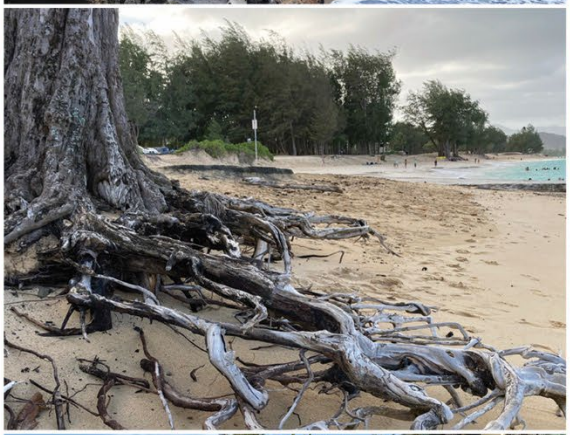

Regional Shoreline Management Scoping Study for the State of Hawai‘i

February 2023

NOAA National Oceanic and Atmospheric Administration U.S. Department of Commerce

Hawaii CZM Program
Coastal Zone Management

TETRA TECH

Sea Engineering, Inc.

Coastal Planners, LLC

REGIONAL SHORELINE MANAGEMENT SCOPING STUDY FOR THE STATE OF HAWAIʻI

Prepared for:

Hawaiʻi Department of Business, Economic Development &Tourism
Office of Planning and Sustainable Development
Coastal Zone Management Program

Prepared by:

Tetra Tech, Inc.; Sea Engineering, Inc.; and Coastal Planners, LLC

February 2023

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The project team was composed of Dr. Catherine Courtney, Mike Donoho, and Megan Brotherton (Tetra Tech, Inc), Andy Bohlander and Chris Conger (Sea Engineering, Inc.), and Thorne Abbott (Coastal Planners, LLC). OPSD and the project team engaged stakeholders from state and county government, private sector researchers, and the Marine and Coastal Zone Advocacy Council (MACZAC). These stakeholders were instrumental in sharing knowledge and on-the-ground experience in shoreline management. The team would like to thank all those who contributed their knowledge and experience at various stages of the project.

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Executive Summary

Rising sea levels, coastal erosion, and more damaging wave events are transforming the coastal environment of Hawai‘i. Homes, infrastructure, ecosystems, and cultural resources are being threatened and lost. Hawaii’s current regulatory framework—focusing on individual parcels—is ill-equipped to address these threats. It does not adequately account for cumulative impacts, long-term trends, or place-based characteristics. A regional shoreline management approach would better address such threats by supporting plans and projects that consider the complex array of shoreline types, ecosystem services, development patterns, and cultural resources.

Damaged pavilion at Baldwin Beach Park, Maui
Source: Maui County Department of Parks and Recreation

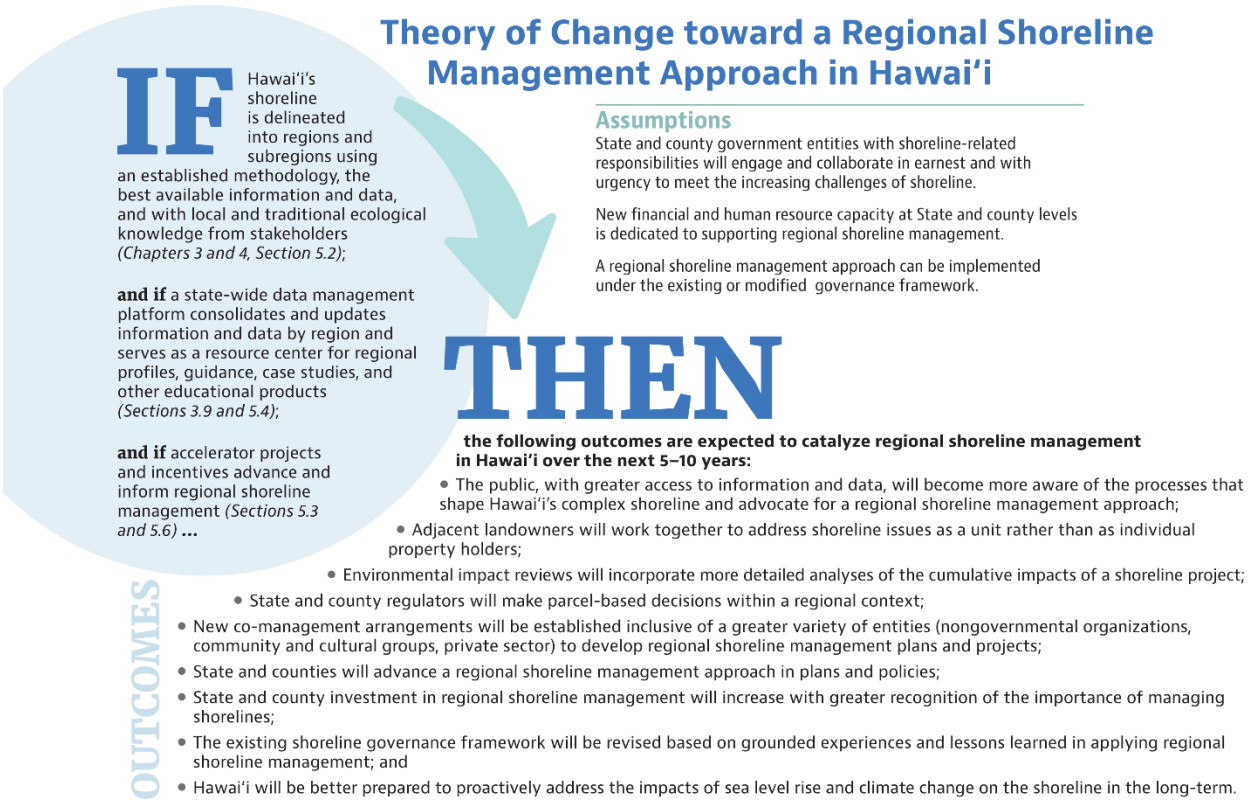
This Regional Shoreline Management Scoping Study is an exploratory step toward implementing a regional shoreline management approach for the State of Hawai‘i. It was prepared by Tetra Tech, Inc., Sea Engineering, Inc. and Coastal Planners, LLC for the State’s Department of Business, Economic Development & Tourism, Office of Planning and Sustainable Development, Coastal Zone Management Program.

The Scoping Study focuses on developing a methodology for delineating shoreline regions and subregions based on literature review, technical knowledge and expertise, and stakeholder input. A 5-year roadmap is proposed with steps for applying the methodology and establishing a regional shoreline management approach. The Scoping Study addresses two key questions:

- Methodology—How can Hawaii's shoreline be compartmentalized into regions and subregions to support a regional shoreline management strategy?
- 5-Year Roadmap—What are potential steps for establishing a regional shoreline management strategy in Hawai'i?

The Scoping Study is a technical document developed primarily by and for coastal scientists, engineers, and coastal planners to support regional shoreline management. Consultations and outreach to a broader range of stakeholders are planned on the key outputs and findings of the study. Below is summary of the study's contents.

Chapter 1 establishes a problem statement and theory of change that links key issues in shoreline management with potential outputs and outcomes of implementing a regional shoreline management approach. The study approach, including stakeholder engagement, and key terms are also described in this chapter.

