going impacts due to commercial aquarium fish collection. The spatial analysis area for cumulative effects is the nearshore waters of the island of O'ahu from the shoreline out to 3 nautical miles. Under HRS 188-31, the DLNR may issue an Aquarium Permit not longer than one year in duration; therefore, the temporal scope of the cumulative impacts analysis is 12 months, because an EA with updated data and analysis would need to be completed on an annual basis.

5.1 HRS §189-3 AND DATA ANALYSIS

HRS §189-3 states:

(a) Upon the demand of the department, every commercial marine licensee shall furnish to the department a report or reports with respect to the marine life taken and any other information the department may require for the purposes of this section.

(b), "Any information submitted to the department by any person in compliance with any requirement under this section shall be confidential and shall not be disclosed, except when required under court order or pursuant to subpoena issued by the department of the attorney general, or with the prior written consent of the person submitting the information, or under cooperative agreements with government agencies of the United States for exchange and use of the information specifically to manage marine life. The department, by rule, may establish procedures necessary to preserve the confidentiality, except that the department may release or make public any of the information in the aggregate or summary form which does not directly or indirectly disclose the identity of any person who submits information."

The DAR complies with this statute by keeping confidential any catch data when less than three collectors report from an individual collection zone (Figure 1). Collection zones depicted in Figure 1 correspond to areas defined by the monthly report fishers are required to provide to DAR. Confidential data are identified as n.d. (not disclosed) in the tables in Section 5.0. The impact of this statute on data analysis is minimal, but can cause confusion when numbers in the text or in the tables do not exactly match up, or do not match previously published reports for which the n.d. data were available (i.e., DAR reports). Although it is possible for 1-2 aquarium fishers to collect large numbers of fish and skew the data, this concern was minimized by the manner in which data were analyzed. Data provided by the DAR for this DEA were evaluated using many parameters, thereby minimizing any bias due to confidentiality. The data were also viewed in aggregate and over extended time periods (i.e., 2000-2017) to further minimize confidentiality issues.

5.2 SOCIOECONOMIC RESOURCES

5.2.1 Direct Effects

From 2000 to 2017, the aquarium fishery in O'ahu added an average of $506,251 (inflation-adjusted 2017 dollars) annually to the state of Hawai'i's economy, while the overall aquarium fishery within the state of Hawai'i added an average of $2,075,088 (inflation-adjusted 2017 dollars) to the economy (DAR 2018a, Table 7). Total *ex-vessel* value (i.e., price received by a fisher for the catch) for O'ahu ranged from a low of $201,210 in 2003 to a high of $741,507 in 2012 (inflation-adjusted 2017 dollars), with an average value over the 18-year period of $506,251. As described in Section 4.1.1, on average, 16.7% of this value is attributable to invertebrate species and 79.4% is attributable to fishes, with the remaining percentages attributable to non-disclosure data, unknown species, and miscellaneous species. Assuming that the average percentages can be applied to the average inflation-adjusted total *ex-vessel* value of $506,251, approximately $401,963 can be attributed to fish collection, and $84,544 can be attributed to invertebrate collection, on average. It should be noted that the dollar value of these fisheries represents only the *ex-vessel* value and does not include the value which would be generated by additional dealer, retail sales, and shipping costs. The actual economic value of the catch is thus substantially greater than the *ex-vessel* values.

Table 7. Summary of commercial aquarium fisher permits and values (fish and invertebrates) by year from 2000 through 2017 for the State of Hawai'i and for O'ahu (DAR 2018a).

Fiscal Year[1]	O'ahu				State of Hawai'i			
	Number of Commercial Aquarium Permits	Number Reporting	Total Value	Total Value Adjusted for Inflation[2]	Number of Commercial Aquarium Permits	Number Reporting	Total Value	Total Value Adjusted for Inflation[2]
2000	68	47	$242,856	$345,696	113	82	$1,000,750	$1,424,529
2001	75	39	$203,984	$282,489	128	75	$936,811	$1,297,351
2002	72	28	$157,387	$214,445	139	63	$935,009	$1,273,982
2003	66	30	$151,039	$201,210	123	68	$1,174,168	$1,564,196
2004	68	39	$341,049	$442,552	145	77	$1,442,946	$1,872,392
2005	76	39	$359,424	$451,112	142	79	$1,579,370	$1,982,259
2006	102	46	$487,187	$437,014	186	87	$2,093,857	$2,545,864
2007	106	50	$480,341	$567,860	195	99	$1,646,167	$1,946,101
2008	85	52	$525,791	$598,607	178	94	$2,065,816	$2,351,908
2009	100	46	$507,860	$580,257	197	92	$1,894,015	$2,164,013
2010	81	45	$550,940	$619,320	178	91	$2,282,618	$2,565,925
2011	81	39	$631,632	$688,300	172	87	$2,188,227	$2,384,550
2012	84	41	$694,539	$741,507	166	77	$2,306,179	$2,462,131
2013	71	32	$508,251	$534,787	153	64	$2,172,561	$2,285,993
2014	78	32	$590,659	$611,577	165	61	$2,322,564	$2,404,818
2015	93	42	$683,282	$706,641	163	69	$2,502,178	$2,587,721
2016	92	39	$563,418	$575,421	166	66	$2,257,021	$2,305,104
2017	126	41	$513,723	$513,723	226	68	$1,932,747	$1,932,747
Average	**85**	**40**	**$455,187**	**$506,251**	**163**	**78**	**$1,818,500**	**$2,075,088**

[1]Fiscal year runs from July 1 through June 30
[2]http://www.usinflationcalculator.com/, adjusted for 2017 values

All commercial aquarium collectors must obtain the state aquarium permit and the CML, which allows them to offer the collected fish for sale. The Aquarium Fish Catch Report requirement is triggered by the CML. Some collectors participate in a dive team. To avoid duplicate fish catch reporting, only a principal diver is required to report the catch and effort for the dive team (DAR, pers. comm., 2018). This process ensures that reported catch data are not duplicated in the State's system. However, this reporting mechanism can lead to confusion by outside observers, as the total number of permit holders is higher than the number of permit holders reporting data (Table 7), giving the appearance of under reporting. The number of non-reporting permit holders is an indicator of industry growth and direct socioeconomic benefits. For the period of 2000 to 2017, the total number of permit holders in O'ahu ranged from 66 to 126 (average = 85), while the number of permit holders reporting ranged from 28 to 52 (average = 40). In 2017, it is estimated that up to 126 individuals were directly employed in the aquarium fishery in O'ahu (up to 226 employed in the state of Hawai'i).

5.2.1.1 No Action Alternative

Under the No Action Alternative, collection of aquarium fish under Aquarium Permits would not occur, though collection of invertebrates may continue using methods not requiring an Aquarium Permit. Based on historic data, under the No Action Alternative an estimated $401,963 (when including just fish species) to $421,707 (when including the $19,744 attributed to non-disclosure data, unknown species, and miscellaneous species) would be eliminated from Hawai'i's economy and potentially over 100 jobs lost from the workforce. The $84,544 attributed to invertebrate collection, and the $19,744 which was not associated with any particular species (up to $104,288 total) may continue to contribute to the economy under the No Action Alternative. Collection of invertebrates may increase as pressure is focused on species that do not require fine mesh nets to harvest, though there is no way to predict or quantify any such increase at this time.

5.2.1.2 Preferred Alternative

Based on historic data, under the Preferred Alternative the commercial aquarium fishery is estimated to add $506,251 to the state of Hawai'i's economy over the 12-month analysis period and continue to provide over 100 jobs. This represents an additional $401,963 to $421,707 added to the economy when compared to the No Action Alternative.

5.2.2 Indirect Effects

5.2.2.1 No Action Alternative

Re-investment of a portion of the profits from the aquarium fishery into the state of Hawai'i's economy under the No Action Alternative would be decreased from current levels due to the loss of an estimated $401,963 to $421,707 of the $506,251 industry (79% to 83% decrease). In addition, funding provided through licenses, other fees, and taxes on aquarium fishers that is used to monitor, protect, and preserve reef fishes and their reef habitats would no longer be available.

5.2.2.2 Preferred Alternative

The average value of the commercial aquarium fishery in O'ahu for the period 2000 to 2017 was $506,251 (inflation-adjusted 2017 dollars). A portion of the income from this fishery would continue to be put back into Hawai'i's economy through re-investment efforts in terms of equipment, maintenance, supplies, and personnel, which would be greater under the Preferred Alternative than under the No Action Alternative due to the higher value of the fishery under this alternative. Funds from the licenses, other fees, and taxes associated with the fishery would continue to go to environmental conservation projects and research implemented by the DLNR and other agencies to monitor, manage, and regulate the fishery to ensure environmental impacts are avoided and minimized.

In addition, while the aquarium fishery directly employs permitted collectors, these collectors hire staff/assistants, sell their catch to wholesalers, who in turn get the fish to the market, which includes pet stores and their customers (Dierking 2002).

5.2.3 Cumulative Impacts

For the period 2000 to 2017, the aquarium fishery in O'ahu added an average of $506,251 (inflation-adjusted 2017 dollars) annually to the state of Hawai'i's economy, while the overall aquarium fishery within the state of Hawai'i added an average of $2,075,088 (inflation-adjusted 2017 dollars) (Table 7). The O'ahu aquarium fishery accounts for approximately 24% of the overall aquarium fishery within Hawai'i. In 2016, the overall Gross Domestic Product (GDP) of Hawai'i was $84.7 billion, of which, the aquarium fishery contributed $2,257,021 (0.003%), of which $563,418 was from the O'ahu landings. Over the 12-month analysis period under the Preferred Alternative, it is estimated that the aquarium fishery in Hawai'i would add an estimated $2,075,088 to the state's economy, of which an estimated $506,251 would be added from the O'ahu aquarium fishery. Under the No Action Alternative, revenue from the aquarium fishery would not cumulatively add to the state's economy, though collection of invertebrates may continue to contribute an estimated $84,544 to $104,288 (if including the $19,744 attributed to miscellaneous or unknown species which may or may not continue to be collected under the No Action Alternative).

5.3 CULTURAL RESOURCES

5.3.1 Direct Effects

Neither alternative under consideration is expected to result in direct impacts to cultural resources over the 12-month analysis period.

5.3.2 Indirect Effects

As noted in Section 4.2.1, the commercial aquarium fishery is not a part of traditional Hawaiian culture. However, over the past 50 years of commercial aquarium fishing within Hawaiian waters, issues surrounding the fishery have served as an impetus to help bridge the gap between traditional native Hawaiian resource management and the 'western' model of management. Native Hawaiians are a part of this fishery and served on the West Hawai'i Fishery Council assisting in the development of the West Hawai'i Regional Fishery Management Area, Fish Replenishment Areas, and regulations guiding the management of the fishery in Hawai'i. As a result, native Hawaiian interest and participation has increased resulting in a more focused, successful, and stable fishery able to monitor issues as they arise.

5.3.3 Cumulative Impacts

Neither alternative under consideration would directly impact cultural resources; therefore, implementation of either alternative would not cumulatively increase adverse impacts to cultural resources. Implementation of the Preferred Alternative would have the beneficial effect of continuing the involvement of native Hawaiians in discussions concerning management of the aquarium fishery.

5.4 BIOLOGICAL RESOURCES

5.4.1 Direct Effects

5.4.1.1 No Action Alternative

Under the No Action Alternative issuance of Aquarium Permits would not occur and commercial aquarium fish collection would not take place. An estimated 72,000 (18-year average; Table 3) individual fish would not be collected from O'ahu. A minor, although unquantifiable, population increase may occur in some species over the 12-month analysis period; however, it should be noted that individual fish targeted by commercial aquarium fishers, either by regulation and/or market demand, are generally small, juvenile fish and not the larger breeding stock. Non-removal of juvenile fish is not anticipated to result in a statistically significant population increase during the 12-month analysis period.

The 165,000 invertebrates currently reported under Aquarium Permits may continue to be collected under the No Action Alternative using methods not requiring an Aquarium Permit. Section 5.4.1.2.4 outlines the potential impacts to these species. Collection of invertebrates may increase as pressure is focused on species that do not require fine mesh nets to harvest.

5.4.1.2 Preferred Alternative

Under the Preferred Alternative, issuance of Aquarium Permits would occur and commercial aquarium fish collection would take place. It is likely that fishing pressure on the species collected in the past would remain relatively the same over the 12-month analysis period, resulting in an estimated 72,000 (18-year average) individual fish and 165,000 invertebrates collected from the island of O'ahu's populations each year (Tables 3 and 5). Total collection (fish and invertebrates) for the island of O'ahu has ranged from 66,733 individuals in 2003 to 501,773 in 2007 (Table 8). Collection numbers of fish for the island of O'ahu have ranged from 35,811 individuals in 2003, to 100,662 in 2012 (Table 3). Collection numbers of invertebrates for the island of O'ahu have ranged from 30,910 individuals in 2003, to 419,804 in 2007. Similar collection numbers of individual species would be expected over the 12-month analysis period.

Table 8. Total O'ahu collection data (fish and invertebrates) under Aquarium Permits from 2000-2017.

Fiscal Year	Total Collection
2000	100,872
2001	122,436
2002	107,779
2003	66,733
2004	327,743
2005	367,666
2006	445,368
2007	501,773
2008	220,927
2009	189,086
2010	201,220
2011	201,594
2012	254,820
2013	214,863
2014	244,939
2015	250,690
2016	232,060
2017	218,762
Total	**4,269,331**
Average	**237,185**

5.4.1.2.1 Top 20 Collected Fish Species

Since 2000, a total of 238 fish species have been collected on the island of O'ahu under Aquarium Permits. Of these 238 species, 124 species account for less than 1% each of the total aquarium fish catch from 2000-2017. An additional 94 species do not have data available due to the DAR confidentiality requirements (Section 5.1). The remaining 20 aquarium fish species collected on the island of O'ahu under Aquarium Permits make up 80% of all fish collected, and these species are summarized in Table 9. Only 3 species have 18-year totals greater than 60,000 individuals: Yellow Tang (273,356 individuals), Kole (175,425 individuals), and Potter's Angelfish (138,669 individuals). These 3 species account for 45.3% of all aquarium fish collected (1,295,700) on O'ahu since 2000, and are described in detail below. The other 17 species that make up the top 20 species account for 33.6% of all aquarium fish collected in O'ahu. Since 2000, collection of these 17 species ranged from 4 to 12,666 individuals per year, with most species averaging below 2,000 individuals over the 18-year period.

The Yellow Tang has been the most collected species every year since 2004. In 2000, 2001, and 2003, more individual Potter's Angelfish and Kole were collected, followed by Yellow Tang. In 2002, Potter's Angelfish was the most collected species, followed by Yellow Tang, then Potter's Angelfish. In recent years (2014–2017) Yellow Tang were collected nearly twice as much as the next highest collected aquarium fish (Kole).

Since 2000, 273,356 Yellow Tang were collected on the island of O'ahu. The average number of Yellow Tang captured each year since 2000 was 15,186 individuals, ranging from a minimum catch of 2,546 individuals (2001) to a maximum of 38,344 individuals (2015). It is anticipated that under the Preferred Alternative between the average of 15,186 and the maximum of 38,344 Yellow Tang would be collected over the 12-month analysis period, representing 7% (average) to 17.7% (maximum) of the estimated O'ahu Yellow Tang population based on CREP data (Table 9).

Since 2000, 175,425 Kole were collected on the island of O'ahu. The average number of Kole captured each year since 2000 was 9,746, ranging from a minimum catch of 2,917 individuals (2002) to a maximum of 17,748 individuals (2015). It is anticipated that under the Preferred Alternative between the average of 9,746 and the maximum of 17,748 Kole would be collected over the 12-month analysis period, representing 0.9% (average) to 1.6% (maximum) of the estimated O'ahu Kole population based on CREP data (Table 9).

Since 2000, 138,669 Potter's Angelfish were collected on the island of O'ahu. The average number of Potter's Angelfish captured each year since 2000 was 7,704 individuals, ranging from a minimum catch of 4,698 individuals (2003) and maximum of 10,940 individuals (2010). It is anticipated that under the Preferred Alternative between the average of 7,704 and the maximum of 11,460 Potter's Angelfish would be captured over the 12-month analysis period, representing 2.6% (average) to 3.9% (maximum) of the estimated O'ahu Potter's Angelfish population based on CREP data (Table 9).

Of the remaining 17 species, only two species, Orangespine Unicornfish and Ornate Wrasse, were collected on average more than 2,000 times per year between 2000 and 2017. The remaining 15 species averaged between 756 and 1,605 individuals collected per year between 2000 and 2017. Under the Preferred Alternative, it is anticipated that similar numbers of the top 20 collected species would be collected over the 12-month analysis period.

Based on CREP (2018) population estimates and the average collection over the past 18 years, 17 of the top 20 collected species would be collected at numbers below 1% of their overall population if an average collection occurs over the 12-month analysis period (Table 9). The remaining three species include the Flame Wrasse, Yellow Tang, and Potter's Angelfish. It is estimated that approximately 28% of the known Flame Wrasse population is collected annually, however, the Flame Wrasse spends much of its time below the 98-foot depth limit of the CREP surveys, and therefore likely often goes undetected, leading to an underestimation of its overall population. Due to this underestimation, it is not possible to know the exact proportion of the population that would be collected for this species, though it is assumed to be less than 28%. Seven percent of the Yellow Tang population and 2.59% of the Potter's Angelfish population would be collected in an average year.

Table 9. Summary of top 20 fish species collected on the island of O'ahu from 2000 to 2017 (DAR 2018a).

Common Name	Scientific Name	O'ahu Population Estimate (CREP 2018)[1]	Average Number Collected per Year[2]	Maximum Number Collected per Year[3]	Average % of Population Collected [4]	Max % of Population Collected [5]
Yellow Tang[6]	*Zebrasoma flavescens*	216,524	15,186	38,344	7.01%	17.71%
Kole[6]	*Ctenochaetus strigosus*	1,144,130	9,746	17,748	0.85%	1.55%
Potter's Angelfish[6]	*Centropyge potteri*	297,372	7,704	11,460	2.59%	3.85%
Orangespine Unicornfish[6]	*Naso lituratus*	950,505	3,285	7,047	0.35%	0.74%
Ornate Wrasse	*Halichoeres ornatissimus*	668,852	2,562	4,066	0.38%	0.61%
Flame Wrasse[7]	*Cirrhilabrus jordani*	5,683	1,605	3,480	28.25%	61.24%
Fourline Wrasse	*Pseudocheilinus tetrataenia*	177,710	1,605	2,722	0.90%	1.53%
Hawaiian Whitespotted Toby	*Canthigaster jactator*	1,888,605	1,590	3,382	0.08%	0.18%
Forcepsfish	*Forcipiger flavissimus*	192,505	1,583	2,817	0.82%	1.46%
Milletseed Butterflyfish	*Chaetodon miliaris*	603,563	1,405	3,154	0.23%	0.52%
Shortnose (Geoffroy's) Wrasse	*Macropharyngodon geoffroy*	746,227	1,355	2,592	0.18%	0.35%
Bicolor Anthias	*Pseudanthias bicolor*	300,208	1,344	3,407	<0.01%	0.01%
Orangeband Surgeonfish	*Acanthurus olivaceus*	1,380,451	1,343	3,875	0.10%	0.28%
Moorish Idol[6]	*Zanclus cornutus*	285,677	1,303	3,614	<0.01%	0.01%
Multiband Butterflyfish	*Chaetodon multicinctus*	806,937	1,007	2,296	0.12%	0.28%
Psychedelic Wrasse	*Anampses chrysocephalus*	146,521	913	1,182	0.62%	0.81%
Eightline Wrasse	*Pseudocheilinus octotaenia*	206,014	892	1,905	0.43%	0.92%
Crowned Puffer	*Canthigaster coronata*	285,677	809	1,848	<0.01%	0.01%
Saddle Wrasse	*Thalassoma duperrey*	11,959,153	804	1,597	<0.01%	0.01%
Fisher's Angelfish[8]	*Centropyge fisheri*	192,591	756	1,627	0.39%	0.84%

[1]Estimated population derived from NOAA data collected between 2010 and 2016 (CREP 2018).
[2]Average calculated from collection reports from 2000 to 2017 (DAR 2018a).
[3]Maximum calculated from collection reports from 2000 to 2017 (DAR 2018a).
[4]Calculated from average collected for each species between 2000 and 2017 and CREP population estimates.
[5]Calculated from the maximum collected for each species between 2000 and 2017 and CREP population estimates.
[6]Regulated species (e.g., bag or size limits) on the island of O'ahu.
[7]See Section 4.4.4.6; the population estimate for this species is likely low due to the species spending much of its time below the 98-foot depth of the CREP surveys.
[8]SGCN.

5.4.1.2.2 Other Regulated Species Collected

The Achilles Tang, Bandit Angelfish, and Hawaiian Cleaner Wrasse are regulated by the DAR in terms of bag limits, size limits, or both. Since 2000, these 3 species account for 1.87% of all fish collected on the island of O'ahu.

The Hawaiian Cleaner Wrasse ranks as the 26th most collected fish since 2000, making up 0.87% (11,243 individuals) of the total fish collection, averaging 625 collected each year. Collection numbers have ranged from a high of 1,060 in 2000 to a low of 287 in 2015 (Table 10). It is anticipated approximately 625 would be collected over the 12-month analysis period.

The Achilles Tang ranks as the 33rd most collected fish since 2000, making up 0.62% (8,092 individuals) of the total fish collection, averaging 450 collected each year. Collection numbers have ranged from a high of 1,266 in 2004 to a low 169 in 2002 (Table 10). It is anticipated that approximately 450 would be collected over the 12-month analysis period.

The Bandit Angelfish ranks as the 47th most collected fish since 2000, making up 0.38% (4,866 individuals) of the total fish collection, averaging 209 collected each year. This species is generally only captured at depths at which normal recreational diving does not occur. Due to the complexity and difficulty of collecting the Bandit Angelfish, its population will likely continue to not receive significant pressure from the commercial aquarium fishery. Collection numbers have ranged from a high of 638 in 2015 to a low of 15 in 2004 (Table 10). It is anticipated that approximately 209 would be collected over the 12-month analysis period.

Table 10. Summary of regulated (non-top 20 collected) fish species collection on the island of O'ahu since 2000 (DAR 2018a).

Common Name	Scientific Name	O'ahu Population Estimate (CREP 2018)[1]	Average Number Collected per Year[2]	Maximum Number Collected per Year[3]	Average % of Population Collected[4]	Max % of Population Collected[5]
Hawaiian Cleaner Wrasse	*Labroides phthirophagus*	NA[6]	625	1,060	NA	NA
Achilles Tang	*Acanthurus achilles*	5,750	450	1,266	7.83%	22.02%
Bandit Angelfish[6]	*Apolemichthys arcuatus*	NA	209	638	NA	NA

[1]Estimated population derived from NOAA data collected between 2010 and 2016 (CREP 2018).
[2]Average calculated from collection reports from 2000 to 2017 (DAR 2018a).
[3]Maximum calculated from collection reports from 2000 to 2017 (DAR 2018a).
[4]Calculated from average collected for each species between 2000 and 2017 and CREP population estimates.
[5]Calculated from the maximum collected for each species between 2000 and 2017 and CREP population estimates.
[6] NA = Data not available due to deep-water habits of species.

5.4.1.2.3 Hawai'i Species of Greatest Conservation Need

A total of 16,426 Psychedelic Wrasse were collected in O'ahu from 2000 to 2017 (DAR 2018a), representing 1.27% of the total fish collected over that time. The average number of Psychedelic Wrasse captured each year since 2000 was 913 individuals, ranging between a minimum catch of 646 individuals (2003) and maximum of 1,182 individuals (2000). It is anticipated that under the Preferred Alternative between the average of 913 and the maximum of 1,182 Psychedelic Wrasse would be collected over the 12-month analysis period, representing 0.62% (average) to 0.81% (maximum) of the estimated O'ahu Psychedelic Wrasse population based on CREP data (Table 11).

A total of 13,610 Fisher's Angelfish were collected in O'ahu from 2000 to 2017 (DAR 2018a), representing 1.05% of the total fish collected over that time. The average number of Fisher's Angelfish captured each year since 2000 was 756 individuals, ranging between a minimum catch of 258 individuals (2015) and maximum of 1,627 (2011). It is anticipated that under the Preferred Alternative between the average of 756 and the maximum of 1,627 Fisher's Angelfish would be collected over the 12-month analysis period, representing 0.39% (average) to 0.84% (maximum) of the estimated O'ahu Fisher's Angelfish population based on CREP data (Table 11).

A total of 143 Tinker's Butterflyfish were collected in O'ahu from 2000 to 2017 (DAR 2018a)[1], representing 0.01% of the total fish collected over that time. The average number of Tinker's Butterflyfish captured each year since 2000 was 13 individuals, ranging between a minimum catch of 0 individuals (2005) and maximum of 40 (2011). It is anticipated that under the Preferred Alternative between the average of 13 and the maximum of 40 Tinker's Butterflyfish would be collected over the 12-month analysis period. It is unknown what proportion of the O'ahu Tinker's Butterflyfish population this represents as CREP survey methods are not necessarily suited to this species' habitat (i.e., depths beyond 98 feet). Because of its deep-water habitat, this species is generally only captured at depths at which normal recreational diving does not occur. Due to the complexity and difficulty of collecting the Tinker's Butterflyfish, its population will likely continue to not receive significant pressure from the commercial aquarium fishery.

Table 11. CREP (2018) estimated populations of psychedelic wrasse, Tinker's butterflyfish, and Fisher's angelfish for the island of Hawai'i and percentage of population taken by commercial aquarium fishers in O'ahu (DAR 2018a).

Common Name	Scientific Name	O'ahu Population Estimate (CREP 2018)[1]	Average Number Collected per Year[2]	Maximum Number Collected per Year[3]	Average % of Population Collected [4]	Max % of Population Collected [5]
Psychedelic Wrasse	*Anampses chrysocephalus*	36,770	913	1,182	0.62%	0.81%
Fisher's Angelfish	*Centropyge fisheri*	18,475	756	1,627	0.39%	0.84%
Tinker's Butterflyfish	*Chaetodon tinkeri*	Unknown	13	40	Unknown	Unknown

[1]Estimated population derived from NOAA data collected between 2010 and 2016 (CREP 2018). All species population estimates are likely low due to the depths at which they occur.
[2]Average calculated from collection reports from 2000 to 2017 (DAR 2018a).
[3]Maximum calculated from collection reports from 2000 to 2017 (DAR 2018a).
[4]Calculated from average collected for each species between 2000 and 2017 and CREP population estimates.
[5]Calculated from the maximum collected for each species between 2000 and 2017 and CREP population estimates.

5.4.1.2.4 Invertebrate Species

Population estimates for invertebrate species are not available for the island of O'ahu.

Only 44 species were reported by enough permits (>2 permits reporting from each area of collection during each year of collection) to determine total number of individuals collected. Collection areas with

[1] No data from 2000–2002, 2004, 2007, 2012, and 2016.

less than three permits reporting fall under the DAR non-disclosure agreement, in which totals are not released publicly (Section 5.1). A total of 2,971,008 individual marine invertebrates have been reported under Aquarium Permits since 2000 on the island of O’ahu.

Of the invertebrates collected on O’ahu, 89.7% (2,664,728 individuals) reported represent just three species; hermit crabs (species not specified), Feather Duster Worms, and Zebra Hermit Crabs (Table 5). An additional 41 species account for the other 10.3% of invertebrates reported collected (excluding non-disclosed data) (DAR 2018a). It is anticipated that these collection levels would continue over the 12-month analysis period. This collection may continue regardless of alternative chosen.

5.4.1.2.5 Reef Habitat

Herbivores, which feed on marine algae, and especially coral scraping herbivores such as parrotfish (Scaridae), are widely considered to play a key role in the overall health and subsequent recovery of coral reefs after disturbances such as bleaching. The four largest groups of herbivorous coral reef fishes are the parrotfishes, damselfishes (Pomacentridae), rabbitfishes (Siganidae), and surgeonfishes (Acanthuridae). No parrotfishes, damselfishes, or rabbitfishes occur in the top 20 list of fish species collected in O’ahu.

Herbivores taken by the aquarium fishery typically consist of the smaller size classes, either by regulation (e.g., HAR 13-77 prohibits the take of more than 6 Yellow Tang/day larger than 5 inches) or by market demand (i.e., minimal market for large adult fish in the aquarium trade). The smaller fish primarily collected by commercial aquarium fishers are the least effective sizes for cropping algae. In addition, bag limits and prohibitions are in place for several herbivorous species in O’ahu, including Yellow Tang (100 total daily, 6 individuals <1.5 inches and 6 individuals >5 inches), Kole (75 total daily, 6 >5 inches) and Potter’s Angelfish (50 total daily]). These three species make up 45.3% of all individuals collected by commercial aquarium fishers in O’ahu since 2000. Even with making up the highest proportion of the catch, analysis based on CREP population estimates indicates the average annual collection of the three species represents less than 7% of the overall island of O’ahu population of Yellow Tang, less than 3% of the overall island of O’ahu population of Potter’s Angelfish, and less than 1% of the overall island of O’ahu population of Kole (Table 9). Therefore, it is not anticipated that a significant reduction in herbivores as a result of commercial aquarium collection would occur under the Preferred Alternative.

In a study analyzing the effects of aquarium collectors on coral reef fishes in Kona, Hawai’i, Tissot and Hallacher (2003) concluded that there were no significant differences in damaged coral between control and collected sites (i.e., sites where aquarium collection occurs) to indicate the presence of destructive fishing practices. In addition, they found no increases in the abundance of macroalgae where the abundance of herbivores was reduced by aquarium collecting.

The DAR has been conducting related observations since 2003 (DAR 2018c). Monitoring of coral reef benthic cover is conducted approximately every four years at 25 permanent monitoring sites. Monitoring is conducted more frequently if substantial benthic change occurs between regular sampling years (e.g. after a coral bleaching event). The analysis compares the presence or absence of commercial aquarium collecting in West Hawaiʻi relative to overall coral cover and changes in coral cover. Major results of the study are summarized below:

- Coral cover was slightly higher within areas closed to the commercial aquarium fishery compared to open areas, but the difference was not statistically significant for any year of monitoring (2003: p = 0.276; 2007: p = 0.275; 2011: p = 0.496; 2014: p = 0.554; 2016: p = 0.673; 2017: p = 0.782). Additionally, there was no apparent trend of declining coral cover in the open areas over time.

- From 2003 to 2017, overall mean coral cover declined less within open areas compared to areas closed to commercial aquarium collection (Closed areas: -22.5% ± 3.4%; Open areas: -15.5% ± 2.3%), but this difference in change in coral cover was not significant (p = 0.093).

- From 2014 to 2016, West Hawaiʻi experienced a severe coral bleaching and mortality event, which peaked in the fall of 2015. Over this time-period, overall mean coral cover decline was slightly less in the areas open to commercial aquarium collection, but again, the difference was not significant (Closed areas: -19.6 % ± 6.0 %; Open areas: -17.6 % ± 1.3 %; p = 0.605).

- From 2016 to 2017, approximately one year after coral post-bleaching mortality subsided, minimal change in coral cover was documented within areas open to commercial aquarium collection (Open areas: 0.07 % ± 2.1 %), compared to a slight decline in mean coral cover in areas closed to collection (Closed: -1.94 % ± 2.3 %), and this difference was statistically significant (p = 0.038).

Based on the above, no significant direct impacts to reef habitat or the resilience of corals to respond to widespread bleaching events due to commercial aquarium fishing would occur under the Preferred Alternative.

5.4.1.2.6 Impact of Aquarium Collection on Overall Fish Populations and Recruitment

While research into the reproductive biology and fecundity (i.e., ability to produce offspring) of specific species of reef fish is limited in availability, some generalities can be derived from available research, and most reef species are long-lived and highly productive. For reef fishes in general, the relationship between size and fecundity is well documented, with larger fish producing exponentially more eggs (Thresher 1984, Berkeley et al. 2004). Moreover, evidence from a diverse set of species indicates that older individuals produce larger, faster growing, and more starvation-resistant larvae (Thresher 1984, Bobko and Berkeley 2004). For these reasons, Birkeland and Dayton (2005) recommend protecting larger or older individuals

Yellow tang is a species which provides a good example of high fecundity, as well as the relationship between size and fecundity. Bushnell et al. (2010) studied yellow tang and found large individual variation in batch fecundity, with a range from 44 to >24,000 eggs per female produced on a single sampling date. Smaller females (3.1-4.75-inch standard length [LS]), produced limited numbers of eggs, while larger females (≥4.75-inch LS) were capable of maximal egg production (>20,000 eggs per batch). Bushnell et al. (2010) estimated the annual fecundity of yellow tang to average 1,055,628 eggs per female (with a standard error of 120,596 eggs).

In addition to high levels of fecundity, many reef fish are long-lived. Choat and Axe (1996) studied four *Naso* species in the Great Barrier Reef, and found life spans of 35 to 40 years, with rapid growth during the first 3 to 4 years of life. Eble et al. (2009) found that the Hawaiian kala (*Naso unicornis*) is also long-lived, with rapid initial growth. Sampled kala ranged in age from 1 to 58 years with the majority of growth occurring within the first 15% of the life span. These two studies indicate that *Naso* species in general exhibit life-spans in excess of 40 years (Eble et al. 2009). While studying habitat- and sex-specific life history patterns of yellow tang, Claisse et al. (2009) found a 41 year old individual. In addition, they found median size and age at the transition between deeper coral-rich and shallow turf dominated habitat use were about 0.75 inch longer and about 2 years older for males than females, and coincided with an increase in reproductive output. The sexual difference in size at habitat transition, combined with sexual size dimorphism results in differences in the size distributions of both sexes in the two habitats (Claisse et al. 2009).

Due to the combination of a high fecundity and long life-span, reef fish can likely sustain fairly high levels of continuous harvest. While specific research into sustainable levels of take has not been conducted for the majority of reef fishes, Ochavillo and Hodgson (2006) suggest collection of between 5% and 25% is sustainable for various reef species in the Philippines that are similar to those found in O’ahu (e.g., tang, wrasse, butterflyfish, angelfish, triggerfish). Seventeen of the top 20 collected species would be collected at numbers below 1% of their overall population if an average collection occurs over the 12-month analysis period (Table 9). For the remaining three species, an estimated 2.59% of the Potter’s Angelfish population, 7% of the Yellow Tang population, and 28% of the Flame Wrasse population would be collected (Table 9). However, the Flame Wrasse occurs primarily below the 98-foot depth limit of the CREP surveys, and therefore the majority of the population goes undetected, leading to an underestimation of its overall population. Due to this underestimation, it is not possible to know the exact proportion of the population that would be collected for this species, though it is assumed to be much less than 28%.

In addition to the low percentage of the populations which are harvested each year for most species, commercial aquarium fishing has a distinct advantage over other types of fishing because it is targeted to specific species, and within those species, it primarily targets specific size-classes which minimizes the impact to the brood stock. Because commercial aquarium fishers target the smaller individuals in populations, the larger individuals with higher fecundity are left within the population.

Based on the low percentage of the overall populations collected annually by commercial aquarium fishers for most species, which is spread throughout the year and across multiple areas, as well as the targeted take of smaller, less fecund individuals, commercial aquarium collection likely has minimal impact on populations in general.

5.4.2 Indirect Effects

5.4.2.1 No Action Alternative

Under the No Action Alternative issuance of Aquarium Permits would not occur and commercial aquarium fish collection would not take place. An estimated 72,000 (18-year average) individual fish would not be collected from O’ahu. A minor, although unquantifiable, increase in number of aquarium fish and SGCN species may occur over the 12-month analysis period which may provide additional viewing opportunities for tourists, an increase in the prey base, additional individual herbivores to maintain the reef, and increased competition between species for available resources. However, data do not exist that would allow for a thorough analysis of such effects.

The 165,000 invertebrates currently reported under Aquarium Permits may continue to be collected under the No Action Alternative using methods not requiring an Aquarium Permit. Removal of 165,000 invertebrates would result in a decrease in number of invertebrates over the 12-month analysis period, which may provide fewer viewing opportunities for tourists, a decrease in the prey base, and reduced competition between species for available resources. However, adequate data do not exist that would allow for a thorough analysis of the potential effects.

5.4.2.2 Preferred Alternative

Under the Preferred Alternative issuance of Aquarium Permits would occur and commercial aquarium fish collection would take place. An estimated 72,000 (18-year average) primarily juvenile fish would be collected from O’ahu and an estimated 165,000 invertebrates (18-year average) would be collected from O’ahu. Removal of over 72,000 primarily juvenile fish and over 100,000 invertebrates would result in a decrease in number of aquarium fish, invertebrates, and SGCN species over the 12-month analysis period, which may provide fewer viewing opportunities for tourists, a decrease in the prey base, and reduced competition between species for available resources. However, adequate data do not exist that would allow for a thorough analysis of the potential effects. Given the low proportion of the island populations of the species that would be removed (Table 9, Section 5.4.1.2), and the geographic area over which the removal would occur (i.e., island of O’ahu), it is anticipated that indirect impacts on viewing opportunities, prey base, and competition would be minor or nonexistent.

Based on the Tissot and Hallacher (2003) study and the 15 years of coral reef data collected and analyzed by the DAR (2018b) as described in Section 5.4.1.2, it is not anticipated that any significant indirect impacts to reef habitat would occur under the Preferred Alternative.

It is anticipated that implementation of the Preferred Alternative would have a minor effect on invasive fish species over the 12-month analysis period. A total of 2,621 individual Bluestripe Snappers and 175 Peacock Grouper, have been reported collected from O’ahu since 2000. The Blacktail Snapper has not been reported as caught from O’ahu over the 18-year analysis period.

5.4.3 Cumulative Impacts

5.4.3.1 Recreation Aquarium Fish Collection

Under HRS 188-31, individuals may use fine mesh nets (< 2-inch mesh) to collect aquatic life for an aquarium. A permit is not required if:

- The net has large mesh (more than two-inch mesh);
- The net has small mesh but is less than three feet in length, height, or width, including the handle; or,
- Using a slurp gun.

An aquarium permit is required if using a small mesh net other than a hand net, or a small mesh hand net larger than the dimensions indicated above. Small mesh throw nets are always prohibited. Even with an aquarium permit, regulations (e.g., minimum size, season, bag limits, etc.) still apply. The aquarium permit only exempts a person from the small mesh restriction. The recreational aquarium permit rules apply everywhere in the state.

Under a recreational aquarium permit, individuals are authorized to collect up to five aquatic animals per day (1,825 per year) (HAR 13.60.4). Since 2000, the number of recreational permits issued for the state (island-specific numbers not available) has averaged 159 annually (DAR 2018a). The DAR collected recreational aquarium fish catch information from 1975 until 1985, after which, data collection was discontinued, and currently no reporting of catch is required for recreational aquarium permit holders. Historic recreational collection data were not digitized or processed into a database, and therefore, are not available for analysis (DAR 2018a).

Because reporting of recreational aquarium catch is not required, the impact of recreational collection on species collected on O’ahu cannot be quantified. It is likely that not all recreational permit holders collect the maximum allowable number (1,825); however, if each of the average 159 statewide permit holders were to collect 50% of the allowable catch (913), it would result in the collection of 145,088 aquatic animals annually.

Because reporting of recreational aquarium catch is not required, the impact of the collection on SGCN cannot be quantified. Nevertheless, it is likely that SGCN are occasionally taken by recreational aquarium permit holders. However, given the low number of SGCN individuals collected by commercial aquarium collectors (average 913 Psychedelic Wrasse/year; average 756 Fisher’s Angelfish/year; average 13 Tinker’s Butterflyfish/year) it is estimated that recreational collectors are collecting fewer individuals of these species.

Because reporting of interactions (e.g., damage from contact with collection equipment) with corals resulting from recreational aquarium collecting and recreational aquarium catch is not required, the impact of the interaction with reef habitat cannot be quantified. However, studies conducted by Tissot and Hallacher (2003) found that aquarium collecting had no significant impact (beneficial nor detrimental) on reef habitat. In addition, 15 years of coral reef data collected and analyzed by the DAR (2018b) found no significant difference in coral cover in areas open to commercial aquarium fish collection. It is assumed that recreational aquarium collection would likewise not have a significant impact.

5.4.3.2 Commercial and Recreational Fishing (Non-Aquarium Fish)

Coral reef species are targeted by non-aquarium commercial fishers using numerous fishing gears including nets, traps, hook and line, spear, hand, and other methods. Commercial fish industry landings in Hawai‘i have increased annually since 2006 and the NOAA reported total landings in 2013 were valued near $108 million dollars (DLNR 2015). Akule (coastal pelagic scads) dominate nearshore commercial landings and are typically collected using surround or fence nets, gillnets or hook and line (WPRFMC 2018). Other top species by weight and value include soldierfishes, parrotfish, surgeonfishes, and goatfishes, which may be targeted because they may bring a high price in some seasons (WPRFMC 2018).

Non-commercial fishing includes subsistence/consumptive, recreational, and cultural fishing and gathering activities that occur in ocean and coastal zones. The State of Hawai'i has the most developed recreational fishing infrastructure in the U.S. Pacific, and is a substantial economic contributor to the State (WPRFMC 2017). The State of Hawai'i does not track non-commercial fish collection. However, creel surveys suggest that the total inshore non-commercial catch from reef areas could be as high as the reported commercial catch (WPRFMC 2017).

The most recent DAR summary report available on the West Hawai'i aquarium fishery (DAR 2014a) analyzed data collected since 2003 by the Hawai'i Marine Recreational Marine Fishing Survey (HMRFS) and subsequently since 2007 by NOAA's Marine Recreational Information Program (MRIP) to gain perspective on the generalized impact on reef fishes by aquarium collecting versus other types of reef fishing activities. Statewide, looking at the period from 2008-2011, the number of reef fishes caught by the recreational and commercial sectors was found to be comparable, averaging 1,511,025 per year for recreational fishers and 1,554,010 per year for commercial (i.e., non-aquarium) fishers. The combined catch was found to be 1.7 times the total statewide take of aquarium fishes (1,810,402/year).

In O'ahu, on average the aquarium fishery annually takes nearly a third (71,983/year) the number of reef fishes taken annually by recreational and other commercial fishers combined (194,674/year). However, unlike the aquarium fishery which targets mostly immature fish, the commercial and recreational fisheries selectively target the larger breeding portion of the population which has profound implications for the sustainable usage of the resource.

The commercial non-aquarium fish industry targets some coral reef species; however, commercial non-aquarium fishers do not directly target most aquarium fish species. Data evaluated for commercial non-aquarium fishing is lacking due to the DAR confidentiality regulations (HRS §189-3). Since most commercial non-aquarium fishers do not target aquarium species, there are usually less than three fishers reporting. Therefore, the data presented in Table 16 is underestimated.

Table 12. Available data on White List species collected by commercial non-aquarium fishers in the State and on the island of O'ahu from 2000-2017. n.d. = Not Disclosed (DAR 2018a).

White List Species	Island of O'ahu Collection	State Collection Total
Achilles Tang	*n.d.*	10,641
Yellow Tang	*n.d.*	*n.d.*
Kole (=Goldring Surgeonfish, Yelloweye, Goldring)	2,607	103,391
Peacock Grouper (=Roi, bluespot peacock grouper)	8,452	17,892
Eyestripe Surgeon (=Palani)	132,214	202,286
Orangeband (=Shoulder) Surgeonfish	79,744	95,380
Saddle Wrasse	238	1,150
Brown Surgeonfish (=Lavender, Forktail Tang)	*n.d.*	58
Bluestripe Snapper (=Taape)	415,242	715,913
TOTAL	**638,497**	**1,146,711**

It is expected that the average number of aquarium fish collected by commercial non-aquarium fishers will continue at these rates (at a minimum) over the 12-month analysis period.

Because reporting of recreational and subsistence non-aquarium catch is not required, the impact of recreational and subsistence collection on reef fish and invertebrates, and SGCN cannot be quantified. However, nearshore recreational and subsistence catch is likely at similar catch levels of commercial non-aquarium fishing (Walsh et al. 2003).

5.4.3.3 Tourism

Hawai'i is a major tourist destination and tourism subsequently contributes the most to the state's economy. Over time this industry has grown and reshaped the native landscapes and sensitive ecosystems through major coastal development, increased energy consumption, and tourism based recreational activities. Major coastal development for tourism (i.e., hotels, resorts, restaurants, recreational outfitters) and associated point source pollution (e.g., petroleum hydrocarbons, pharmaceuticals, heavy metals, and sediment from agriculture and development) threaten the quality of coral reef ecosystems (State of Hawai'i 2010). When coral reefs are damaged, it could potentially expose reef dependent organisms and leave them vulnerable to other threats such as disease, predation, and climate change (State of Hawai'i 2010), including the reef fishes and other aquatic animals targeted by both commercial and recreational aquarium fishers.

Human interaction with native flora and fauna is also a growing concern. Damage to sensitive ecosystems (i.e., coral reefs, tide pools, shorelines) through tourism based recreation overuse (e.g., SCUBA diving, snorkeling, etc.) have been attributed to killing many aquatic organisms that in turn may affect many more species that rely on such organisms as a food source. Damage to coral reef habitat in association with tourism (through coastal development, point source pollution, and recreational activities) threatens most reef fish and invertebrate species that are dependent on reefs for habitat and foraging in the foreseeable future (State of Hawai'i 2010).

5.4.3.4 Climate Change

Warming of the planet and rising average temperatures may produce variations in precipitation and temperature patterns, sea levels, and storm severity. This process is commonly referred to as "climate change." Changes in sea surface temperatures have been documented, with temperatures warmer than normal in recent years (increase of 0.22 °F per decade), and even reaching record levels of thermal stress in September 2015 (Casey and Cornillon 2001; Gove et al. 2016). Warmer water temperatures can result in coral bleaching. When water is too warm, corals will expel the algae living in their tissues causing the coral to turn completely white. When coral bleaches, it is not dead; corals can survive a bleaching event, but they are under more stress and are subject to mortality. In 1998, global coral bleaching and die-off was unprecedented in geographic extent, depth, and severity. Researchers predict that coral bleaching events would occur when the average sea temperatures are 33.8 °F or more above average (DLNR 2015). In the fall of 2015, leeward reefs of Hawai'i Island suffered catastrophic coral mortality due to widespread and severe coral bleaching. Survey results indicated that overall coral bleaching prevalence averaged 53.3%, and resulted in an average coral cover loss of 49.7%. Regional differences in bleaching prevalence and subsequent coral mortality were not detected. High post-bleaching mortality was detected for the coral species, *P. meandrina, P. evermanni*, and *Porites lobate* (Kramer et al., 2016). Acidification can also damage corals and marine life that depend on minerals for shell/skeletal development. The acidity of the Pacific Ocean has increased by about 25% over the last 300 years, and is predicted to increase 40-50% by 2100 (EPA 2016).

Changes in climate currently impact the physical resources of Hawai'i. Warming sea temperatures and acidification could result in damage, disease outbreaks, and ultimately death of coral reefs. The weakening or loss of coral reef ecosystems may threaten entire marine ecosystems in the region as many organisms, including numerous fish species, are not only dependent on these ecosystems for suitable habitat, but due to the isolation of the islands in the central pacific, are unable to move to new environments that provide suitable conditions for survival (EPA 2016).

Several reef fish and invertebrate species are endemic to the Hawaiian Archipelago (including Johnston Atoll) and therefore may be impacted when faced with changes in climate over time (e.g., warming temperatures, habitat loss due coral bleaching, etc.). The extent and severity of impacts to reef species from climate change has been ongoing for decades and are expected to increase in the foreseeable future. If environmental fluctuations resulting from climate change (e.g., tropical storms, coral bleaching episodes, acidification, etc.), or other natural or human factors, change habitat conditions, fishing mortality may present a higher risk to some reef fish and invertebrate species and SGCN

5.5 EVALUATION OF SIGNIFICANCE CRITERIA

1. The Preferred Alternative does not involve an irrevocable commitment or loss or destruction of any natural or cultural resource. If the average collection based on 18 years of data were to occur over the 12-month analysis period, the collection of 17 of the top 20 collected aquarium species would result in the loss of less than 1% of their respective overall island of O'ahu populations (Section 5.4.1.2, Table 9 - Average Percent of Island of O'ahu Population). Two of the remaining three species (Yellow Tang [7%] and Potter's Angelfish [2.6%]) would be collected at less than 10% of their overall population. Based on available data, 28% of the Flame Wrasse population may be collected in an average annual collection; however, the Flame Wrasse population is likely underestimated due to its deepwater and secretive habits, and CREP population surveys were completed at a maximum depth of 98 feet. Therefore, the actual proportion of the population that would be removed is likely much less than 28%. Ochavillo and Hodgson (2006) suggest collection of between 5%-25% is sustainable for various reef species similar to those found in O'ahu (e.g., tang, wrasse, butterflyfish, angelfish, triggerfish).

   Based on the results of the Tissot and Hallacher (2003) study and the 15 years of data collected and analyzed by the DAR (2018c), no significant direct impacts to reef habitat due to commercial aquarium fishing would occur under the Preferred Alternative.

   The Applicant's action does not include any activities different from or in addition to those that have occurred in the past. There would be no construction of permanent or semi-permanent infrastructure, no discharges into coastal, surface or ground waters, and no dredging, and no significant use of hazardous materials that could be released into the environment.

The DLNR's issuance of Aquarium Permits is not anticipated to result in significant beneficial or adverse impacts to water and air quality, geology and soil resources, aesthetics, noise, vegetation, terrestrial wildlife and avian species, threatened and endangered species, land use, public health and safety, communications, historical resources, transportation, utilities, or population and demographics from the current baseline condition.

2. The Preferred Alternative does not curtail the range of beneficial uses of the environment. Act 306 has created a platform on which the public can learn about and participate in the management of the fishery. Since the Act's implementation, the DAR has created Fish Replenishment Areas in the state and conducts annual monitoring and research on the fish and coral, ensuring that the full range of beneficial uses of the environment remain now and into the future. The loss of the aquarium fishery may mean the loss of funds to support monitoring and research that benefits reef ecosystems.

3. The Preferred Alternative does not conflict with the State's long-term environmental policies, goals, or guidelines as expressed in chapter 344 HRS.

4. The Preferred Alternative does not substantially affect the economic welfare, social welfare, and cultural practices of the community or State, but plays an important role as a nearshore fishery in the state. For the period 2000 to 2017, the aquarium fishery in O'ahu added an average of $506,251 (inflation-adjusted 2017 dollars) annually to the state of Hawai'i's economy, while the overall aquarium fishery within the state of Hawai'i added an average of $2,075,088 (inflation-adjusted 2017 dollars) to the economy. In 2017, it is estimated that up to 100 individuals were directly employed in the aquarium fishery in O'ahu (up to 266 employed in the state of Hawai'i). Loss of the fishery would result in the loss of income, tax revenue, and jobs.

5. The Preferred Alternative will not affect public health.

6. The Preferred Alternative does not involve substantial secondary impacts, such as population changes or effects on public facilities. There is no expectation that populations or the public will be negatively impacted by continuing the fishery.

7. The Preferred Alternative does not involve a substantial degradation of environmental quality. Two studies have concluded that the fishery has no significant impact on coral or the reef ecosystem (Tissot and Hallacher 2003; DAR 2018c).

8. The Preferred Alternative does not have significant cumulative effect upon the environment or involve commitment for larger actions.

9. The Preferred Alternative does not affect threatened or endangered species or their habitats.

10. The Preferred Alternative does not detrimentally affect air or water quality or ambient noise levels. On average, approximately 40 boats are involved in the island of O'ahu's fishery as compared to the thousands of other boats on the waters of Hawai'i.

11. The Preferred Alternative would not significantly affect or suffer damage by being located in environmentally sensitive areas, geologically hazardous land, estuaries, freshwater, or coastal water. As noted earlier, the fishery has been active since the late 1940s. Regulations have been implemented restricting the fishery from sensitive areas.

12. The Preferred Alternative does not substantially affect scenic vistas and viewplanes identified in county or state plans or studies.

13. The Preferred Alternative does not require substantial energy consumption.

Under HRS 188-31, the DLNR may issue a commercial Aquarium Permit to a qualified party for a period of one year in duration, subject to renewal. Therefore, this EA analyzes the direct, indirect and cumulative impacts of Aquarium Permits on affected resources for a period of one year. However, at the end of one year, if environmental conditions presented in this EA (e.g., annual catch, population estimates and/or trends, reef health, etc.) are not materially different than those analyzed in this EA, then this EA may adequately disclose the environmental impacts of new or renewed Aquarium Permits. Consequently, DLNR will reevaluate the analysis contained in this EA on an annual basis prior to renewal or issuance of commercial Aquarium Permits and it will assess if any new information exists warranting reevaluation of this analysis.

6.0 AGENCIES, ORGANIZATIONS, AND INDIVIDUALS CONSULTED

6.1 FEDERAL AGENCIES

The following federal agencies were consulted during the development of this DEA:

- National Oceanic and Atmospheric Administration, Coral Reef Ecosystem Program;
- Western Pacific Regional Fishery Management Council.

6.2 STATE AGENCIES

The following state agencies were consulted during the development of this DEA:

- Hawai'i Department of Land and Natural Resources, Division of Aquatic Resources;
- Hawai'i State Department of Health, Office of Environmental Quality Control.

6.3 COMMUNITY ORGANIZATIONS

The following community organizations were consulted during the development of this DEA:

- Hawai'i Fishermen's Alliance for Conservation and Tradition;

- Hawai'i Hunting, Farming & Fishing Association;
- Pacific Islands Fisheries Group.

6.4 INDEPENDENT REVIEWERS

The Applicant solicited independent scientific peer reviews of the information contained in this DEA from the following individuals:

- Dr. Rob Toonen, Researcher, Hawai'i Institute of Marine Biology, SOEST, University of Hawaiʻi at Mānoa;
- Dr. Brian Bowen, Researcher, Hawai'i Institute of Marine Biology, University of Hawaiʻi at Mānoa;
- Dr. Richard Pyle, Database Coordinator, Associate Zoologist, Dive Safety Officer, Bernice Pauahi Bishop Museum.

Comments from Dr. Bowen and Dr. Pyle, along with resumes for each, are included in Appendix A.

7.0 LIST OF PREPARERS

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APPENDIX A

Independent Reviewer Comments and Resumes

Dr. Brian Bowen, Researcher
Hawai'i Institute of Marine Biology, University of Hawaiʻi at Mānoa

From: Brian Bowen [mailto:bbowen@hawaii.edu]
Sent: Thursday, March 08, 2018 7:42 PM
To: Lynch, James M.
Subject: Re: Hawaii AQ Fishery

Jim:

Attached my comments/suggestions on the draft Hawaii EA. My suggested changes are on pages 7,23,33,37,40,41,43-46,52,55, 94, plus references. I added two references to further document life history.

None of these changes are pertinent to the science, just matters of presentation.

I find the conclusions about the preferred alternative to be supported by the best available science, and don't know of any science that was omitted or overlooked. It is an impressive document.

Yes, you can use my comments publicly. Thank you for doing this.

Brian

March 2018

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1987 Master of Science, Marine Biology, College of William and Mary
Advisor: Dr. John A. Musick

1992 Doctor of Philosophy, Genetics, University of Georgia
Advisor: Dr. John C. Avise

Thesis Titles

Bowen, B.W. 1987. Population structure of the white perch, *Morone americana*, in lower Chesapeake Bay. M.A. thesis, College of William and Mary, Williamsburg VA.

Bowen, B.W. 1992. Evolutionary genetics and natural history of marine turtles. Ph.D. dissertation, Univ. of Georgia, Athens.

Professional Experience

1975-present Advanced scuba, rescue diver, nitrox diver

1981 Appalachian Trail, walked 2140 miles from Georgia to Maine

1983-85 Marine Turtle Stranding Network, Virginia

1984 Groundfish Survey, National Marine Fisheries Service

1984-85 Chesapeake Bay Monthly Trawl Surveys

1986-2000 12 international expeditions to collect specimens of sea turtles

1992-97 Established and directed the Conservation Genetics Core in the Biotechnology Program at University of Florida

1994 Organized a conservation genetics workshop for biologists from developing nations (February 1994), funded by the U.S. Agency for International Development and the National Science Foundation.

1994 Organized a colloquium, Phylogeography of the Testudines, for the annual meeting of the Society for Study of Amphibians and Reptiles

1994-96 National Science Foundation Panelist: Conservation and Restoration Biology

1995 Organized and convened the International Symposium on Conservation

	Genetics of Marine Turtles, with W.W. Witzell (September 1995)
1996	Workshop on Endangerment and Extinction in the Sea, organized by Elliot Norse, Center for Marine Conservation, Washington D.C.
1997-2002	Assistant Professor, Dept. of Fisheries and Aquatic Sciences, Univ. of Florida
1997-2011	Lecturer in short course organized by Stephen O'Brien: Recent Advances in Conservation Genetics, NIH/Smithsonian/Natl. Zoo
1998	New graduate course: Marine Phylogeography
1999	National Science Foundation Panelist: Biological Oceanography
1999	Marine Mammal Molecular I.D. Workshop, La Jolla, CA (June)
2000	Organized a colloquium, Taxonomic Status of the Black Turtle, for the annual meeting Sea Turtle Biology and Conservation, Orlando, FL
2000-2002	Annual expeditions to Bahamas to survey reef organisms, using the Florida research vessels Suncoaster and Bellows (with S.A. Karl)
2003 – 2006	Assistant research professor, Hawaii Institute of Marine Biology, Univ. of Hawaii
2003 - present	International expeditions to collect reef fishes at Christmas Island (Pacific Ocean), American Samoa, Okinawa, Marshall Islands, Johnston Atoll, Palau, Cocos/Keeling, Christmas Island (Indian Ocean), French Polynesia, Chagos, Saudi Arabia, Cook Islands, Djibouti, Philippines, and elsewhere
2005 – 2010	Three domestic expeditions (24 – 30 days) as chief HIMB scientist on the NOAA research vessel Hiialakai, to conduct scuba sampling in the Northwest Hawaiian Islands (Papahanaumokuakea Marine National Monument)
2006 – 2010	Associate Research Professor, Hawaii Institute of Marine Biology, Univ. of Hawaii.
2007	Hosted and organized the short course with Stephen O'Brien: Recent Advances in Conservation Genetics, Jan. 7-20, 2007.
2007-2016	Chair, HIMB Departmental Personnel Committee
2008	Mesophotic Reef Research Priorities Workshop, Jupiter Beach, FL (July)
2008	IUCN Marine Turtle Specialist Group, Burning Issues, Shepherdstown, West Virginia (August)
2008 – 2010	Training on the Silent Diving "Evolution" closed-circuit rebreather, to facilitate deep reef exploration
2009	Convened symposium *Phylogeography of Reef Fishes* with Luiz Rocha at the 8th Indo-Pacific Fish Conference, Fremantle, Australia (June)
2010 - present	Research Professor, Hawaii Institute of Marine Biology, Univ. of Hawaii
2016	National Science Foundation Panelist: Graduate Research Fellowship Program (Evolution and Systematics)
2016	Organizer: National Academy of Sciences Sackler Colloquia: *In Light of Evolution X: Comparative Phylogeography* (January 8-9), with Francisco Ayala and John Avise

Awards

1990	American Society of Ichthyologists and Herpetologists, Stoye Award for best student paper in herpetology
1991	Annual Marine Turtle Symposium, award for best student paper
1992	University of Georgia, Charles C. Anderson Memorial Award for research excellence in a dissertation thesis
1996	Fellow, American Association for the Advancement of Science
2015	Kobe Award (Japan) for lifetime achievement in aquatic biology
2016	University of Hawaii Board of Regents Excellence in Research Award

Graduate Students and Post-Doctoral Researchers

<u>M.S. Program</u>
Joseph Roman (1998), Jeff Colborn (1999), Andrew Muss (1999), Ellen Waldrop (2014), Anna Pauliina Ahti (2014), Richard Coleman (2014), Garrett Johnson (2016)

<u>Ph.D. Program</u>
Angelica Garcia-Rodriguez (2000), Luiz Rocha (2003 w/Debra Murie), Jennifer Schultz (2009), Toby Daly-Engel (2009 w/Kim Holland), Jeff Eble (2010), Timothy Clark (2010 w/Kim Holland), Michelle Gaither (2011), Craig Musburger (2012 w/Kim Holland), Christie Wilcox (2014), Joshua Copus (current), Richard Coleman (current), Sean Canfield (current), Michael Hoban (current), Cassie Ka'apu-Lyons (current), Derek Kraft (current), Keith Kamikawa (current), Charley Westbrook (current)

<u>Post-Doctoral Program</u>
Matthew Craig (2005 - 2009)
Luiz Rocha (2006 - 2008)
Joseph DiBattista (2009 – 2012)
Kim Andrews (2010 – 2012)
Iria Fernandez Silva (2010 – 2013)
Jean-Paul Hobbs (2014 – 2015)

Professional Societies

American Genetics Association
International Biogeography Society
International Society for Reef Studies
Society for the Study of Evolution
American Academy of Underwater Sciences

Professional Affiliations

Graduate Faculty, Marine Biology Graduate Program, Univ. of Hawaii
Graduate Faculty, Dept. of Cell and Molecular Biology, Univ. of Hawaii
Graduate Faculty, Dept. of Biology, Univ. of Hawaii
Graduate Faculty, Ecology, Evolution, and Conservation Biology Program (EECB), Univ. of Hawaii

Advisory Positions

1994 - present	IUCN Species Survival Commission, Marine Turtle Specialist
1994-2000	Conservation Committee, Soc. Study of Amphibians and Reptiles
1998-2010	Fundacao Pro-TAMAR (Brazil) Ad-Hoc Consultants Committee
2000-2002	Lab for Conservation Genetics, Max Planck Inst., Scientific advisor
2001-2002	Steering Committee, North Atlantic Biogeography Project
2005 - 2016	Reserve Advisory Council, NW Hawaiian Islands Marine Sanctuary
2006-2012	Science and Statistics Committee, Western Pacific Regional Fishery Management Council
2006-2008	Research Council, UH School of Oceanography (SOEST)
2009-2010	National Research Council, Committee on the Review of Sea Turtle Population Assessment Methods
2010 – present	International Steering Committee, Indo-Pacific Fish Conference
2010 – present	Genome 10K Project Associate
2011 – present	EECB Grants Committee (internal grants at UH)

2011	NOAA PIFSC External Program Review – Sea Turtles
2012 – 2013	University of Hawaii Diving Control Board
2013 – present	Chair, University of Hawaii Diving Control Board
2014 - present	UH Marine Biology Graduate Program, curriculum committee
2016 – 2017	UH Biology Department, graduate instruction committee
2016 – 2017	Chair, marine mammal faculty search committee
2017 – present	UH Biology Department, graduate admissions committee

Editorial Positions

1993-1999	*Genetica*, Associate Editor
1996-2004	*Herpetological Review*, Associate Editor
1998-2000	*Evolution*, Associate Editor
2000-2012	*Molecular Ecology*, Editorial Review Board
2003-2013	*Journal of Heredity*, Associate Editor

Invited Presentations (includes 39 international presentations in 22 nations and territories)

1990 U.S Air Force Base, Ascension Island, U.K.

1991 Southwest Fisheries Science Center, La Jolla CA

1992 Archie Carr Center for Sea Turtle Research, University of Florida
National Marine Fisheries Service, Charleston Lab, Charleston SC
Hopkins Marine Lab, Stanford University, Pacific Grove CA
CINVESTAV Graduate Research Institute, Merida, Yucatan, Mexico

1993 Drexel University, Philadelphia PA
University of Central Florida, Orlando FL
Louisiana State University, Baton Rouge LA
Annual Interuniversity Congress on Marine Turtles, Mazatlan, Mexico

1994 Second World Congress of Herpetology, Adelaide, Australia
Society for the Study of Evolution, annual meeting, Athens GA
Symposium on Molecular Genetics of Marine Mammals, La Jolla CA

1995 American Assn. for Advancement of Science, annual meeting, Atlanta GA
University of Vermont, Burlington VT
Society for Study of Amphibians and Reptiles, annual meeting, Boone NC

1996 Western Society of Naturalists, annual meeting, Seattle WA
Crocodilian DNA Workshop, Univ. of South Carolina, Columbia SC
Florida Academy of Sciences, annual meeting, Melbourne FL
University of California, Santa Cruz CA
American Genetics Association, annual meeting, Athens GA
University of South Florida, St. Petersburg, FL
Atwood Memorial Lecture, University of Toronto, Ontario, Canada
Dickinson Memorial Lecture, University of Richmond, Richmond, VA

1997 National Shellfish Association, annual meeting, Gulf Coast FL
Gulf Coast Research Lab, Ocean Springs, MS
Florida Wildlife Rehabilitators Association, Live Oak, FL
Southampton University, Long Island, NY

1998 Annual Symposium on Sea Turtle Biology and Conservation, Mazatlan, Mexico, **Keynote address**
Society for Study of Amphibian and Reptiles, annual meeting, Guelph, Canada
Universidad Federal da Paraíba, Joáo Pessoa, Brazil
TAMAR Sea Turtle Station, Isla Fernando de Noronha, Brazil
Duke University, Durham, NC
Ninth Annual Meeting of the Japanese Sea Turtle Society, Yagushima, Japan, **Keynote address**
University of South Florida, Tampa, FL

1999 Universite Laval, Quebec City, Canada
Marine Mammal Molecular Identification Workshop, La Jolla, CA
International Seminar on the Biology and Conservation of Sea Turtles, Santa Marta, Colombia
Centre d'Etude et de Decouverte des Tortue Marines, Reunion Is., French Indian Ocean Territory

	University of South Carolina, Columbia, SC
2000	Sea Turtle Biology and Conservation, annual meeting, Orlando, FL
	Whitney Marine Lab, Volusia, FL
	College of Veterinary Medicine, Univ. of Florida
	Society for Conservation Biology, annual meeting, Missoula, MT
	College of Charleston, Charleston SC
2001	Wheaton College, Norton, MA
	Whitney Marine Lab, Volusia, FL
	Keynote address, FECES 9th Annual Meeting, Ordway, FL
	University of South Carolina, Columbia, SC
	University of New Orleans, LA
2002	Montana State University, Missoula, MT
	McGill University, Montreal, Quebec, Canada
	Univ. of Southern California, Los Angeles, CA
	Univ. of Hawaii, Honolulu, HI
	National Conservation Training Center, Shepherdstown, WV
	Florida Atlantic University, Boca Raton, FL
2003	Annual Hawaii Conservation Conference, Honolulu, HI
	International Biogeography Society, inaugural meeting, Mesquite, NV
	Dept. of Zoology, University of Hawaii, Manoa HI
2004	International Coral Reef Symposium, Okinawa, Japan
	Dept. of Biology, University of Hawaii, Hilo HI
	American Samoa Community College, Pago, Pago, Am. Samoa
2005	Smithsonian Tropical Research Institute, Bocas del Toro, Panama
2006	Hanauma Bay Nature Reserve, Hawaii
2007	Sea of Islands Forum, Honolulu, Hawaii
2008	Air Force Command, Diego Garcia, British Indian Ocean Territory
	Hopkins Marine Station, Stanford University
	Pelagic Fisheries Research Program, SOEST, Honolulu
	EECB Program, University of Hawaii
2009	Smithsonian Tropical Research Institute, Gamboa, Panama
	Eighth Indo-Pacific Fish Conference, Fremantle, Australia:
	Phylogeography of Indo-Pacific Reef Fishes (Symposium Organizer)
	Pacific Science Intercongress, Tahiti, **Keynote Address**
	Western Pacific Regional Fisheries Management Council
2010	Conservation Genetics Course, White Oak Plantation, Florida
	International Sea Turtle Society, Goa, India, **Keynote Address**
	Association for Tropical Biology and Conservation, Bali, Indonesia
	American Genetics Association, Hilo, HI
2011	King Abdullah University of Science and Technology, Saudi Arabia
	Evolution of Life on Pacific Islands and Reefs, Honolulu, HI
	22nd Pacific Science Congress, Kuala Lumpur, Malaysia
	Conservation Genetics Course, Aquidauana, Pantanal, Brazil
	Google Managers Retreat, Princeville, Kauai, HI
	International Congress of Conservation Biology, Auckland NZ
2012	Smithsonian Tropical Research Institute, Gamboa, Panama
	National Center for Evolutionary Synthesis, Duke Univ., Durham NC
	University of the South Pacific, Cook Islands
	Smithsonian Journeys/Celebrity Cruise Line speaker, Bermuda
	King Abdullah University of Science and Technology, Saudi Arabia
2013	Oceanographic Center, Nova Southeastern University, FL
	University of the Ryukyus, Japan
	Ninth Indo-Pacific Fish Conference, Okinawa, Japan
	Gordon Research Conference on Marine Molecular Ecology, Hong Kong
	Ocean University of China, Qindao, China
	Oceanographic Institute, Chinese Academy of Sciences, China
	Hawaii Pacific University, Kailua, HI
	Bureau of Fisheries and Aquatic Resources, Quezon, Philippines
2014	King Abdullah University of Science and Technology, Saudi Arabia
	Texas A&M University, College Station Campus, **Plenary Speaker**
	Texas A&M University, Corpus Christi Campus

	Smithsonian Botanical Symposium on Biogeography, Washington D.C.
	University of California, Santa Cruz CA
2015	Atmosphere and Ocean Research Institute, Univ. Tokyo, Japan (March)
	Suma Aqualife Park, Kobe, Japan (May 23)
	Hotel Okura, Kobe, Japan (Ceremony to accept Kobe Award, May 24)
2016	University of California, Irvine CA
2017	University of Tokyo/University of Hawaii Joint Symposium on Ocean, Coastal, and Atmospheric Science, Honolulu
	University of Ryukyus, Okinawa, Japan

ELECTRONIC MEDIA

On Lionfish Invasion
https://www.hakaimagazine.com/article-short/invasive-lionfish-may-be-superfish-hybrids
https://blog.oup.com/2017/10/lionfish-perfect-invader/

Think-Tech on population genetics with Rob Toonen
https://www.youtube.com/watch?v=idwR098oOaE

On the colonization of Hawaii
Voice of the Sea VOS4-12 The Kiritimati to Hawai'i Connection
https://vimeo.com/237805099 or https://youtu.be/4jPlTfQIFcM

Voice of the Sea VOS5-3 Fish Origins Revealed in DNA
https://vimeo.com/257572127 or https://youtu.be/7n13RLwV58g

BOOKS

Bowen, B.W. and W.N. Witzell (eds.) 1996. Proceedings of the International Symposium on Sea Turtle Conservation Genetics. NOAA Tech. Memo. NMFS-SEFSC-396. Silver Spring, MD

Helfman, G.S., B.B. Collette, D.E. Facey, B.W. Bowen. 2009. The Diversity of Fishes, Second Edition. Wiley-Blackwell, Oxford, UK

National Research Council. 2010. Sea Turtle Status and Trends: Integrating Demography and Abundance. National Academies Press, Washington, D.C. *Authors*: K.A. Bjorndal (*chair*), B.W. Bowen, M. Chaloupka, L.B. Crowder, S.S. Heppell, C.M. Jones, M.E. Lutcavage, D. Policansky, A.R. Solow, B.E. Witherington.

CHAPTERS

Bowen, B.W. 1995. Molecular genetic studies of marine turtles. Pp. 585-588 *In* Biology and Conservation of Sea Turtles, Second Edition, K. Bjorndal (ed.) Smithsonian Institution Press, Washington, D.C.

Bowen, B.W. and J.C. Avise. 1995. Conservation genetics of marine turtles. Pp. 190-237 *In* Conservation Genetics: Case Histories from Nature, J.C. Avise and J.L. Hamrick (eds). Chapman and Hall, NY.

Bowen, B.W. and S.A. Karl. 1996. Population structure, phylogeography, and molecular evolution. Pp. 29-50 *In* The Biology of Sea Turtles, P.L. Lutz and J.A. Musick (eds.), CRC Press, Boca Raton, FL

Bowen, B.W. 1997. Complex population structure and the conservation genetics of migratory marine mammals: lessons from sea turtles. *In* Molecular Genetics of Marine Mammals, A.E. Dizon, S.J. Chivers, and W.F. Perrin (eds.), J. Marine Mammalogy, Special Publication 3:77-84.

FitzSimmons, N.N., B.W. Bowen, and C. Moritz. 1999. Population identification. Pp. 72-79 *In* K. Eckert, K.A. Bjorndal, A. Abreu-Grobois (eds.) Research and Management Techniques for the Conservation of Marine Turtles. IUCN/SSC Marine Turtle Specialist Group Publication No. 4.

Bowen, B.W. 2003. What is a loggerhead turtle? The genetic perspective. Pp. 7 – 27 *In* A.B. Bolten and B. Witherington (eds.) The Biology of Loggerhead Sea Turtles. Smithsonian Institution Press, Washington, D.C.

Briggs, J.C., B.W. Bowen and M.A. Rex. 2004. Introduction to Biogeography of the Sea. Pp. 233-237 *In* Lomolino and Brown (eds.) Frontiers in Biogeography. Sinauer Assoc., Sunderland MA.

Friedlander, A., J. Caselle, J. Beets, C. Lowe, B.W. Bowen, T. Ogawa, K. Kelly, T. Calitri, M. Lange, and B. Anderson. 2007. Biology and ecology of the recreational bonefish fishery at Palmyra

Atoll National Wildlife Refuge with comparisons to other Pacific Islands. Pp. 28-56 *In* J.S. Ault (ed.) Biology and Management of the World Tarpon and Bonefish Fisheries. CRC Press, Boca Raton, FL

Bowen, B.W., S.A. Karl, and E. Pfeiler. 2007. Resolving evolutionary lineages and taxonomy of bonefishes (*Albula* spp.). Pp. 147-154 *In* J.S. Ault (ed.) Biology and Management of the World Tarpon and Bonefish Fisheries. CRC Press, Boca Raton, FL

Sheppard, C.R.C., B.W. Bowen, C.A. Chen, M.T. Craig, J.A. Eble, N.N. Fitzsimmons, C.-H. Gan, M.R. Gaither, M. Gollock, S. Keshavmurthy, H. Koldewey, J.A. Mortimer, D. Obura, M. Pfeiffer, A.D. Rogers, A.L.S. Sheppard, C. Vogler, G. Worheide, M.-C. Yang, C. Yesson. 2013. British Indian Ocean Territory (the Chagos Archipelago): Setting, Connections and the Marine Protected Area. Pp. 223 – 240 *In* C.R.C. Sheppard (ed.) Coral Reefs of the United Kingdom Overseas Territories, Springer Netherlands.

Eble, J.A., B.W. Bowen, G. Bernardi. 2015. Phylogeography of coral reef fishes. Pp. 64 – 75 *In* C. Mora (ed.) Ecology of Fishes on Coral Reefs. University of Hawaii Press, Honolulu

Toonen, R.J., B.W. Bowen, M. Iacchei, J.C. Briggs. 2016. Marine Biogeography. *In* R.M. Kliman (ed.) The Encyclopedia of Evolutionary Biology. Pp. 166 – 178. Oxford: Academic Press

Bowen, BW, Gaither MR, DiBattista JD, Iacchei M, Andrews KR, Grant WS, Toonen RJ, Briggs JC. 2017. Comparative phylogeography of the ocean planet. Pp. 5 – 21 *In* Avise JC, Ayala FJ, Eds. In the Light of Evolution, Volume X: Comparative Phylogeography. Washington, DC: The National Academies Press. doi: 10.17226/23542.

Spalding, H.L., J.M Copus, R.K. Kosaki, K. Longenecker, A.D. Montgomerey, J.L. Padillo-Gamino, F.A. Parrish, M.S. Roth, S.J. Rowley, B.W. Bowen, R.J. Toonen, R.L. Pyle. Hawaiian Archipelago. In Puglise K (ed.) Mesophotic Coral Ecosystems. Springer, New York *In review*

Hixon, M.A., B.W. Bowen. Marine Fishes. In Maclean N (ed.) The Living Planet: The Present Status of the World's Wildlife *In prep*

ESSAYS, COMMENTARIES, AND POPULAR PUBLICATIONS

Bowen, B.W. 1992. C.I.T.E.S and Scientists: Conservation in Conflict. Marine Turtle Newsletter 58:5-6.

Bowen,B.W., J.C. Avise. 1994. Conservation research and the legal status of PCR products. Science 266:713.

Bowen, B.W., J.C. Avise. 1994. Tracking turtles through time. Natural History 103(12):36-42.

Bowen, B.W. 1996. Exploring the oceans with DNA sequences. Guest Essay*In* M.R. Cummings, Biology: Science and Life. West Publishing. p. 565.

Bowen, B.W. 1996. Conservation genetics of crocodiles: lessons from marine turtles. Pp. 5-7 *In* J.M. Dantzler (ed.) Crocodilian DNA Research: a report on a workshop on the genetics of the crocodilians. Occasional Papers in Environmental Policy 96-1, Center for Environmental Policy, University of South Carolina, Columbia.

Bowen, B.W. A.L. Bass. 1996. Are the naturalists dying off? Conservation Biology 10:923-924.

Bowen, B.W., W.N. Witzell. 1996. Introduction: Sea turtle conservation genetics. *In* B.W. Bowen and W.N. Witzell (eds.) Proceedings of the International Symposium on Sea Turtle Conservation Genetics. NOAA Tech. Memo. NMFS-SEFSC-396.

Bowen, B.W. 1996. Comparative phylogeography of green and loggerhead turtles. *In* B.W. Bowen and W.N. Witzell (eds.) Proceedings of the International Symposium on Sea Turtle Conservation Genetics. NOAA Tech. Memo. NMFS- SEFSC-396.

Bowen, B.W., D. Crouse. 1997. Landscape-level management in the marine realm. Guest Essay *In* G.K. Meffe and C.R. Carroll, Principles of Conservation Biology, Second Edition.

Bowen, B.W., A.L. Bass. 1997. Movement of hawksbill turtles: what scale is relevant to conservation, and what scale is resolvable with mtDNA data? Chelonian Conservation and Biology 2:440-442.

Encalada, S. E., J.C. Zurita, B.W. Bowen. 1999. Genetic consequences of coastal development: the sea turtle rookeries at X'cacel, Mexico. Marine Turtle Newsletter 83:8-10.

Bowen, B.W., S.A. Karl. 1999. In war, truth is the first casualty. Conservation Biology 13: 113-116.

Bowen, B.W. 2000. A field born in conservation's cold war. Trends in Ecology and Evolution 15:1-3.

Bowen, B.W., S.A. Karl. 2000. Meeting report: Taxonomic status of the East Pacific green turtle (*Chelonia agassizii*). Marine Turtle Newsletter 89:20-22.

Bowen, B.W. 2001. Applications of molecular genetic markers for the conservation of marine turtles. Pp. 69 *In* Connaissance et conservation des tortues marines du Sud-Ouest de l'Ocean Indien (S. Ciccione, D. roos, and J.-Y. Le Gall, eds.). Editions du Centre d'Etude et de Decouverte des Tortue Marines de la Reunion. Reunion Is., France (in French and English).

Roman, J., B.W. Bowen. 2001. In search of the mock turtle. New Scientist 171(2307):28-31.

Bowen, B.W. 2005. Alfred Russell Wallace Award Recipient: John C. Briggs. International Biogeography Society Newsletter 3(1): 5-6.
Bowen, B.W., W.S. Grant, Z. Hillis-Starr, D. Shaver, K.A. Bjorndal, A.B. Bolten, A.L. Bass. 2007. The advocate and the scientist; Debating the commercial exploitation of endangered hawksbill turtles. Molecular Ecology 16:3514-3515.
Bowen, B.W. 2007. Sexual harassment by a male green turtle (*Chelonia mydas*). Marine Turtle Newsletter 117:10.
Friedlander, A., G. Aeby, S. Balwini, B. Bowen, R. Brainard, A. Clark, J. Kenyon, J. Maragos, C. Meyer, P. Vroom, J. Zamzow. 2008. The state of coral reef ecosystems of the Northwestern Hawaiian Islands. Pp. 263-306 In Waddell, J.E. and A.M. Clarke (eds.). The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States: 2008. NOAA Technical Memorandum NOS NCCOS 73. NOAA/NCCOS Center for Coastal Monitoring and Assessment's Biogeography Team. Silver Spring, MD. 569 pp.
Friedlander, A., J. Maragos, R. Brainard, A. Clark, G. Aeby, B. Bowen, E. Brown, K. Chaston, J. Kenyon, C. Meyer, P. McGowan, J. Miller, T. Montgomery, R. Schroeder, C. Smith, P. Vroom, W. Walsh, I. Williams, W. Wiltse, J. Zamzow. 2008. Status of coral reefs in Hawaii and United States Pacific Remote Island Areas (Baker, Howland, Palmyra, Kingman, Jarvis, Johnston, Wake). Pp. 213-224 In Wilkinson, C. (ed.) Status of the Coral Reefs of the World: 2008. Global Coral Reef Monitoring Network, Townsville, Australia. 298 pp.
Bowen, B.W., B. Wallace. 2010. How sea turtles have weathered past climate changes. SWOT (State of the world of sea turtles) Vol. V:13-15.
Toonen, R.J., C. Bird, J. Eble, A. Faucci, G. Concepcion, K. Andrews, D.Skillings, M. Iacchei, I. Baums, B.W. Bowen. 2010. Where have all the larvae gone? Patterns of connectivity in the Hawaiian Archipelago. Proceedings of the American Academy of Underwater Sciences, In: NW Pollock (ed). Diving for Science 2010. Proceedings of the 29th American Academy of Underwater Sciences Symposium. Dauphin Island, AL: AAUS.
Bowen, B.W. 2010. Interview with John C. Briggs, recipient of the 2005 Alfred Russel Wallace Award. Frontiers in Biogeography 2(3):78 – 80.
Donovan, M. K., I. D. Williams, A. M. Friedlander, K. Longnecker, J. P. Beets, B. W. Bowen, E. C. Franklin. 2011. Catalog of Coral Reef Fish Life History Specimens for the Hawaiian Islands. Pacific Islands Fish. Sci. Cent. Admin. Rep. H-11-05, 13 pp.
Bowen, B.W. 2013. Testudines erectus: Beware the male sea turtle. Asian Diver 127(4):50 – 51.
DiBattista, J.D., M.R. Gaither, J.-P.A. Hobbs, L.A. Rocha, B.W. Bowen. 2017. Response to Delrieu-Trottin et al.: Hybrids, color variants and the consistently devilish taxonomy of pygmy angelfishes. Journal of Heredity 108:337 – 339.

PEER-REVIEWED PUBLICATIONS

Bowen, B.W., A. B. Meylan, J.C. Avise. 1989. An odyssey of the green sea turtle, *Chelonia mydas*: Ascension Island revisited. Proc. Natl. Acad. Sci. USA 86:573-576.
Avise, J.C., B.W. Bowen, T. Lamb. 1989. DNA fingerprints from hypervariable mitochondrial genotypes. Mol. Biol. Evol. 6:258-269.
Bowen, B.W., J.C. Avise. 1990. The genetic structure of Atlantic and Gulf of Mexico populations of sea bass, menhaden, and sturgeon: the influence of zoogeographic factors and life history patterns. Marine Biology 107:371-381.
Meylan, A.B., B.W. Bowen, J.C. Avise. 1990. A genetic test of the natal homing versus social facilitation models for green turtle migration. Science 248:724-727.
Bowen, B.W., A.B. Meylan, J.C. Avise. 1991. Evolutionary distinctiveness of the endangered Kemp's ridley. Nature 352:709-711.
Avise, J.C., B.W. Bowen, E. Bermingham, A.B. Meylan, T. Lamb. 1992. Mitochondrial DNA evolution at a turtle's pace: evidence for low genetic variability and reduced microevolutionary rate in the Testudines. Mol. Biol. Evol. 9: 457-473.
Bowen, B.W., A.B. Meylan, J.P. Ross, C.J. Limpus, G.H. Balazs, J.C. Avise. 1992. Global population structure and natural history of the green turtle (*Chelonia mydas*) in terms of matriarchal phylogeny. Evolution 46: 865-881.
Karl, S.A., B.W. Bowen, J.C. Avise. 1992. Global population structure and male-mediated gene flow in the green turtle (*Chelonia mydas*): RFLP analysis of anonymous nuclear DNA regions. Genetics 131:163-173.
Bowen, B.W., W.S. Nelson, J.C. Avise. 1993. A molecular phylogeny for marine turtles: trait mapping, rate assessment, and conservation relevance. Proc. Natl. Acad. Sci. USA 90: 5574-5577.

Bowen, B.W., J.C. Avise, J.I. Richardson, A.B. Meylan, D. Margaritoulis, S. Hopkins-Murphy. 1993. Population structure of the loggerhead turtle (*Caretta caretta*) in the northwest Atlantic Ocean and Mediterranean Sea. Conservation Biology 7:834-844.

Laurent, L., J. Lescure, L. Excoffier, B.W. Bowen, M. Domingo, M. Hadjichristophorou, L. Kornaraki, G. Trabuchet. 1993. Genetic relationships between Mediterranean and Atlantic populations of loggerhead turtle *Caretta caretta* with a mitochondrial marker. Comptes Rendus de l'Academie des Sciences, Paris, Sciences de la vie 316:1233-1239.

Allard, M.W., M.M. Miyamoto, K.A. Bjorndal, A.B. Bolten, B.W. Bowen. 1994. Support for natal homing in green turtles from mitochondrial DNA sequences. Copeia 1994:34-41

Ferl, R.J., G. Lu, B.W. Bowen. 1994. Evolutionary implications of the family of 14-3-3 brain protein homologs in *Arabidopsis thaliana*. Genetica 92:129-138.

Encalada, S.E., S. Eckert, B.W. Bowen. 1994. Forensic applications of mitochondrial DNA markers: origin of a confiscated green turtle. Marine Turtle Newsletter 66:1-3.

Avise, J.C., B.W. Bowen. 1994. Investigating sea turtle migration using DNA markers. Current Opinion in Genetics and Development 4:882-886.

Bowen, B.W., T.A. Conant, S.R. Hopkins-Murphy. 1994. Where are they now? The Kemp's ridley headstart project. Conservation Biology 8:853-856.

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Dr. Richard Pyle, Database Coordinator, Associate Zoologist, Dive Safety Officer
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-------- Original Message --------
From: Richard Pyle <pylediver@gmail.com> on behalf of Richard Pyle <deepreef@bishopmuseum.org>
Date: Sun, March 11, 2018 7:51 PM -0700
To: "Lynch, James M." <jim.lynch@klgates.com>
Subject: Review of Draft Environmental Assessments of Issuance of Commercial Aquarium Permits for the Islands of O'ahu and Hawai'i

To Whom it May Concern:

I have read and reviewed copies of the Draft Environmental Assessments of Issuance of Commercial Aquarium Permits for the Islands of both O'ahu and Hawai'i. My review is based on my expertise acquired over several decades as professional marine biologist and ichthyologist, including research and publications relating specifically to the Marine Aquarium trade.

Overall, I was extremely impressed with the thoroughness and accuracy of both draft Assessments. I have cross-checked many of the data summaries and other conclusions cited in the Assessments against the original published literature, and in all cases I have found them to be both accurate and complete as represented in the Assessments. Moreover, I found that the conclusions and recommendations included in both Assessments to be entirely appropriate and consistent with the available scientific data, as well as my own personal research and observations concerning the marine aquarium industry in Hawaii, and the particular species involved. The summary of the history and context of the industry in Hawaii is also accurate, complete, and represented without bias.

I was also very impressed with the wording, format, data tables, figures, and literature cited as presented in both Assessments. The content is complete and accurate, and the tone is neutral and appropriate.

I have provided some specific very minor suggestions on grammar and formatting, none of which affect the meaning and content of the overall Assessments.

Please feel free to contact me with any specific questions, comments, concerns, or requests for qualification or elaboration on any specific parts of either of the Draft Assessments.

Sincerely,

Richard L. Pyle, PhD
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PERSONAL:

Born: 24 March 1967, Kailua, Hawaii
Married to Dr. Lisa A. Privitera (1994), daughter Cara (born 1995), son Owen (born 2000)

EDUCATION:

2003	Ph.D. – Department of Zoology, University of Hawaii at Manoa, Honolulu, Hawaii
1992	B.S. – Department of Zoology, University of Hawaii at Manoa, Honolulu, Hawaii
1985	High School Diploma, Punahou High School, Honolulu, Hawaii

EMPLOYMENT:

2010–present	Dive Safety Officer, B.P. Bishop Museum, Honolulu, Hawaii
2002–present	Database Coordinator, Department of Natural Sciences, B.P. Bishop Museum, Honolulu, Hawaii
2000	Graduate Teaching Assistant (Ichthyology Lab) – Department of Zoology, University of Hawaii at Manoa, Honolulu, Hawaii
1999–2002	Graduate Research Assistant (John E. Randall, PI) – Department of Zoology, University of Hawaii at Manoa, Honolulu, Hawaii
1997–present	Associate Zoologist – Department of Natural Sciences, B.P. Bishop Museum, Honolulu, Hawaii
1990–present	President – LavaVideo Productions, Inc.
1986–1997	Collections Technician – Ichthyology Collection, Department of Natural Sciences, B.P. Bishop Museum, Honolulu, Hawaii
1985–1986	Vice President/Chief Collector – Feetlebomb Fish of Palau, Inc., Koror, Palau
1985	Student Aquarist – Waikiki Aquarium, Honolulu, Hawaii

PROFESSIONAL SERVICE:

2012–present	Member, Catalog of Life Global Team
2010–present	Board of Editors, *Indo-Pacific Fishes*
2010–present	Steering Committee Member, PLoS Biodiversity Hub
2010–present	Principal Science Advisor – *One World Ocean* Campaign, MacGillivray Freeman Films
2009–2010	Committee Member, Special Committee on Electronic Publication, International Committee for Botanical Nomenclature.
2009–present	Committee Member, International Committee for Bionomenclature
2008–present	Founding Board Member, Plazi.ch Association (Plazi)
2008–2009	Program Committee, International Conference on Biodiversity Informatics (e-Biosphere)
2008–present	Convener, Taxonomic Names and Concepts Group, Biodiversity Information Standards (TDWG)
2008–present	Council Member, International Commission on Zoological Nomenclature (ICZN)
2007–present	Steering Committee, World Registry of Marine Species (WoRMS)
2007–present	Member, Informatics Advisory Board, Encyclopedia of Life (EoL)

2006–present	Commissioner, International Commission on Zoological Nomenclature (ICZN)
2006	Active Participant in the Global Biodiversity Information Facility (GBIF) Globally Unique Identifiers (GUID) Workshop Series
2005	Active Participant in the development of the Taxonomic Concept Schema (TCS), Taxonomic Databases Working Group (TDWG)
2003–present	Founding Board Member, Chief Technology Officer (2003–2005), Chief Science Officer (2005–2014), Chief Technology Officer (2014–present), Association for Marine Exploration (AME)
2001–present	Committee Member, Pacific Basin Information Node, National Biological Information Infrastructure
2001	Promising Technology Committee – All Species Foundation, San Francisco, California
2001	CEO Search Committee – All Species Foundation
2000–present	Manuscript Reviewer – *Marine Technology Society*
2000–2003	Scientific Advisor – MacGillivray Freeman Films
2000–2001	Database Consultant & Scientific Advisor – All Species Foundation
2000–2001	Organizing Committee – All Species Foundation
1998	Secretary, Diving Control Board – University of Hawaii at Manoa
1997–present	Board of Advisors – International Association of Nitrox and Technical Divers (IANTD)
1997–present	Web Site Development Group – Bernice P. Bishop Museum
1996–present	Database Development Group – Bernice P. Bishop Museum
1996	Manuscript Reviewer – *Evolution*
1996	"Major Contributor" – Scientific Diving: A general Code of Practice. (N.C. Flemming and M.D. Max, eds.). Second Edition (1996), Sponsored by the World Underwater Federation (CMAS) and UNESCO's Intergovernmental Oceanographic Commission (IOC). UNESCO Publishing, Paris. xviii+278 pp.
1995–1996	Board of Directors – Aquademy, Inc. (A California nonprofit public benefit corporation)
1995–2005	Diving Control Board Member – University of Hawaii at Manoa
1995–present	Board of Advisors – *Immersed* technical journal
1995–present	Data Standards Subcommittee – American Society of Ichthyologists and Herpetologists
1994–present	Experimental Test Diver and Technical Consultant – Cis-Lunar Development Laboratories, Inc.
1994–1995	Organizing Committee Member – 20th Annual Albert L. Tester Memorial Symposium, University of Hawaii at Manoa
1994	Technical Advisor – CMAS/UNESCO Code of Practice for Scientific Diving
1994	Manuscript Reviewer – *Pacific Science*
1992–1996	Editorial Board and Contributing Editor – *AquaCorps* technical journal
1991–present	Scientific Advisor – American Association of Zoological Parks and Aquariums Marine Fishes Taxon Advisory Group
1991–1993	Hawaii State Shark Task Force
1990–present	Board of Directors – Hawaii Tropical Fish Association
1989–present	Contributing Editor – *Freshwater and Marine Aquarium Magazine*
1984–1985	Volunteer Aquarist – Waikiki Aquarium

GRANTS & AWARDS:

Pending:

2017 **PI**: ABI Development: Expanding the Global Names Architecture through development of the Global Names Usage Bank. National Science Foundation (DBI-1661545), 2016 ($1,677,706).

Funded:

2016 **PI:** Preparation for an Expedition to Rapa Nui. NOAA Sanctuary Foundation, 2016 ($15,000).

2016 **PI:** Survey of Mesophotic Coral Ecosystems in the Papahānaumokuākea Marine National Monument. National Oceanic and Atmospheric Administration (NOAA), 1 September 2016 ($45,000).

2015 **PI:** Survey of Mesophotic Coral Ecosystems in the Papahānaumokuākea Marine National Monument. National Oceanic and Atmospheric Administration (NOAA), 1 September 2015 ($45,000).

2014 **Co-PI:** Foundation Reefs: A Proposal to the Seaver Institute (Brian W. Bowen, PI), Seaver Institute, 1 June 2014 ($20,800.00, of a total of $101,353).

2014 **PI:** Survey of Mesophotic Coral Ecosystems in the Papahānaumokuākea Marine National Monument. National Oceanic and Atmospheric Administration (NOAA), 1 September 2014 ($40,000).

2013 **Co-PI:** Foundation Reefs: A Proposal to the Seaver Institute (Brian W. Bowen, PI), Seaver Institute, 1 June 2013 ($20,800.00, of a total of $101,513).

2013 **Co-PI:** Combined Submersible and Rebreather Diver Operations for Scientific Research. (Kenneth R. Longenecker, PI), Hawaii Undersea Research Laboratory (HURL). 1 June 2013 ($29,891.92).

2012 **Co-PI:** Foundation Reefs: A Proposal to the Seaver Institute (Brian W. Bowen, PI), Seaver Institute, 1 June 2012 ($20,800.00, of a total of $101,513).

2012 **PI:** Survey of Mesophotic Coral Ecosystems in the Papahānaumokuākea Marine National Monument. National Oceanic and Atmospheric Administration (NOAA), 1 September 2012 ($90,000).

2011 **PI:** Survey of Mesophotic Coral Ecosystems in the Papahānaumokuākea Marine National Monument. National Oceanic and Atmospheric Administration (NOAA), 1 September 2011 ($40,000).

2010 **PI:** Survey of Mesophotic Coral Ecosystems in the Papahānaumokuākea Marine National Monument. National Oceanic and Atmospheric Administration (NOAA), 1 September 2010 ($50,000).

2010 **Co-PI:** Collaborative Research: ABI: Innovation: The Global Names Architecture, an infrastructure for unifying taxonomic databases and services for managers of biological information (PI of Bishop Museum Component; David J. Patterson, PI; Stanley D. Blum and Chris Freeland, Co-PIs for the collaborative proposal). National Science Foundation (DBI-1062441), 2010 ($325,291; as part of a collaborative proposal totaling $2,123,648).

2010 **PI:** Collaborative Research: BiSciCol Tracker: Towards a tagging and tracking infrastructure for biodiversity science collections (PI of Bishop Museum component; Nico Cellinese [originally Reed S. Beaman], PI; Steven R Manchester, Gustav Paulay, Norris H Williams, P. Bryan B. Heidorn, Robert P. Guralnick, Neil Davies, Jonathan A. Coddington, Christopher P. Meyer, Thomas M. Orrell and George K. Roderick, Co-PIs for the collaborative proposal), National Science Foundation (DEB-0956415), 2010 ($316,136; as part of a collaborative proposal totaling $1,799,472).

2009 **PI:** Survey of Mesophotic Coral Ecosystems in the Papahānaumokuākea Marine National Monument. National Oceanic and Atmospheric Administration (NOAA), 1 September 2009 ($70,000).

2009 **Co-PI:** Holistic management of coastal ecosystems: roles of deep hermatypic reefs (Kenneth R. Longenecker, PI), Hawaii Undersea Research Laboratory (HURL). 1 June 2009 ($136,367).

2009 **Subcontract:** Development of the Global Names Usage Bank (GNUB), Global Biodiversity Information Facility (GBIF), 1 January 2009. ($5,000).

2009 **PI:** Development of a Species Portal for Pacific Islands (Year 3), Pacific Basin Information Node (PBIN) of the National Biological Information Infrastructure (NBII). 1 November 2008. ($70,000).

2008 **Subaward PI:** Deep Reef Survey component of the Moorea Biocode Project (Neil Davies, PI), Gordon and Betty Moore Foundation, 1 January 2008. ($46,834).

2008 **PI:** Development of a Species Portal for Pacific Islands (Year 2), Pacific Basin Information Node (PBIN) of the National Biological Information Infrastructure (NBII). 1 November 2008. ($100,000).

2007 **Contract:** ZooBank LSID and TAPIR Implementations. International Commission on Zoological Nomenclature (ICZN), through Global Biodiversity Information Facility (GBIF), 31 May 2007. ($5,000).

2007 **Partner Researcher:** Providing Access to Authoritative New Names: the Zootaxa-ZooBank Interface (Zhi-Qiang Zhang, PI), Global Biodiversity Information Facility (GBIF), 1 April 2007. ($49,000).

2007 **Lead PI:** CRES 2007: Investigating the Deep (50-100 m) Coral Reefs of Hawai‘i. Coral Reef Ecosystem Studies (CRES), National Oceanic and Atmospheric Administration (NOAA), 11 Nov 2006. ($1,499,961).

2007 **Co-PI:** Comparing Hawaii’s Deep Reef Coral Communities (Anthony Montgomery, PI), Hawaii Undersea Research Laboratory (HURL). 1 October 2007 ($72,279).

2007 **PI:** Development of a Species Portal for Pacific Islands (Year 1), Pacific Basin Information Node (PBIN) of the National Biological Information Infrastructure (NBII). 1 October 2007 ($100,000).

2007 **Co-PI:** Catalog of Fishes 2.0: Improving Services and Preparing for Community Participation (Stan Blum, PI), National Science Foundation (NSF DBI-0642321). 15 April 2007 ($642,461)

2006 **Co-PI:** Development of geographic, taxonomic, specimen, and image data for online access (Allen Allison, PI), Pacific Basin Information Node (PBIN) of the National Biological Information Infrastructure (NBII). 1 October 2006 ($120,000).

2005 **Co-PI:** Development of geographic, taxonomic, specimen, and image data for online access (Allen Allison, PI), Pacific Basin Information Node (PBIN) of the National Biological Information Infrastructure (NBII). 1 October 2005 ($150,000).

2004 **Co-PI:** Development of geographic, taxonomic, specimen, and image data for online access, including Collaboration on the Development of a Pacific Biodiversity Information Forum and Survey of Taxonomic Capacity in Pacific Islands (Allen Allison, PI), Pacific Basin Information Node (PBIN) of the National Biological Information Infrastructure (NBII). 1 October 2004 ($175,000).

2003 **Co-PI:** Exploration of the deep slopes of the US Line and Phoenix Islands to investigate the biogeography of deepwater fish and corals, and identify paleo-shorelines (Frank A. Parrish, PI), NOAA's Undersea Research Program (NURP). ($5,000, plus 10 PISCES IV/V submersible dives).

2003 **Co-PI:** Continued Development of an Information Utility Focused on Hawaii and the Pacific Region Using Bishop Museum's Vouchered Collections and Documented Data (Allen Allison, PI), Pacific Basin Information Node (PBIN) of the National Biological Information Infrastructure (NBII). 1 October 2003 ($150,000).

2002 **Co-PI:** Development of an Information Utility Focused on Hawaii and the Pacific Region Using Bishop Museum's Vouchered Collections and Documented Data (Allen Allison, PI), Pacific Basin Information Node (PBIN) of the National Biological Information Infrastructure (NBII). 1 October 2002 ($150,000).

1999 **PI:** Doctoral Fellowship Award for the Systematic and Biogeographic analysis of the Fish Family Pomacanthidae (administered through the Department of Zoology, University of Hawaii). ($30,000).

1998 **Co-PI:** Preparation of Bishop Museum Marine Invertebrates Catalogues and Species Listings for Publication on the World Wide Web. (Steve L. Coles, PI), Charles H.and Margaret B. Edmondson Research Foundation Research Fund.

1991 Student Travel Award, American Society of Ichthyologists and Herpetologists, 73rd Annual Meeting, University of Texas at Austin, Texas ($200).

Approved but not Funded:

2003 PBI: Global Inventory of 75 Families of Coral-Reef Actinopterygian (Ray-Finned) Fishes (John E. Randall, PI), Planetary Biodiversity Inventories (PBI), Biodiversity Surveys & Inventories (BS&I), Division of Environmental Biology (DEB), National Science Foundation (NSF). ($7,457,882).

Awards and Honors:

2005 NOGI Award for Science Diving, Academy of Underwater Arts and Sciences
2004 "GEnius Award", *Esquire* Magazine ($45,000)
2004 "Best and Brightest", *Esquire* Magazine
1996 Finalist, Rolex Awards for Enterprise
1994 Honorable Mention, Stoye Award, American Society of Ichthyologists and Herpetologists, 74th Annual Meeting, University of Southern California, Los Angeles, California
1993 Best Paper Award, 19th Annual Albert L. Tester Memorial Symposium, University of Hawaii at Manoa ($700).

DIVING QUALIFICATIONS:

Certifications:

2000 IANTD Cis-Lunar Technical Rebreather Instructor (#2846)
1999 IANTD Cis-Lunar Mixed Gas Rebreather Instructor (#2846)
1999 IANTD Advanced EANx Instructor (#2846)
1997 IANTD Cis-Lunar MK-5P Supervisor (#2846)
1996 DAN Oxygen Provider (#2846)
1994 Cis-Lunar MK-4P Experimental Diver
1994 IANTD Trimix Diver (#345)
1993 IANTD Nitrox Diver (#2347)
1982 PADI Advanced Open Water Diver (#813214240)
1981 PADI Basic Diver

Experience:

1994–present	4,000+ hours – Mixed-gas, Closed-Circuit Rebreather
1989–present	250+ dives – open-circuit trimix/nitrox
1981–present	5,000+ dives – air SCUBA

FIELD EXPEDITIONS:

1980	Christmas Island, Kiribati
1983	Palau (twice); Pohnpei
1984	Christmas Island, Kiribati (twice)
1985	Christmas Island, Kiribati
1986	Palau (twice)
1987	Christmas Island, Kiribati (twice)
1988	Christmas Island, Kiribati (twice); Guam; Pohnpei; Johnston Atoll
1989	Christmas Island, Kiribati; Midway Atoll; Rarotonga
1990	Mauritius; Ogasawara Islands; Izu (Japan); Guam
1991	Easter Island; Midway Atoll; Rarotonga
1992	Kerama Islands; Ogasawara Islands; Rarotonga
1993	Solomon Islands
1995	Papua New Guinea (Milne Bay)
1997	Palau (http://www.bishopmuseum.org/research/treks/palautz97/); Hong Kong
1998	Papua New Guinea (D'Entrecasteaux Islands); Necker Island
2000	Black coral Survey off Maui (in conjunction with NOAA)
2001	Fiji (http://www.coralfilm.com), American Samoa (http://www2.bishopmuseum.org/PBS/samoatz01/)
2002	Fiji
2004	Fiji
2005	Green Island (Taiwan); Pulley Ridge, Gulf of Mexico; Christmas Island, Kiribati
2006	Espiritu Santo (Vanuatu)
2007	Caroline Islands (Chuuk, Puluwat, Grey Feather Bank, Fais, Ulithi, Yap, Kayangel, Palau Islands)
2009	Papua New Guinea (Kamiali); Northwestern Hawaiian Islands (Nihoa Island, Necker Island, Laysan Island, Pearl and Hermes Reef, Kure Atoll, Midway Atoll)
2010	Fiji; Cayman Islands; Eilat (Red Sea); Northwestern Hawaiian Islands (Nihoa Island, French Frigate Shoals, Pearl and Hermes Reef, Midway Atoll); Maui
2011	Maui; South Africa (Sodwana Bay); Northwestern Hawaiian Islands (Nihoa Island, French Frigate Shoals, Lisianski, Laysan, Gardiner Pinnacles, Pearl and Hermes Reef); Cocos Island
2012	Moorea; Indonesia; Cook Islands (Rarotonga); Northwestern Hawaiian Islands (Nihoa, French Frigate Shoals, Maro Reef, Pearl and Hermes Reef, Midway Atoll)
2013	Oahu (HURL collaboration); Philippines
2014	Philippines; Pohnpei; Northwestern Hawaiian Islands (Kaula Rock, French Frigate Shoals, Lisianski, Pearl and Hermes Reef, Midway Atoll)
2015	Pohnpei, Northwestern Hawaiian Islands (), Maui/Hawaii
2016	Northwestern Hawaiian Islands; Pohnpei, Lehua, Midway
2017	American Samoa

PUBLISHED INTERVIEWS, PROFILES, AND BIOGRAPHIC EXCERPTS:

1. Kawai, Tadashi. 1989. Profile of Randall Kosaki and Richard Pyle. *Tropical Marine Aquarium Magazine* 25:38–39, 2 figs. (In Japanese)
2. Kawai, Tadashi. 1990. Interview with Richard Pyle. *Tropical Marine Aquarium Magazine* 28:40–41, 3 figs. (In Japanese)
3. Gilliam, B. 1992. Bishop Museum Deep Project, Hawaii. p. 154–156. *In*: Deep Diving: An Advanced Guide to Physiology, Procedures and Systems. (Gilliam, B., R. Von Maier, J. Crea, and D. Webb, eds). Watersport Publishing, Inc., San Diego. 255 pp.
4. Somers, L.H. 1992. Chapter 18. Looking Ahead: Mixed Gas in Scientific Diving. *In*: Mount, T. and B. Gilliam (Eds.). Mixed Gas Diving: The Ultimate Challenge for Technical Diving. Watersport Publishing, Inc., San Diego. 392 pp.
5. Silverstein, Joel. 1995. Richard Pyle Ph.D. (Phish Doctor): an exclusive interview. *Sub Aqua Journal.* 5(2):16–19, 4 figs.
6. Kelly, Jim. Is deep air dead? *AquaCorps*, 13:39–44.
7. Ambrose, Greg. 1996. Breathe Deep: Isle divers test new gear that recycles air, allowing them to probe deeper and stay longer. *Honolulu Star Bulletin* April 3, 1996:A-1,A-8. (Related articles: Ambrose, Greg. 1996. Rebreather opens up a new ocean frontier. *Honolulu Star Bulletin* April 3, 1996:A-8; Ambrose, Greg. 1996. 'Twilight Zone' yields to crystal clear waters. *Honolulu Star Bulletin* April 3, 1996:A–8.)
8. Comper, Walter and Win Remley. 1996. Rebreather roundtable: DeepTech and seven industry experts take a hard look at rebreather safety issues and training standards. *DeepTech* 5:48–56.
9. Montres Rolex S.A. 1996. Richard Pyle, United States. Project: Investigate biodiversity in the undersea Twilight Zone (Exploration and Discovery). P. 146–147. *In*: *Spirit of Enterprise: The 1996 Rolex Awards.* Secretariat of the Rolex Awards for Enterprise, Geneva, Switzerland.191 pp.
10. Halstead, B. 1996. Hi-Tek Adventure. *Scuba Diver*, September/October 1996: 61–64.
11. Watt, J.D. 1997. Exploring the Twilight Zone with Richard Pyle. *SCUBA Times* 18(6) No. 104: 64.
12. Barskey, S., M. Thurlow, and M. Ward. 1998. Mention on pp. 42–43, of Chapter 2: Applications for Rebreathers. *In:* The Simple Guide to Rebreather Diving. Best Publishing Company, Flagstaff. xxvi + 228 pp.
13. Donnelly, D. 1998. Hawaii: This Pyle no Gomer. *Honolulu Star Bulletin* April 8, 1998:C–16.
14. TenBruggencate, J. 1998. Unknown fish swims into sight. *The Honolulu Advertiser* June 10, 1998:A–1.
15. TenBruggencate, J. 1998. Hawaii's Environment: Divers still discovering new species. *The Honolulu Advertiser* June 15, 1998:B–1.
16. Menduno, M. 1998. A fish nerd's journey into the Twilight Zone. *Aqua* 1(4):70–73, 132–133.
17. Tanaka, H. 1998. Jack Fruits and Rich Flavors from Hawaii. The Firefishes: *Nemateleotris decora, helfrichi* and *magnifica*. *Fish Magazine*. No. 393 (December 1998): 123–125, 130–135. In Japanese.
18. Allen, G.R., R. Steene, and M. Allen. 1998. Exploring the "Twilight Zone". pp. 4–6. *In:* A Guide to Angelfishes and Butterflyfishes. Odyssey Publishing/Tropical Reef Research, Perth. 250 pp.
19. Tanaka, H. 1999. Jack Fruits and Rich Flavors from Hawaii No. 2: Rich Fauna of Hawaii. *Fish Magazine*. No. 395 (February 1999): 132–135, 138–139. In Japanese.
20. Houston, Robert. 2001. Achievers: Into the Twilight Zone. *Action Asia Magazine*, June/July 2001:40–43.

21. Almogy, B. 2001 (17 February). אל תוך אזור הדמדומים [Into the Twilight Zone]. מתוך מגזין [*Out Magazine*] No. 28. (http://mag.diving.org.il/?p=169) [In Hebrew].
22. Stephens, J. 2003. Into the Twilight Zone. pp. 87–96 In: *Living Mirrors*: A Coral Reef Adventure. Umbrage Editions, New York.
23. Hall, Howard and Michele Hall. 2003. Sixty Fathoms Under the Sea. National Wildlife: World Addition 41(3):52-56.
24. Fathoms Magazine, Winter 2003
25. Anonymous, 2003. Lights, Camera, Dive! One Fish, Two Fish. Ranger Rick Magazine. pp. 38–39.
26. Paul, Melanie. 2004. On the record with Richard Pyle. *Nitrox Diver*. Summer, 2004. 14–17.
27. America's Best and Brightest: Richard Pyle, extreme diver. *Esquire Magazine* December 2004.
28. Boruchowitz, David E. 2005. Richard Pyle, PhD—Aquarist, Ichthyologist...Movie Star! *Tropical Fish Hobbyist* 54(1).
29. Waikiki Aquarium Newsletter
30. Kimura, Rufus 2009. Into the Twilight Zone. *Hana Hou! The Magazine of Hawaiian Airlines*, 12(1):43–47.
31. Nelson, Shane 2008. Delving Deeper: Scientists get an unprecedented look at Hawaii's reefs. *Honolulu Magazine*, March 2008, p. 42. http://www.honolulumagazine.com/Honolulu-Magazine/March-2008/Delving-Deeper/
32. Earle, S.A. and L.K. Glover. 2009. Chapter 5. Pacific Ocean. pp.142–181 [R.L. Pyle feature on p. 176]. *In:* Earle, S.A. & L.K. Glover (eds.). Ocean: An Illustrated Atlas. National Geographic Society, Washington, DC. 352 pp. (ISBN: 978-1-4262-0319-0)
33. Crist, D.T., G. Sowcroft & J.M. Harding. 2009. Where no one has gone before. pp. 185–186. In: Crist, D.T., G. Sowcroft & J.M. Harding (eds.). World Ocean Census: A Global Survey of Marine Life. Firefly Books, Ltd., Buffalo, New York. 256 pp. (ISBN-13: 978-1-55407-434-1; ISBN-10: 1-55407-434-7)
34. Walters, Pat. 2010. Mammoth Project to Digitize the Tree of Life Could Uncover Thousands of New Species. Popular Science. February 2010:27.
35. auf dem Kampe, Jörn. 2011. Porträt: Im Rausch der Riffe. *GEO Magazine*. 11:64–70.
36. Kamida, David. 2011. Natural Science: Diving the depths of Maui. *Ka'Elele: The Messenger. The Journal of Bernice Pauahi Bishop Museum*. Summer 2011:10–11.
37. Shapiro, Michael. 2012. Moorea's Ark. *Hana Hou! The Magazine of Hawaiian Airlines*, 15(4):62–73.
38. Steene, Roger
39. Weiss, Kenneth R. 2016. The Far Atolls: Twenty-five days in the Papahānaumokuākea Marine National Monument. *Hana Hou!* 19.4 (August/September): 110–125. http://hanahou.us/issues/19.4/feat-nw-hawn-islands.html
40. Weiss, Kenneth R. 2017. Naturalist Richard Pyle explores the mysterious, dimly lit realm of deep coral reefs. *Science* 355(6328): 900–904. http://www.sciencemag.org/news/2017/03/naturalist-richard-pyle-explores-mysterious-dimly-lit-realm-deep-coral-reefs
41. Frerck, Bob. 2017. Richard Pyle Explores Mysterious, Deep Coral Reefs. Blue Ocean Network. Mar 11, 2017. http://blueocean.net/richard-pyle-explores-mysterious-deep-coral-reefs/
42. Menduno, Michael. 2017. The race to save the greatest library on Earth. Research, Education and Medicine: Researcher Profile. Alert Diver. November 2, 2017. 57-61. http://www.alertdiver.com/Richard_Pyle

FILM AND RADIO PROJECTS AND INTEVIEWS:

1. **Videographer**: *Pele Meets the Sea*. 1990. LavaVideo Productions. Educational Videotape
2. **Interviewee**: 1992. Thomas Horton Associates, Inc. The Discovery Channel.
3. **Footage**: *World of Wonder: Underwater Volcano* (Episode 113). 1995. GRB Entertainment. The Learning Channel.
4. **Technician**: *Sea Tek: Rebreathers segement.* 1996. GRB Entertainment. The Learning Channel.
5. **Footage**: *Sea Tek: Birth of an Island.* 1996. GRB Entertainment. The Learning Channel.
6. **Feature, Footage**: *Incredible Frontiers-I Extreme Divers: Lava Divers*. 1997. GRB Entertainment. The Learning Channel.
7. **Footage**: *Oceans: Episode I*. 1997. The Discovery Channel.
8. **Footage**: *Oceanarium – An Edutainment Project*. 1997. Intenational Tourist Attractions, Israel.
9. **Footage**: *Planet of Ocean, Episode 2: Into the Abyss*. 1998. NHK.
10. **Feature**: *Mysteries of the Twilight Zone*. 1998. Thomas Lucas Productions. The Discovery Channel/National Geographic.
11. **Technician, Videographer**: *Hammeheads: Nomads of the Sea*. 1998. Thomas Lucas Productions. The Discovery Channel.
12. **Interviewee**: *Hawaiian Diving Adventures: Midway Atoll.* 1998. Cal Hirai and Kimo Santos. Oceanic Cable Channel 16.
13. **Feature**: *Hawaiian Diving Adventures: Midway Atoll.* 1998. Cal Hirai and Kimo Santos. Oceanic Cable Channel 16.
14. **Feature**: Footage: *How'd They Do That?: Lava Divers segment.* 1998. The Learning Channel.
15. **Footage**: *Savage Earth*. 1998. Granada Television. PBS/ITV Network.
16. **Footage**: *Visual Earth: Exploring the Oceans*. 1998. TERC. CD-ROM production.
17. **Technician**: *Reflections* (underwater HDTV video production featuring musician Paul Gillman with dolphins). 1999.
18. **Footage**: *Volcanoes of the Deep*. 1999. Paula S. Apsell, NOVA/WGBH.
19. **Feature**: *Aquanauts: New Species*. 1999. The Learning Channel.
20. **Feature**: *Aquanauts: Volcanoes*. 1999. The Learning Channel.
21. **Footage**: *Savage Planet*. 1999. Granada Television. PBS/ITV Network.
22. **Footage**: *Restless Earth*. 1999. Fulcrum Productions.
23. **Footage**: *Volcanoes Video*. 1999. Auckland Museum.
24. **Footage**: *A Walk to Red Rocks*. 1999. DMP Films.
25. **Footage**: *If We Had No Moon*. 2000. York Films. Discovery Channel.
26. **Footage**: *Hawaii: Fire from the Sea*. 2000. Chrisman Films.
27. **Footage**: *Firewalkers*. 2000. Parallax Films.
28. **Feature, Footage**: *Xtreme Machines*. 2001. Pioneer Productions. Discovery Channel.
29. **Feature, Footage**: *Volcano*. 2001. Pioneer Productions. Discovery Channel.
30. **Host Researcher, Footage**: *JASON XII*. 2001. Media Arts. Jason Project.
31. **Feature**: *Enduring Extremes*. 2001. Wall to Wall Television. Discovery Health Channel.
32. **Feature**: *Coral Reef Adventure*. 2003. MacGillivray Freeman Films. IMAX feature film (http://www.coralfilm.com)
33. **Feature, Footage, Producer**: *Rebreather FUNdamentals*. 2003. Gallant Aquatic Ventures, Incorporated / International Association of Nitrox and Technical Divers.
34. **Producer & Editor:** *Uncharted Waters*. Association for Marine Exploration.
35. **Feature**: *Expedition Pacific Abyss*. 2007. British Broadcasting Corporation (BBC). Discovery Channel. 14 October 2007

36. **Feature**: *Pacific Abyss*. 2008. British Broadcasting Corporation (BBC).
37. **Support**: *Kilauea: Mountain of Fire*. 29 March 2009. Nature, PBS. (http://video.pbs.org/video/1133372360/; http://www.pbs.org/wnet/nature/kilauea-mountain-of-fire-video-full-episode/4825/)
38. **Feature**: [Educational DVD thingy]
39. **Advisor**: *One World Ocean*. MacGillivray Freeman Films.
40. **Feature**: *Dinofish*, 2012. Earth-Touch (PTY) Ltd., National Geographic. 1 April 2012.
41. **Feature**: *DeepSee Synergy*, 2012. Howard Hall Productions, 15 August 2012 (https://vimeo.com/47595340)
42. **Feature**: *Nature's Greatest Secret: The Coral Triangle. Episode 1 – A Deep Secret*. Wild Fury. International Broadcast. August 2013 (http://vimeo.com/107782561 [Tralier])
43. **Feature**: *Ocean Mysteries with Jeff Corwin* ABC television. Season 3, episode 307. November 2013.
44. **Interviewee**: Bytemarks Café. Episode 313: Diving into the Twilight Zone. 27 August 2014. (http://www.bytemarkscafe.org/2014/08/27/episode-313-diving-into-the-twilight-zone/)
45. **Interviewee**: Hawaii's Aquarium Fishery: Regulated, Valuable, Sustainable. 20 November 2016 (https://youtu.be/50L6JcMOVLQ)
46. **Feature**: *Sea of Hope*. National Geographic Society. 15 January 2017.

PUBLIC PRESENTATIONS:

Scientific and Technical (Invited):

1. **Invited Panelist**: Evacuation and Treatment Panel (45 min), *tek.93: An Emerging Dive Technologies Conference*, 18–19 January 1993, Orlando, Florida. R.W. Bill Hamilton, Chair. (Sponsored by *AquaCorps* technical journal)
2. **Invited Panelist**: Tech Ops: A Tutorial on Technical Diving (60 min), *tek.93: An Emerging Dive Technologies Conference*, 18–19 January 1993, Orlando, Florida. John Crea, Chair. (Sponsored by *AquaCorps* technical journal)
3. **Invited Panelist**: Medical, Academic, & Government Institutions Panel (60 min), *The Deep Diving Forum: A Question of – How Deep is Safe?*, 20 January 1993, Orlando, Florida. R.W. Bill Hamilton, Chair. (Sponsored by the Scuba Diving Resource Group)
4. **Invited Speaker**: Using Trimix to explore the Twilight Zone (25 min), *Diving Technologies Conference and Exhibition (tek.94)*, 19–23 January 1994, New Orleans, Louisiana. (Sponsored by *AquaCorps* technical journal)
5. **Invited Session Chair**: In-water Recompression as an emergency treatment for decompression illness (60 min), *Diving Technologies Conference and Exhibition (tek.94)*, 19–23 January 1994, New Orleans, Louisiana. (Sponsored by *AquaCorps* Magazine)
6. **Invited Speaker**: The potential uses of closed-circuit rebreathers in marine biological research (25 min), *AquaCorps Rebreather Forum*, 20–25 May 1994, Key West, Florida. (Sponsored by *AquaCorps* technical journal)
7. **Invited Speaker**: Systematics of reef and shore fishes of Oceania (30 min), *Marine and Coastal Biodiversity in the Tropical Island Pacific Region: I. Species Systematics and Information Management Priorities*, 2–4 November 1994, East-West Center, Honolulu, Hawaii. (Sponsored by the Ocean Policy Institute of the Pacific Forum/CSIS)
8. **Invited Speaker**: Patterns of coral reef fish biogeography in the Pacific region (30 min). *Marine and Coastal Biodiversity in the Tropical Island Pacific Region: I. Species Systematics and Information Management Priorities*, 7–9 November 1994, East-West

Center, Honolulu, Hawaii. (Sponsored by the Ocean Policy Institute of the Pacific Forum/CSIS)

9. **Invited Panelist**: Deep Air (60 min), Diver Safety Session, *Dive into the Future: The Dive Technologies Conference & Exhibition (tek.95)*, 21–24 January 1995, Moscone Center, San Francisco, California. Hal Watts, Chair. (Sponsored by Imbert, Ciesielski, & Fructus)
10. **Invited Session Co-chair**: Gearing Up (60 min), *Dive into the Future: The Dive Technologies Conference & Exhibition (tek.95)*, 21–24 January 1995, Moscone Center, San Francisco, California. Gary Gentile, Co-Chair. (Sponsored by *Scuba Times* Magazine)
11. **Invited Speaker**: Exploring the Twilight Zone (30 min), *Dive into the Future: The Dive Technologies Conference & Exhibition (tek.95)*, 21–24 January 1995, Moscone Center, San Francisco, California. (Sponsored by *AquaCorps* technical journal)
12. **Invited Session Chair**: In-water Recompression (60 min), *Diver Safety: The Dive Technologies Conference & Exhibition (tek.95*), 21–24 January 1995, Moscone Center, San Francisco, California. (Sponsored by Imbert, Ciesielski, & Fructus)
13. **Invited Panelist**: Dive Into the Internet (60 min), *Dive into the Future: The Dive Technologies Conference & Exhibition (tek.95*), 21–24 January 1995, Moscone Center, San Francisco, California. David Story, Chair. (Sponsored by *AquaCorps* technical journal)
14. **Invited Speaker**: The use of nitrox in closed circuit rebreathers for scientific purposes (45 min), *American Academy of Underwater Sciences Nitrox Diving Workshop*, 30 September – 4 October 1995, Wrigley Marine Science Center, Catalina Island, California (Sponsored by the American Academy of Underwater Sciences)
15. **Invited Speaker**: Using closed-circuit, mixed gas rebreathers to explore the Twilight Zone (30 min), *Diving Technologies Conference and Exhibition (tek.96)*, 12–16 January 1996, Ernest K. Morial Convention Centre, New Orleans, Louisiana. (Sponsored by *AquaCorps* technical journal)
16. **Invited Panelist**: Deep Diving Forum (120 min), *Diving Technologies Conference and Exhibition (tek.96)*, 12–16 January 1996, Ernest K. Morial Convention Centre, New Orleans, Louisiana. R.W. Hamilton, Chair. (Sponsored by *AquaCorps* technical journal)
17. **Invited Panelist**: Understanding Trimix Tables (60 min), *Diving Technologies Conference and Exhibition (tek.96)*, 12–16 January 1996, Ernest K. Morial Convention Centre, New Orleans, Louisiana. R.W. Hamilton, Chair. (Sponsored by *AquaCorps* technical journal)
18. **Invited Panelist**: Future of Rebreathers (60 min), *Diving Technologies Conference and Exhibition (tek.96)*, 12–16 January 1996, Ernest K. Morial Convention Centre, New Orleans, Louisiana. Michael Menduno, Chair. (Sponsored by *AquaCorps* technical journal)
19. **Invited Panelist**: Rebreather Maintenance & Logistics (60 min), *Rebreather Forum 2.0*. 26–28 September, 1996. Redondo Beach, CA.
20. **Invited Speaker**: Using Mixed-Gas Closed-Circuit rebreathers for deep decompression diving. End User Operational Experience (90 min), *Rebreather Forum 2.0*. 26–28 September, 1996. Redondo Beach, CA.
21. **Invited Speaker**: Keeping up with the times: Technical diving practices for in-water recompression (45 min). In-Water Recompression: A symposium and Workshop. *Undersea and Hyperbaric Medical Society Annual Scientific Meeting*. 24 May 1998. Seattle, Washington.
22. **Invited Seminar Speaker**: Using advanced diving technology to explore the deep coral reefs (60 min.), 17 December 1998, *Bodega Marine Laboratory*, University of California – Davis. (Sponsored by the Bodega Marine Laboratory)

23. **Invited Speaker**: In Water Recompression (35 min.), 24 April 1999, *OZTeK99 – Diving Technologies & Rebreather Forum*, Australian National Maritime Museum, Sydney, Australia. (Sponsored by OZTeK99)
24. **Invited Featured Evening Lecture Speaker**: Deep Reef Explorations (45 min.), 24 April 1999, *OZTeK99 – Diving Technologies & Rebreather Forum*, Australian National Maritime Museum, Sydney, Australia. (Sponsored by OZTeK99)
25. **Invited Speaker and Panelist**: Mixed Gas Closed Circuit Rebreather Use for Identification of New Reef Fish Species from 200–400 fsw (40 min), 3 November 1999, Technical Diving Forum: Assessment and feasibility of Technical Diving Operations for Scientific Exploration. *American Academy of Underwater Sciences Workshop*, West Coast Santa Cruz Hotel, Santa Cruz, California.
26. **Invited Speaker**: Using Advanced Diving Technology to Explore the Twilight Zone (60 min), 6 November 1999, *BioForum: Innovative Research in Field Biology. California Academy of Sciences*, San Francisco, California.
27. **Invited Symposium Speaker**: How Many Reef Fishes are we Missing?: Patterns of New Species Discovery on Deep Coral Reefs in the Indo-Pacific (15 min), *American Society of Ichthyologists and Herpetologists*, 80th Annual Meeting, 14–20 June, 2000, Universidad Autonoma De Baja California Sur, La Paz, Mexico.
28. **Invited Participant**: Original Organizing Meeting, All Species Foundation, 18–19 September 2000, California Academy of Sciences, San Francisco, CA.
29. **Invited Speaker**: Insights on Deep Bounce Dive Safety From the Technical Diving Community (20 mins), Panel On Diving Safety, Scientific Session III: Diving Safety, *16th Meeting of the United States-Japan Cooperative Programs on Natural Resources (UJNR)*, 1–3 November 2001, East-West Center, Honolulu, Hawaii.
30. **Invited Session Chair and Presenter**: Surface Logistics and Consumables for Open-Circuit and Closed-Circuit Deep Mixed-Gas Diving Operations (15 minutes), Session 43: Rebreathers, Tools For The Next Generation, *Marine Technology Society/IEEE Oceans 2001*, 5–8 November 2001, Hilton Hawaiian Village, Honolulu, Hawaii.
31. **Invited Presentation**: Hawaii Biological Survey: Taking inventory of the fauna and flora of the Hawaiian Islands. *Biodiversity Informatics Cooperation – Pacific Basin*, 10–12 June 2002, Maui, Hawaii.
32. **Invited Panelist**: E-types Workshop, All Species Foundation, 5–6 November 2002, Smithsonian Institution, Washington, DC.
33. **Invited Speaker**: Exploring Deep Reefs with Closed-Circuit Rebreathers (30 min), *2nd International Coelacanth Symposium*, 4–7 December 2002, Marathon, Florida. (via telephone)
34. **Invited Joint Presentation** (with Bill Steiner, Mark Fornwall, Lloyd Loupe, Shannon McElvaney, Melia Lane-Kamahele, and Ron Salz): Biodiversity and Information in Hawaii: A Partnership Presentation (90 min), *NBII All Node Meeting*, 6–9 January 2003, Maui, Hawaii.
35. **Invited Speaker**: Empirical Observations Relating To 'Deep Stops': A Fish Nerd's Perspective (30 min), *Deep Stops and Modern Decompression Strategies Workshop, National Association of Underwater Instructors (NAUI)*, 22–23 February 2003, Tampa, Florida. (via telephone)
36. **Invited Speaker**: Fishes of the Pacific Region (20 min) 20th Pacific Science Congress: "Science and Technology for Healthy Environments". 17–21 March 2003, The Sofitel Central Plaza Bangkok Hotel, Bangkok, Thailand. (Delivered by Allen Allison)

37. **Invited Panelist**: Second E-types Workshop, All Species Foundation, 12–14 May 2003, Smithsonian Institution, Washington, DC.
38. **Invited Speaker and Panelist**: Modeling Needs for the All-Species Hawaii Initiative. Biodiversity Modeling Workshop, National Biological Information Infrastructure. 28 July – 1 August 2003, Maui High Performance Computing Center, Kihei, Maui.
39. **Invited Presentation and Discussion**: Taxonomer Schema Explanation (4 hrs). SEEK Taxon Group, 23–28 January 2004, National Center for Ecological Analysis and Synthesis, University of California at Santa Barbara, Santa Barbara, California.
40. **Invited Keynote Speaker**: Banquet presentation (1 hr). Marine Aquarium Conference of North America. 11 September 2004, New England Aquarium, Boston, Massachusetts.
41. **Invited Speaker**: Tapping into an Unexplored Undersea Realm: the Biodiversity of Deep Coral Reefs (20 min), National Marine Educators Association Conference, 14 July 2005, Maui Community College, Kahului, Maui. http://www.hawaii.edu/maui/oceania/NMEA05.html
42. **Invited Moderator**: ECAT Seed Money Prioritization E-Conference, Global Biodiversity Information Facility (GBIF), May 25 – June 1, 2005.
43. **Invited Speaker**: Implementing the Digital Taxonomic Revolution: Strategies for a Successful Web-Based Registry of Taxonomic Names. ZooBank Symposium. 18 December 2005. Annual Meeting of the Entomological Society of America. Ft. Lauderdale, Florida. (via internet) http://www.nhm.ac.uk/hosted_sites/iczn/Fort_Lauderdale_ZB_Symposium.htm
44. **Invited Speaker**: CoML 1.
45. **Invited Participant**-GBIF-GUID 1
46. **Invited Speaker**: CoML 2.
47. **Invited Participant**-GBIF-GUID 2
48. **Invited Speaker**: New Caledonia.
49. **Invited Speaker**: Explorers' Club.
50. **Invited Speaker**: ZooBank Symposium, Smithsonian, May 2007.
51. **Invited Participant**: Overview of *Encyclopedia Pacifica*, ZooBank, CoF, Creefs (10 min). Encyclopedia of Life (EoL) Informatics (Data Model) Workshop. 10–11 February 2007. MBL, Woods Hole, Massachusetts, USA.
52. Mesophotic Coral Ecosystems (NOAA Workshop - Florida)
53. TDWG 2008
54. **Invited Speaker:** ZooBank and the Global Names Architecture. 8 January 2009. Interoperability of Museum, Taxonomic, and DNA Databases. 7–9 January 2009. Database Working Group, Consortium for the Barcode of Life, Field Museum of Natural History, Chicago, Illinois. (20 min)
55. **Invited Speaker:** Exploring Life on the Edge of Darkness. 11 February 2009. Looking for Life: Adventures and Misadventures in Species Exploration. International Institute of Species Exploration (IISE). Arizona State University, Tempe, Arizona. (30 min)
56. **Invited Speaker:** Taxonomy Comes of Technological Age. 2 June 2009. e-Biosphere 09: The International Conference on Biodiversity Informatics. 1–3 June 2009. Queen Elizabeth II Conference Centre, Westminster, London, UK http://www.youtube.com/watch?v=PSzL2NwRemU
57. **Invited Speaker:** ZooBank and the Global Names Architecture. 4–5 June 2009. International Committee on Bionomenclature, Natural History Museum, London, UK.
58. **Invited Participant:** IUCN Red List workshop to assess the extinction risks of Butterflyfishes and Angelfishes. 5–9 October 2009, Global Marine Species Assessment, Biodiversity Assessment Unit, IUCN Species Programme, Georgia Aquarium, Atlanta, Georgia.

59. **Invited Speaker:** The Global Names Architecture: Integration In Action (NOT "Inaction"). 11 November 2010. TDWG (Biodiversity Information Standards) Annual Conference. CORUM Conference Center, Montpellier, France (90 min)
60. **Invited Banquet Speaker:** A Brief History of Deep Coral-Reef Exploration: A Fish-Nerd's tale. 27 March 2010. American Academy of Underwater Sciences Annual Symposium: "Diving For Science". Waikiki Aquarium, Honolulu, Hawaii. (40 min) (https://youtu.be/gHEHHLnfwNg)
61. **Invited Speaker**: A History of Cis-Lunar Rebreathers. 15 May 2010. Inner Space Conference. Cayman Islands. (45 min)
62. **Invited Speaker:** Adventures of a Fish Nerd: Learning to Dive Deep the Hard Way. 19 June 2010. The 1st International Technical Scientific Diving Workshop. The Interuniversity Institute for Marine Sciences. Eilat, Israel. (60 min)
63. **Invited Speaker:** Logistical and Practical Considerations for Deep (100m+) Mixed-gas Diving in Remote Locations. 21 June 2010. The 1st International Technical Scientific Diving Workshop. The Interuniversity Institute for Marine Sciences. Eilat, Israel. (60 min)
64. **Invited Speaker:** Undiscovered Biodiversity within Pacific Mesophotic Coral Ecosystems. 23 June 2010. The 1st International Technical Scientific Diving Workshop. The Interuniversity Institute for Marine Sciences. Eilat, Israel. (30 min)
65. **Invited Speaker:** Mesophotic Coral Ecosystems of the Au‘au Channel, Hawai‘i (DeepCRES/Hawaii). 27 August 2010. Site Visit Symposium for the Hawaii Deep-CRES project. NOAA Papahānaumokuākea Marine National Monument Conference Room. Hawaii Kai, Hawaii. (15 min)
66. **Invited Session Chair:** Taxon Names & Concepts (Introduction, 6 Presentations, Discussion session). TDWG (Biodiversity Information Standards) Annual Conference. Woods Hole, MA, 27 September 2010 (105 min)
67. **Invited Speaker:** Mesophotic Coral Ecosystems of the Au‘au Channel, Hawai‘i (DeepCRES/Hawaii). 6 October 2010. Western Pacific Regional Fishery Management Council, 105th Meeting of the Scientific and Statistical Committee. Honolulu, Hawaii. (15 min)
68. **Invited Speaker and Panelist:** Exploring deep coral reefs in the tropical Pacific. 18 October 2010. FishBase Symposium 2010 — Discover! Naturhistoriska riksmuseet. Stockholm, Sweden. (45 min, plus Panel Discussion)
69. **Invited Participant and Committee Member**: IUBS/IUMS International Committee On Bionomenclature (ICB): BioCode Working Group Meeting. 21–23 October, 2010. Botanischer Garten und Botanisches Museum Dahlem, Freie Universität Berlin. Berlin, Germany.
70. **Invited Keynote Speaker:** Towards a Global Names Architecture: The Future of Indexing Scientific Names. 28 October 2011. Anchoring Biodiversity Information: From Sherborn to the 21st Century and Beyond. Flett Theatre, The Natural History Museum, London, UK
71. **Invited Speaker:** Endangered: Earth's Greatest Library. 2 November 2011. TEDx Honolulu. Cupola Theatre at Honolulu Design Center, Honolulu, Hawaii. http://www.youtube.com/watch?v=ZRFGUT594ug
72. **Invited Keynote Speaker:** A Brief History of Everything that Really Matters. 14 November 2011. Life and Literature, 14–15 November 2011. Biodiversity Heritage Library. Field Museum of Natural History, Chicago, Illinois. (60 min) http://www.lifeandliterature.org/2011/12/life-and-literature-speaker_08.html
73. NOMINA meetings (check all)
74. Public Presentation: Cook Islands.

75. **Invited Keynote Speaker:** British Subaqua Club annual meeting, 27 November 2012. NEC, Birmingham, England. (60 min.)
76. Literature Group – Pro-iBiosphere, February 2013
77. GUIDs – Pro-iBiosphere (15 min)
78. Ellinor presentation - Austria
79. **Invited Speaker:** Deep Diving, New Species Discovery, and the Greatest Library on Earth. Marine Biology Seminar, University of Hawaii, 8 March 2013 (60 min.)
80. **Featured lecturer:** Deep Diving Discoveries. Science Alive! Family Sunday, Atherton Halau, Bishop Museum, Honolulu, Hawaii. 17 March 2013 (40 min.)
81. **Invited Speaker:** Fishing the Twilight Zone: A Panoply of Nerdry. Honolulu Nerd Nite #3. Mercury Bar, Honolulu, Hawaii. 10 April 2013 (25 min)
82. Pro-iBiosphere (Berlin), May 2013 [http://wiki.pro-ibiosphere.eu/wiki/Workshops_Berlin,_May_2013]
83. **Invited Participant:** AntCat Technical Workshop (including presentation on the Global Names Architecture). Romberg Tiburon Center, San Francisco, California. 25-26 August 2013.
84. **Presentation:** The Global Names Architecture. California Academy of Sciences, San Francisco, California. 27 August 2013 (25 min)
85. **Invited Participant:** AntCat Editorial Workshop (including presentation on the Global Names Architecture). Romberg Tiburon Center, San Francisco, California. 29–30 August 2013 (20 min)
86. **Invited Speaker:** Why do we explore? The importance of discovering and documenting biodiversity. NOAA Marine Science Educators conference. Waikiki Aquarium, Honolulu, Hawaii. 18 October 2013 (20 min)
87. **TDWG 2013 Organizer**
88. **TDWG 2013 Presentation**
89. **Singapore**
90. Ellinor presentation - DC
91. **Manila**
92. **Invited Lecturer:** Deep Diving, New Species Discovery, and the Greatest Library on Earth. Guest Lecture for Marine Biology Course. University of Hawaii at Manuoa, St. John Hall, room 011. 1 April 2014. (1 hour)
93. **Invited Speaker:** In-Water Recompression: Where Have We Been; Where Are We Going? In Water Recompression Controversies Symposium, Kona Kai Resort, San Diego, California. 28 April 2014. (30 mins)
94. **Co-Authored Presentation:** (presented by Ellinor Michel). Global Digital Infrastructure for Biological Nomenclature and Taxonomy. Forum Herbulot 2014: How to accelerate the inventory of biodiversity.
95. **Invited Presentation:** (presented by Ellinor Michel). Global Digital Infrastructure for Biological Nomenclature and Taxonomy. (http://www.slideshare.net/EllinorM/michel-digital-nomenclaturegnazoobank2014conamesconfv2)
96. **Invited Speaker:** Deep Diving, New Species Discovery, and the Greatest Library on Earth. Natural Sciences Annex, Room 101, University of California, Santa Cruz, California.. 22 October 2014. (1 hour, 60 people)
97. **Invited Speaker:** Deep Diving, New Species Discovery, and the Greatest Library on Earth. Conference Room, California Academy of Sciences, San Francisco, California. 23 October 2014. (1 hour, 40 people)

98. **Workshop Participant and Presenter:** Biocollections Identifiers Workshop. Swedish Museum of Natural History, Stockholm, Sweden. 24–25 October 2014. (2 days,)
99. **Workshop Session Chair:** Darwin Core Workshop: Nomenclature in Darwin Core. TDWG – Biodiversity Information Standards. Elmia Congress Centre, Jönköping, Sweden. 28 October 2014 (90 min, 60 people)
100. **Invited Speaker and Panelist:** Why Technology Makes Rebreathers the Norm and Not the Exception. Divers Equipment and Marketing Association (DEMA), Las Vegas Convention Center, Las Vegas, Nevada (Room N242). 20 November 2014. (1 hour, 25 people)
101. **Invited Speaker:** Deep Diving, New Species Discovery, and the Greatest Library on Earth. Special Science Seminar, Natural History Museum, London (Flett Events Theatre). 14 January 2015. (1 hour; 80 people) http://youtu.be/8cUnkz9wSCU
102. **Invited Speaker:** The ZooBank Experience. The Future of Digital Nomenclature – an 'ICDN'? (NOMINA 14) International Committee for Bionomenclature Meeting. Mineralogy Meeting Room (Earth Science Building), Natural History Museum, London. 15 January 2015. (2.5 hours; 9 people)
103. **Invited Speaker:** Rebreather Evolution in the Foreseeable Future. Rebreathers and Scientific Diving Training Workshop, Wriggly Marine Science Center, University of Southern California, Catalina Island. 16 February 2015 (30 minutes, 50 people)
104. **Invited Speaker:** Use of Rebreathers for Biological Research and Remote Field Operations. Rebreathers and Scientific Diving Training Workshop, Wriggly Marine Science Center, University of Southern California, Catalina Island. 17 February 2015 (60 minutes, 50 people)
105. **Invited Presenter:** Overview of Poseidon SE7EN Rebreather, hands-on session. Rebreathers and Scientific Diving Training Workshop, Wriggly Marine Science Center, University of Southern California, Catalina Island. 17 February 2015 (30 minutes, 50 people)
106. **Invited Presenter:** Deep Diving, New Species Discovery, and the Greatest Library on Earth. Sustainable Oceans Summit, McDonough School of Business, Rafik B. Hariri Building, Georgetown University, Washington, D.C. 25 April 2015 (12 minutes, 200 people)
107. **Invited Presenter and Participant:** ZooBank. Global Registry of Biodiversity Repositories: Designing GRBio Version 2, U.S. National Museum of Natural History, Smithsonian Institution, Washington, DC. 27-28 April 2015 (10 minutes, 21 people)
108. **Invited Presentation:** Update on the status of ZooBank. International Committee on Bionomenclature. 32nd International Union of Biological Sciences General Assembly & Conference in Berlin 14 December 2015 (15 min, 15 people)
109. **Invited Presentation:** ZooBank, Registration & the Digital Future for Nomenclature. BioNomenclature: Making nomenclatural codes, concepts and tools fit for modern research. 32nd International Union of Biological Sciences General Assembly & Conference in Berlin 15 December 2015 (20 min, 60 people)
110. **Invited Presentation:** ZooBank Status. International Commission on Zoological Nomenclature. 32nd International Union of Biological Sciences General Assembly & Conference in Berlin 16 December 2015 (120 min, 16 people)
111. **Invited Presentation and Symposium Organizer:** The Habitat Persistence Hypothesis. Mesophotic and Deep-Sea Coral Ecosystems: A Tribute to the Pioneering Efforts of Dr. John Rooney, 13th International Coral Reef Symposium, Honolulu, 21 June 2016 (15 min, 120 people). (https://youtu.be/N4-8tlh5fC0)
112. **Guest Lecturer:** Documenting the Global Biodiversity Library: Explorations and Discoveries on Deep Coral Reefs. Hawaii Pacific University, Hawaii Loa campus, Kailua. 6 October 2016. (60 min; 45 people).

113. **Invited Participant:** Names in November
114. **Invited Participant:** Update on the ICZN and ZooBank. American Association for Zoological Nomenclature (AAZN). Washington, DC, 12 December 2016 (Remote Paricipation via telephone) (15 min, 12 people).
115. **Invited Presentation:** Documenting the Global Biodiversity Library: Explorations and Discoveries on Deep Coral Reefs. U.S. National Museum of Natural History, Smithsonian Institution, Washington, D.C. 6 January 2017 (60 mins, 100 people)
116. American Samoa presentation
117. **Woods Hole presentation (Remsen)**
118. **Woods Hole presentation (rebreather)**
119. **PechaKucha**
120. **Invited Presentation:** Exploring deep coral reefs with high-tech SCUBA. University of the Ryukyus, Okinawa. 17 November 2017 (30 mins, 25 people)
121. **Invited Presentation:** Physics and "Fizzyology": The Battle of the Bends in Deep-Sea Diving. Nerd Nite: Bishop Museum Takeover! Anna O'Brien's, Honolulu, Hawaii. 6 March 2018 (20 mins, 150 people)
122. **Invited Panelist:** Expert Panel Discussion & Film Screening for "Chasing Coral" documentary. The Global Issues Network 2018 Conference, Le Jardin Academy, Kailua, Hawaii. 9 March 2018 (60 mins, 200 people)
123. **Invited Presentation:** Exploring the uniqueness of Marine Biodiversity in the Hawaiian Archipelago: Workshop on Ocean Health and Biodiversity. The Global Issues Network 2018 Conference, Le Jardin Academy, Kailua, Hawaii. 11 March 2018 (40 mins x 2 workshops, 50 people total)

Scientific and Technical (Other):

124. **Presenter:** Deep Thoughts: Comments on the use of Trimix for exploring the 'Twilight Zone', American Society of Ichthyologists and Herpetologists, 71st Annual Meeting, 15–20 June 1991, New York, New York.
125. **Presenter:** Using Nitrox to extend bottom times for moderate-depth SCUBA dives (12 min), American Society of Ichthyologists and Herpetologists, 71st Annual Meeting, 15–20 June 1991, New York, New York.
126. **Presenter:** Probing the `Twilight Zone': Investigating Deepwater Ichthyofauna (20 min), 17th Annual Albert L. Tester Memorial Symposium, 16 April 1992, Department of Zoology, University of Hawaii, Honolulu, Hawaii.
127. **Presenter:** The Twilight Zone: The potential, problems, and theory behind using mixed gas, surface-based scuba for research diving between 200 and 500 feet (30 min), American Academy of Underwater Sciences Twelfth Annual Scientific Diving Symposium, September, 1992, Wilmington, North Carolina. (P. Sharkey, co-author and presenter)
128. **Presenter:** Mixed Gas Research Diving (30 min), 1992 International Conference on Underwater Education, 10–11 October 1992, Philadelphia, Pennsylvania. (P. Sharkey, co-author and presenter).
129. **Presenter:** The reef and shore fishes of the Ogasawara Islands: a biogeographic perspective (20 min), 18th Annual Albert L. Tester Memorial Symposium, 23 April 1993, Department of Zoology, University of Hawaii, Honolulu, Hawaii.
130. **Presenter:** Biogeographical analysis of the reef and shore fishes of the Ogasawara Islands (12 min.), American Society of Ichthyologists and Herpetologists, 73rd Annual Meeting, 29 May–2 June 1993, University of Texas at Austin, Austin, Texas.

131. **Presenter:** Using new diving techniques to explore the 'Twilight Zone' (60 min.), Bishop Museum Research Seminar Series, 31 August 1993, Bishop Museum, Honolulu, Hawaii.
132. **Presenter:** Evoluncheon Seminar, 9 November 1993, University of Hawaii, Honolulu, Hawaii.
133. **Presenter:** Patterns of hybridization in coral reef fishes (20 min), 19th Annual Albert L. Tester Memorial Symposium, April 1994, Department of Zoology, University of Hawaii, Honolulu, Hawaii.
134. **Presenter:** Patterns of hybridization in coral reef fishes (20 min), American Society of Ichthyologists and Herpetologists, 74th Annual Meeting, 2–8 June 1994, University of Southern California, Los Angeles, California.
135. **Presenter:** Patterns of hybridization in coral reef fishes (20 min), Ecological and Evolutionary Ethology of Fishes, 9th Conference, 15–18 May, 1994, University of Victoria, British Columbia.
136. **Presenter:** Use of new diving technology to explore the Twilight Zone (60 min), American Society of Ichthyologists and Herpetologists, 74th Annual Meeting, 2–8 June 1994, University of Southern California, Los Angeles, California.
137. **Presenter:** How Many Reef Fishes are we Missing?: Patterns of New Species Discovery on Deep Coral Reefs in the Indo-Pacific (15 min), 25th Annual Albert L. Tester Memorial Symposium, 13 April 2000, Department of Zoology, University of Hawaii, Honolulu, Hawaii.
138. **Presenter:** A comprehensive database management tool for systematic and biogeographic research (Poster), American Society of Ichthyologists and Herpetologists, 80th Annual Meeting, 14–20 June, 2000, Universidad Autonoma De Baja California Sur, La Paz, Mexico.
139. **Presenter:** Exploring Deep Coral Reefs: Past, Present, and Future (20 min), Hawaii Institute of Marine Biology Student Colloquium, 5 December 2001, Kaneohe, Hawaii.
140. **Presenter:** Counting angelfishes on the head of a pin? The science and art of taxonomy as applied to the Poamcanthidae (60 min), PhD Dissertation Defense presentation, University of Hawaii at Manoa, 5 December 2003, Honolulu, Hawaii.
141. **Presenter:** Protonyms, References, and Assertions: An introduction to the Taxonomer data model (20 min), TDWG – Biodiversity Information Standards. University of Canterbury, Christchurch, New Zealand. 14 October 2004.
142. **Presenter:** Recent Discoveries of New Fishes Inhabiting Deep Pacific Coral Reefs, with Biogeographic Implications (20 min), 7th Indo-Pacific Fish Conference, Taipei, Taiwan. 18 May 2005.
143. **Presenter:** Video highlights of deep coral reefs. (30 min), 7th Indo-Pacific Fish Conference, Taipei, Taiwan. 19 May 2005.
144. **Presenter:** LSIDs for Taxon Names: The ZooBank Experience (15 min), TDWG – Biodiversity Information Standards. SÚZA Conference Center, Bratislava, Slovakia. 18 September 2007.
145. **Co-Author:** The Presence of Deep-Coral Reefs (40 – 120 M) in Hawaii. Montgomery, Anthony, Rooney, John, Pyle, Richard, Boland, Raymond, Parrish, Frank, Spalding, Heather, Longnecker, Ken, Popp, Brian, presented by A. Montgomery. 11th International Coral Reef Symposium: Reef Status and Trends. Ft. Lauderdale, FL. 8 July 2008.
146. **Co-Author:** Efficiency and safety of scientific diving – Closed Circuit Rebreathers. Sieber, A., Pyle, R., & Sjöblom, K., presented by A. Sieber. 7 October 2009. 2nd International Symposium on Occupational Scientific Diving (ISOSD2009) of ESPD, Organised by Finnish Scientific Diving Steering Association, Tvärminne Zoological Station, University of Helsinki, Finland. (20 min).

147. **Co-Author:** Baseline surveys of exploited reef-fish populations at Kamiali, Papua New Guinea: challenges and progress working in a remote, subsistence economy. Longenecker, K., Langston. R, Pyle, R., Pence, D. & Talbot, S. authors, presented by K. Longenecker. 26 March 2010. American Academy of Underwater Sciences Annual Symposium: "Diving For Science". Honolulu, Hawaii. (20 min)
148. **Co-Author:** New report of black coral species from the Northwestern Hawaiian Islands. Wagner, D., Toonen, R.J., Papastamatiou, Y.P., Kosaki, R.K., Gleason, K.A., McFall, G,B, Boland, R.C. & Pyle, R.L., presented by D. Wagner. 26 March 2010. American Academy of Underwater Sciences Annual Symposium: "Diving For Science". Honolulu, Hawaii. (20 min)
149. **Co-Author:** Technical diving used for mesophotic coral ecosystem characterization in the Papahānaumokuākea Marine National Monument. Kosaki, R., Pyle, R.L., Boland, R., McFall, G., Gleason, K., presented by R. Kosaki. 26 March 2010. American Academy of Underwater Sciences Annual Symposium: "Diving For Science". Honolulu, Hawaii. (20 min)
150. **Presenter:** TDWG 2010 (Check others)
151. TDWG 2011
152. NOMINA
153. **Presentation (Presented by Dmitry Y Mozzherin):** Identifiers for Biodiversity Informatics: The Global Names Approach. Biodiversity Information Standards (TDWG), Santa Clara de San Carlos, Costa Rica, 8 December 2016 (15 mins)
154. **GSA 25 May 2017**
155.

Popular and Educational:

156. **Invited Presentation**: Using new diving techniques to explore the 'Twilight Zone' (60 min.), *Hawaiian Malacological Society Meeting*, 1 September 1993, First United Methodist Church, Honolulu, Hawaii.
157. **Invited Presentation**: Using new diving techniques to explore the 'Twilight Zone' (60 min.), *Underwater Photography Society*, Epic Dives Hawaii, Kaneohe, Hawaii.
158. **Invited Presentation**: Using new diving techniques to explore the 'Twilight Zone' (60 min.), *Windward Dive Club*, Kaneohe, Hawaii.
159. **Invited Presentation**: Using new diving techniques to explore the 'Twilight Zone' (60 min.), *Sea Camp, YMCA*, Kaneohe, Hawaii.
160. **Invited Plenary Speaker**: Rare fishes, the Twilight Zone, and thoughts on captive propagation (90 min), *Marine Aquarium Conference of North America*, 6th Annual Meeting, October 1994, Cleveland, Ohio. (Sponsored by the Marine Aquarium Society of North America).
161. **Invited Presentation**: Applications of rebreathers for underwater photographers (60 min), *Underwater Photography Society, Hawaii Chapter meeting*, 14 March 1995, Windward Community College, Mahi Room 113. (Sponsored by the Underwater Photography Society, Hawaii Chapter).
162. **Invited Presentation**: Using new diving techniques to explore the 'Twilight Zone' (60 min.), *Sea Lancers Dive Club*, 18 September, 1996, Hickam Air Force Base, Honolulu, Hawaii.
163. **Invited Speaker**: Fishes of Kaneohe Bay (60 min), *UCLA Summer Program*, 17 October 1996, Hawaii Institute of Marine Biology, Kaneohe, Hawaii.

164. **Invited Presentation**: Using advanced diving techniques to explore the 'Twilight Zone' (60 min). *Hawaiian Malacological Society Meeting*, 5 February 1997, First United Methodist Church, Honolulu, Hawaii.
165. **Guest Lecturer**: Patterns of Coral Reef Fish Distributions, and the Exploration of the Twilight Zone (75 min), Biology 320: The Atoll, *University of Hawaii at Manoa*. 18 February 1997. Honolulu, Hawaii.
166. **Banquet Speaker**: Diving Into the Twilight Zone (75 min). *Hawaii Council of Diving Clubs annual banquet*, 8 March 1997, Waikiki Aquairum, Honolulu, Hawaii.
167. **Invited Speaker**: Exploring the Twilight Zone (60 min). *Department of Land and Natural Resources*, Honolulu, Hawaii. Fall 1997.
168. **Invited Speaker**: Exploring the Twilight Zone (60 min). *B.P. Bishop Museum Evening Lecture Series*, Honolulu, Hawaii. Fall 1997.
169. **Invited Speaker**: "Meet a Deep Sea Explorer" (60 min). *Bishop Museum In the Dark Day Camp*, 25 March 1998, B.P. Bishop Museum, Honolulu, Hawaii.
170. **Invited Speaker**: Exploring the Twilight Zone (60 min). *Bishop Museum "Explorers" Series*, 30 March 1998, B.P. Bishop Museum, Honolulu, Hawaii.
171. **Invited Presentation**: Closed Circuit Rebreathers and the 'Twilight Zone' (60 min.), *Sea Lancers Dive Club*, 12 December, 1998, Hickam Air Force Base, Honolulu, Hawaii.
172. **Invited Speaker**: History of Fish Exploration in Hawaii (60 min.), *Waikiki Aquarium Evening Lecture Series*, Honolulu, Hawaii. Spring 1999.
173. **Featured Evening Lecture Speaker**: Exploration into the Ocean's Twilight Zone, New Species from Deep Coral Reefs Using Advanced Diving Technology (120 min), 17 November 1999, *Marine Ornamentals '99*. Hilton Waikaloa Village, Kailua-Kona, Hawaii.
174. **Guest Lecturer**: Reef Fishes (50 minutes), Zoology 200: Marine Biology. *University of Hawaii at Manoa*. 23 January 2001. Honolulu, Hawaii.
175. **Guest Lecturer**: Reef Fishes (75 minutes), Zoology 480: Ichthyology. *University of Hawaii at Hilo*. 19 April 2001. Hilo, Hawaii.
176. **Featured Evening Speaker**: Exploring Deep Coral Reefs: Past, Present, and Future (45 min), *Hawaii Aquaculture Association Annual Meeting*, 19 January 2002, B. P. Bishop Museum, Honolulu, Hawaii.
177. **Invited Presentation**: Applications of Advanced Diving Technology for Underwater Science: The Deep, the Long, and the Quiet (60 min), *Pagen-Pauley Summer Program*, 2 July 2002, Hawaii Institute of Marine Biology, Kaneohe, Hawaii.
178. **Invited Presentation**: Applications of Advanced Diving Technology for Underwater Science: The Deep, the Long, and the Quiet (60 min), MacGillivray Freeman Films Staff Presentation, 6 August 2002, *MacGillivray Freeman Films*, Laguna Beach, California.
179. **Invited Presentation**: So many fish, so little time…Using advanced diving technology to explore the 'Twilight Zone' (45 min), *Marin Community Foundation*, 8 August 2002, Marin Community Foundation, San Francisco, California.
180. **Invited Presentation**: Exploring the Twilight Zone, and Behind The Scenes of *Coral Reef Adventure*. (15 min x 3 presentations), *Tech Museum of Innovation*, 5 March 2003, San Jose, California.
181. **Invited Presentation**: Exploring the Twilight Zone, and Behind The Scenes of *Coral Reef Adventure*. (25 min x 2 presentations), *National Museum of Naval Aviation*, 20 March 2003, Pensacola, Florida.
182. **Invited Presentation**: Scientist On Tour Series: Exploring the Twilight Zone, and Behind The Scenes of *Coral Reef Adventure*. (60 min x 4 presentations), *First Ward Elementary School*, 7 April 2003, Charlotte, North Carolina.

183. **Invited Presentation**: Scientist On Tour Series: Exploring the Twilight Zone, and Behind The Scenes of *Coral Reef Adventure*. (45 min), *Discovery Place*, 7 April 2003, Charlotte, North Carolina.
184. **Invited Presentation**: Scientist On Tour Series: Exploring the Twilight Zone, and Behind The Scenes of *Coral Reef Adventure*. (45 min), *Bethlehem Center*, 7 April 2003, Charlotte, North Carolina.
185. **Invited Presentation**: Scientist On Tour Series: Exploring the Twilight Zone, and Behind The Scenes of *Coral Reef Adventure*. (45 min x 2 presentations), *Cochran Middle School*, 8 April 2003, Charlotte, North Carolina.
186. **Invited Presentation**: Scientist On Tour Series: Exploring the Twilight Zone, and Behind The Scenes of *Coral Reef Adventure*. (60 min), *Grier Heights Community Center*, 8 April 2003, Charlotte, North Carolina.
187. **Invited Presentation**: Scientist On Tour Series: Exploring the Twilight Zone, and Behind The Scenes of *Coral Reef Adventure*. (30–45 min x 11 presentations), Carnegie Science Center (SciTech Festival), 10–13 April 2003, Pittsburgh, Pennsylvania.
188. **Invited Presentation**: Scientist On Tour Series: Exploring the Twilight Zone, and Behind The Scenes of *Coral Reef Adventure*. (45 min x 3 presentations), *Museum of Discovery and Science*, 17 April 2003, Ft. Lauderdale, Florida.
189. **Invited Presentation**: Scientist On Tour Series: Exploring the Twilight Zone, and Behind The Scenes of *Coral Reef Adventure*. (60 min), *Oregon Museum of Science and Industry*, 22 April 2003, Portland, Oregon.
190. **Invited Presentation**: Scientist On Tour Series: Exploring the Twilight Zone, and Behind The Scenes of *Coral Reef Adventure*. (25 min x 8 presentations), *Duluth OMNIMAX Theatre*, 24–25 April 2003, Duluth, Minnisota.
191. **Invited Presentation**: Scientist On Tour Series: Exploring the Twilight Zone, and Behind The Scenes of *Coral Reef Adventure*. (30 min x 3), *Cincinnati Museum Center at Union Terminal*, 6–7 May 2003, Cincinnati, Ohio.
192. **Invited Presentation**: Scientist On Tour Series: Exploring the Twilight Zone, and Behind The Scenes of *Coral Reef Adventure*. (30 min), *Newport Aquarium*, 7 May 2003, Newport, Kentucky.
193. **Invited Presentation**: Scientist On Tour Series: Exploring the Twilight Zone, and Behind The Scenes of *Coral Reef Adventure*. (90 min), *Reuben H. Fleet Science Center*, 21 June 2003, San Diego, California.
194. **Invited Presentation**: Scientist On Tour Series: Exploring the Twilight Zone, and Behind The Scenes of *Coral Reef Adventure*. (30 min x 3 presentations), *Tech Museum of Innovation*, 2–3 August 2003, San Jose, California.
195. **Invited Presentation**: Scientist On Tour Series: Exploring the Twilight Zone, and Behind The Scenes of *Coral Reef Adventure*. (30 min x 5 presentations), *Great Lakes Science Center*, 12–13 December 2003, Cleveland, Ohio.
196. **Invited Presentation**: Exploring Deep Coral Reefs/"Uncharted Waters" (60 min), *Sea Lancers Dive Club*, 22 September 2004, Hickam Air Force Base, Honolulu, Hawaii.
197. **Invited Presentation**: A dive into the reef's Twilight Zone (20 min). TED2004: The Pursuit of Happiness, Monterey Conference Center, Monterey, California, 27 February 2004. (http://www.ted.com/talks/richard_pyle_dives_the_twilight_zone)
198. **Invited Presentation**: Exploring the Twilight Zone (30 min) Lanikai Elementary School, Kailua, Hawaii. 10 April 2006.

199. **Invited Presentation**: Exploring the Twilight Zone (30 min) SCUBAnaut International group (60 min) Bernice P. Bishop Museum, Ichthyology Collection, Honolulu, Hawaii. 19 October 2007.
200. **Guest lecturer:** Le Jardin Academy High School Advanced Placement Biology class, "Exploring Deep Coral Reefs", 9 May 2008 (45 min x 3 classes)
201. Waikiki Aquarium
202. **Invited Speaker:** Into the Twilight Zone: Exploring the Deep Coral Reefs (60 min). 12 June 2008. Atherton Halau, Bernice P. Bishop Museum, Honolulu, Hawaii.
203. Sweden-Life at the Twilight Zone (60 min). Universeum, Gothenburg, Sweden.
204. **Guest lecturer:** "Advanced Topics in Marine Biology" class, Cindy Hunter professor (45 min), 3 March 2009, University of Hawaii, Honolulu, Hawaii.
205. **Guest lecturer:** Le Jardin Academy High School Biology class, "Taxonomy and Systematics", 5 March 2009 (45 min x 3 classes)
206. **Speaker:** Life as a Marine Biologist. 20 March 2009. Waimanalo School Career Day, Waimanalo Intermediate School, Waimanalo, HI. (30 min. x 5 classes)
207. **Speaker:** Exploring Life on the Edge of Darkness. 60 min. 16 April 2009. Harvard Club Brown Bag Luncheon, Atherton Halau, Bishop Museum, Honolulu, HI
208. **Invited Speaker:** Back to the Future in Underwater Exploration: An Old Technology Comes of Age. 60 min. 7 October 2009. Georgia Aquarium Brown Bag Lunch Series, Atlanta, GA.
209. **Guest lecturer:** University of Hawaii at Manoa for Biol 404 Advanced Topics in Marine Biology, "Exploring Deep Coral Reefs", 18 February 2010 (75 min.)
210. **Guest lecturer:** Hawaii Institute of Marine Biology for Tropical Ecology visiting class, "Exploring Deep Coral Reefs", 29 March 2010 (75 min.)
211. **Guest lecturer:** Le Jardin Academy High School Advanced Placement Biology class, "Exploring Deep Coral Reefs", 15 April 2010 (45 min x 3 classes)
212. **Invited Speaker:** Exploring the Twilight Zone: New Technology to find New Species, Midwest Marine Conference, Bloomfield Hills, MI, 22 May 2010 (60 min)
213. **Guest lecturer:** Le Jardin Academy High School Biology class, "Taxonomy and Systematics", 15 March 2011 (45 min x 3 classes)
214. **Guest lecturer:** Le Jardin Academy High School Advanced Placement Biology class, on Taxonomy and Systematics, April 2012 (75 min x 3 classes)
215. **Guest lecturer:** Le Jardin Academy High School Advanced Placement Biology class, on Taxonomy and Systematics, 25–26 April 2013 (75 min x 3 classes)
216. **Invited Presentation:** The Greatest Library on Earth. Saranac Lake Free Library, Saranac Lake, New York. 8 July 2013 (1 hour)
217. **Invited Keynote Speaker: MACNA 2013**
218. **Invited Speaker:** Commencement Speech for a group of graduating Eagle Scouts (Boy Scouts of America), St. John Vianney Chapel, Kailua, Hawaii. 12 January 2014 (15 min)
219. **Guest lecturer:** Le Jardin Academy High School DP Biology class, on Taxonomy and Systematics, 25–26 April 2014 (75 min x 3 classes)
220. **Invited Presenter:** (with Neal Evenhuis and Sonia Rowley) Natures Wonders Exhibit, presented to Bishop Museum Docents. Long Gallery, Bernice P. Bishop Museum. 26 August 2014. (1 hour)
221. **Invited Speaker:** Fishing the Twilight Zone. NOAA Ship R/V Hiʻialakai, Papahānaumokuākea Marine National Monument. 24 September 2014 (20 min)
222. **Invited Speaker:** Diving with Coelacanths. NOAA Ship R/V Hiʻialakai, Papahānaumokuākea Marine National Monument. 24 September 2014 (30 min)

223. **Invited Joint Presentation:** (with Sonia Rowley). Exploring deep coral reefs. Bernice P. Bishop Museum, Hawaiian Hall Atrium. 28 November 2014 (25 min, 15 people)
224. **Invited Presentation:** Exploring Papahānaumokuākea. Bernice P. Bishop Museum, Science Adventure Center. December 3 2014 (1 hour).
225. **Invited Joint Presentation:** (with Sonia Rowley). Exploring deep coral reefs. Bernice P. Bishop Museum, Hawaiian Hall Atrium. 19 January 2015 (25 min)
226. **Guest lecturer:** Le Jardin Academy High School Advanced Placement Biology class, on Taxonomy and Systematics, 30 April–1 May 2015 (75 min x 3 classes)
227. **Invited Joint Presentation:** (with Sonia Rowley and Brian Greene). Exploring deep coral reefs in Pohnpei. College of Micronesia, Pacific Small Business Center Building, Top Floor. 26 July 2015 (60 min, 150 people)
228. **Invited Joint Presentation:** (with Sonia Rowley and Brian Greene). Exploring deep coral reefs in Pohnpei. Conservation Society of Pohnpei. 26 July 2015 (60 min, 20 people)
229. **Invited Presentation:** Closed Circuit Rebreathers. NOAA Ship R/V Hiʻialakai, Papahānaumokuākea Marine National Monument. XX September 2015 (60 min, 20 people)
230. **Invited Presentation:** Creatures of the Deep. Waikiki Aquarium Distinguished Lecture Series. Thurston Memorial Chapel of his alma mater, Punahou School, Honolulu. 19 November 2015 (75 min, 300 people) https://youtu.be/ZD3RuqLP18U
231. Monument Expansion (CEQ)
232. Bishop Museum Interns, 1 April 2016 (12 people)
233. **TOTP1**
234. **Invited Speaker:** Poseidon Rebreathers. NOAA Diving Center Safety Board Meeting, Daniel K. Inouye Regional Center (IRC), Ford Island, Honolulu, 26 February 2016 (45 min; 25 people).
235. **Featured Speaker:** Saving the Biodiversity Library. Honolulu Science Café, JJ's Bistro, Honolulu, 19 April 2016 (60 min; 20 people).
236. **Guest lecturer:** Le Jardin Academy High School DP Biology class, on Taxonomy and Systematics, 28–29 April 2016 (75 min x 3 classes)
237. **Featured Speaker:** Saving the Biodiversity Library. Rotary Club of Honolulu Sunset, Waikiki Yacht Club, Honolulu, 20 June 2016 (25 min; 35 people).
238. **TOTP2**
239. **MACNA**
240. **Invited Lecturer:** Exploring deep coral reefs in Hawaii. Aloha Bowl Team Home School Group, Aliamanu Military Reservation, Honolulu, 3 October 2016 (45 min; 15 people).
241. **DEMA – Evolution of Oxygen Sensors**, 16 November 2016 (60 people)
242. **Coral Fish Hawaii**, 20 November 2016 (20 people)
243. **Invited Panel:** Follow-up discussion on premiere of the film, "Sea of Hope", National Geographic Grosvenor Auditorium, Washington, D.C. 5 January 2017 (20 mins, 300 people)
244. **Invited Presentation:** Exploration and Discoveries on Deep Coral Reefs. NOAA National Marine Sanctuary of American Samoa Center. 27 February 2017 (45 mins, 120 people)
245. **Guest lecturer:** Le Jardin Academy High School DP Biology class, on Taxonomy and Systematics, 28–29 April 2017 (75 min x 3 classes)
246. **Invited Presentation:** (Douglas McCauly and Stephen Palumbi, co-presenters) Science in support of the Papahānaumokuākea Marine National Monument. Office of Earl Comstock, Office of Policy and Strategic Planning, U.S. Department of Commerce, Washington, D.C. 14 June 2017 (45 mins, 6 people)

247. **Invited Presentation:** Building a Common Nomenclatural Infrastructure. National Center for Biotechnology Information, Bethesda, Maryland. 16 June 2017 (90 mins, 22 people)

Other National and International Meetings and Conferences:

U.S.- Japan Workshop on Elasmobranchs as Living Resources, American Elasmobranch Society, 10–14 December 1987, Honolulu, Hawaii.

American Society of Ichthyologists and Herpetologists, 69th Annual Meeting/American Elasmobranch Society, 5th Annual Meeting, 17–23 June 1989, San Francisco, California.

Ecological and Evolutionary Ethology of Fishes, 7th Conference, 19–23 May, 1990, Flagstaff, Arizona.

Pacific Science Congress, 17th Annual Conference, Honolulu, Hawaii.

American Academy of Underwater Sciences, 11th Annual Scientific Diving Symposium, 26–29 September 1991, Honolulu, Hawaii.

Implementing Enriched Air Nitrox (EAN) Technology: A Community Guideline, 13–14 January 1992, Houston, Texas.

PUBLICATIONS

Scientific and Technical:

1. **Pyle, R.L.** 1988. A new subspecies of butterflyfish (Chaetodontidae) of the genus *Roaops* from Christmas Island, Line Islands. *Freshwater and Marine Aquarium Magazine* 11(9):56–62,123–124, 10 figs.
2. **Pyle, R.L.** 1990. *Centropyge debelius*, a new species of angelfish (Teleostei: Pomacanthidae) from Mauritius and Réunion. *Révue française Aquariologie* 17(2):47–52, 7 figs.
3. Kosaki, R.K., **R.L. Pyle**, J.E. Randall and D.K. Irons. 1991. New records of fishes from Johnston Atoll, with notes on biogeography. *Pacific Science* 45(2):186–203, 17 figs.
4. **Pyle, R.L.** 1992. The peppermint angelfish *Centropyge boylei*, n.sp. Pyle and Randall. *Freshwater Mar. Aquar.* 15(7):16–18, 3 figs. + cover.
5. **Pyle, R.L.** and J.E. Randall. 1992. A new species of *Centropyge* (Perciformes: Pomacanthidae) from the Cook Islands, with a redescription of *C. boylei*. *Révue française Aquariologie* 19(4):115–124, 7 figs.
6. **Pyle, R.L.** 1992. The Twilight Zone. *AquaCorps: Mix*. 3(1):19, 1 fig.
7. **Pyle, R.L.** 1993. Marine Aquarium Fish. In: *Nearshore Marine Resources of the South Pacific: Information for Fisheries Development and Management.* (A. Wright and L. Hill, eds.), Institute of Pacific Studies, Suva; Forum Fisheries Agency, Honiara; and International Centre for Ocean Development, Canada. 135–176.
8. Randall, J.E., J.L. Earle, **R.L. Pyle**, J.D. Parrish, and T. Hayes. 1993. Annotated checklist of the fishes of Midway Atoll, Northwestern Hawaiian Islands. *Pacific Science* 47(4): 356–400.
9. Sharkey, P. and . **R.L. Pyle**. 1993. The Twilight Zone: The potential, problems, and theory behind using mixed gas, surface based scuba for research diving between 200 and 500 feet. *In*: Diving for Science...1992. Proceedings of the American Academy of Underwater Sciences Twelfth Annual Scientific Diving Symposium. (L.B. Cahoon, ed.), American Academy of Underwater Sciences, Costa Mesa, CA. pp. 173–187.
10. Sharkey, P. and **R.L. Pyle**. 1993. The Twilight Zone: Mixed Gas Research Diving. *In*: Proceedings of the 1992 International Conference on Underwater Education. (H. Vidders, ed.), National Association of Underwater Instructors, Montclair, CA.

11. **Pyle, R.L.** and J.E. Randall. 1994. A review of hybridization in marine angelfishes (Perciformes: Pomacanthidae). *Environmental Biology of Fishes* 41: 127–145.
12. **Pyle, R.L.** and J.E. Randall. 1994. A review of hybridization in marine angelfishes (Perciformes: Pomacanthidae). *In:* Balon, E.K., M.N. Bruton, and D.L.G. Noakes (Eds.) Women in ichthyology: an anthology in honour of ET, Ro and Genie. Developments in environmental biology of fishes 15, Kluwer Academic Publishers, Boston, pp.127–145.
13. **Pyle, R.L.** and E.H. Chave. 1994. First record of the chaetodontid genus *Prognathodes* from the Hawaiian Islands. *Pacific Science* 48(1): 90–93.
14. **Pyle, R.L.** 1995. Chapter 12. Pacific reef and shore fishes. *In:* Maragos, J.E., M.N.A. Peterson, L.G. Eldredge, J.E. Bardach, and H.F. Takeuchi (Eds.). *Marine and Coastal Biodiversity in the Tropical Island Pacific Region. Volume 1. Species Systematics and Information Management Priorities*. Program on Environment, East-West Center, Honolulu, Hawaii, pp. 205–238.
15. **Pyle, R.L.** and D.A. Youngblood. 1995. The case for in-water recompression. *aquaCorps*, No. 11:35–46.
16. **Pyle, R.L.** 1996. Section 7.9. Multiple gas mixture diving, Tri-mix. *In:* Flemming, N.C. and M.D. Max (Eds.) Scientific Diving: a general code of practice, Second Edition. United Nations Educational, Scientific and Cultural Organization (UNESCO), Paris; and Scientific Committee of the World Underwater Federation (CMAS), Paris, pp. 77–80.
17. **Pyle, R.L.** 1996. Section 8.2.27. Underwater volcanoes and igneous intrusions. *In:* Flemming, N.C. and M.D. Max (Eds.) Scientific Diving: a general code of practice, Second Edition. United Nations Educational, Scientific and Cultural Organization (UNESCO), Paris; and Scientific Committee of the World Underwater Federation (CMAS), Paris, pp. 113–114.
18. **Pyle, R.L.** 1996. Section 11.16. Therapy in the Absence of a Recompression Chamber (in part). *In:* Flemming, N.C. and M.D. Max (Eds.) Scientific Diving: a general code of practice, Second Edition. United Nations Educational, Scientific and Cultural Organization (UNESCO), Paris; and Scientific Committee of the World Underwater Federation (CMAS), Paris, pp. 160–161.
19. **Pyle, R.L.** 1996. Exploring deep coral reefs: how much biodiversity are we missing? *Global biodiversity*, 6(1):3–7 (Published in both English and French versions).
20. **Pyle, R.L.** 1996. Adapting to Rebreather Diving. *Immersed* Advanced Diving Journal 1(2):12–21.
21. **Pyle, R.L.** 1996. The Twilight Zone. *Natural History*, 105(11):59–62.
22. **Pyle, R.L.** 1996. A Learner's Guide to Closed Circuit Rebreather Diving. *In*: Proceedings of the Rebreather Forum 2.0. 26–28 September, 1996. Redondo Beach, CA, pp. P45–P67.
23. **Pyle R.L.** and D. Youngblood. 1997. In-water recompression as an emergency field treatment of decompression illness (Revised). *SPUMS J*. 27(3):154–169.
24. Gill, A.C., **R.L. Pyle**, and J.L. Earle. 1996. *Pseudochromis ephippiatus*, new species of dottyback from southeastern Papua New Guinea (Teleostei: Perciformes: Pseudochromidae). *Révue française Aquariologie* 23(3–4):97–100.
25. Earle, J.L. and **R.L. Pyle**. 1997. *Hoplolatilus pohlei*, a new species of sand tilefish (Perciformes: Malacanthidae) from the deep reefs of the D'Entrecasteaux Islands, Papua New Guinea. *Copeia* 1997(2):383–387.
26. Randall, J.E., K. Kato, H. Ida, **R.L. Pyle**, and J.L. Earle. 1997. Annotated checklist of the inshore fishes of the Ogasawara Islands. National Science Museum Monographs No. 11. National Science Museum, Tokyo. 74 pp + 19 col. pls.

27. **Pyle, R.L.** 1997. The Importance of Deep Safety Stops: Rethinking Ascent Patterns From Decompression Dives. *South Pacific Underwater Medical Society Journal* (SPUMS) 27(2):112–115.
28. **Pyle, R.L.** 1997. A new angelfish of the genus *Genicanthus* (Perciformes: Pomacanthidae) from the Ogasawara Islands and Minami Tori Shima (Marcus Island). *Révue française Aquariologie* 24(3–4):87–92.
29. Basset, Y., V. Novotny, S. E. Miller & **R. L. Pyle**. 1997 Parataxonomists and digital photography in ecological and entomological research: experience from Papua New Guinea and Guyana. AMBIO: A Journal of the Human Environment.
30. **Pyle, R.L.** 1997. MK-5P Electronically Controlled, Mixed-Gas Closed-Circuit Rebreather: Manual of Operation. Version 1.0. Cis-Lunar Development Laboratories. 136 pp.
31. **Pyle, R.L.** 1998. Chapter 7. Use of advanced mixed-gas diving technology to explore the coral reef "Twilight Zone". pp. 71–88. *In:* Tanacredi, J.T. and J. Loret (Eds.). Ocean Pulse: A Critical Diagnosis. Plenum Press, New York. xii + 201 pp.
32. **Pyle, R.L.** 1999. Keeping up with the times: application of technical diving practices for in-water recompression. pp.74–88. *In:* Kay, E. and Spencer, M.P. (eds.) In-Water Recompression: The Forty Eighth Workshop of the undersea and Hyperbaric Medical Society. Undersea and Hyperbaric Medical Society and Diver's Alert Network. 108 pp.
33. **Pyle, RL.** 1999. Mixed-Gas, Closed-Circuit Rebreather Use for Identification of New Reef Fish Species from 200 – 500 fsw. pp. 53–65. *In:* Hamilton R.W., D.F. Pence, and D.E. Kesling (eds.) Assessment and Feasibility of Technical Diving Operations for Scientific Exploration. American Academy of Underwater Sciences, Nahant, Massachusetts. 83 pp.
34. **Pyle, R.L.** 1999. Patterns of coral reef fish biogeography in the Pacific region. pp. 157–175. *In:* Eldredge, L.G., J.E. Maragos, P.F. Holthus, and H.F. Takeuchi (Eds.). Marine and Coastal Biodiversity in the Tropical Island Pacific Region. Volume 2. Population, Development, and Conservation Priorities. Program on Environment, East-West Center / Pacific Science Association, Bishop Museum, Honolulu, Hawaii, 456 pp.
35. **Pyle, R.L.** 1999. MK-5P—MOD 1 Electronically Controlled, Mixed-Gas Closed-Circuit Rebreather: Manual of Operation. Cis-Lunar Development Laboratories. 144 pp.
36. **Pyle, R.L.** 2000. Assessing Undiscovered Fish Biodiversity on Deep Coral Reefs Using Advanced Self-Contained Diving Technology. *Marine Technology Society Journal* 34(4):82–91.
37. Basset, Y., V. Novotny, S.E. Miller & **R.L. Pyle**. 2000. Quantifying biodiversity: Experience with parataxonomists and digital photography in New Guinea and Guyana. *BioScience* 50(10):899–908.
38. Randall, J.E. and **R.L. Pyle**. 2001. Three new species of labrid fishes of the genus *Cirrhilabrus* from islands of tropical Pacific. *Aqua*, 4(3):89–98.
39. Randall, J.E., **R.L. Pyle** and R.F. Myers. 2001. Three examples of hybrid surgeonfishes (Acanthuridae). *Aqua*, 4(3):115–120.
40. Randall, J.E. and **R.L. Pyle**. 2001. Four new serranid fishes of the anthiine genus *Pseudanthias* from the South Pacific. *Raffles Bulletin Zoology* 49(1):19–34.
41. Parrish, F. and **R.L. Pyle**. 2001. Surface Logistics and Consumables for Open-Circuit and Closed-Circuit Deep Mixed-Gas Diving Operations Proceedings of the MTS/IEEE Oceans 2001 Conference, Volume 3:1735–1737.
42. **Pyle, R.L.** 2001. Anti-evolution Standards Rejected in Hawai'i. *Reports of the National Center for Science Education* November/December 2000. 20(6):4–5.
43. **Pyle, R.L.** 2002. Chaetodontidae. pp. 3224–3265. *In:* Carpenter, K.E. and V.E. Niem (Eds.) Living marine resources of the western central Pacific. Volume 5. Bony fishes part 3

(Menidae to Pomacentridae). Food and Agriculture Organization of the United Nations (FAO), Rome. i–iv+2791–3379.

44. **Pyle, R.L.** 2002. Pomacanthidae: Angelfishes. pp. 3266–3286. *In:* Carpenter, K.E. and V.E. Niem (Eds.) Living marine resources of the western central Pacific. Volume 5. Bony fishes part 3 (Menidae to Pomacentridae). Food and Agriculture Organization of the United Nations (FAO), Rome. i–iv+2791–3379.
45. **Pyle, R.L.** 2002. Insights on Deep Bounce Dive Safety From the Technical Diving Community. Proceedings of the16th Meeting of the United States-Japan Cooperative Programs on Natural Resources (UJNR), 1–3 November 2001, East-West Center, Honolulu, Hawaii. pp. 47–53.
46. Pence, D.F. and **R.L. Pyle**. 2002. University of Hawaii dive team completes Fiji deep reef fish surveys using mixed-gas rebreathers. *SLATE*. April: 1–3.
47. Parrish, F.A. and **R.L. Pyle**. 2002. Field comparison of open-circuit scuba to closed-circuit rebreathers for deep mixed-gas diving operations. *Marine Technology Society Journal*. 36(2):13–22.
48. **Pyle, R.L.** 2003. A systematic treatment of the reef-fish family Pomacanthidae (Pisces: Perciformes). Ph.D. Dissertation, Department of Zoology, University of Hawaii. xv+422 pp.
49. **Pyle, R.L.** 2004. Comparison of Open vs. Closed Circuit System in Deep Mix Diving. The Coelacanth, Fathom the Mystery: Proceedings of International Coelacanth Symposium, 4–7 December 2003, Marathon, Florida. Aquamarine Fukushima, Marine Science Museum, Fukushima Prefecture. pp. 32–37.
50. **Pyle, R.L.** 2004. Taxonomer: a relational data model for managing information relevant to taxonomic research. *Phyloinformatics*, 1:1–54.
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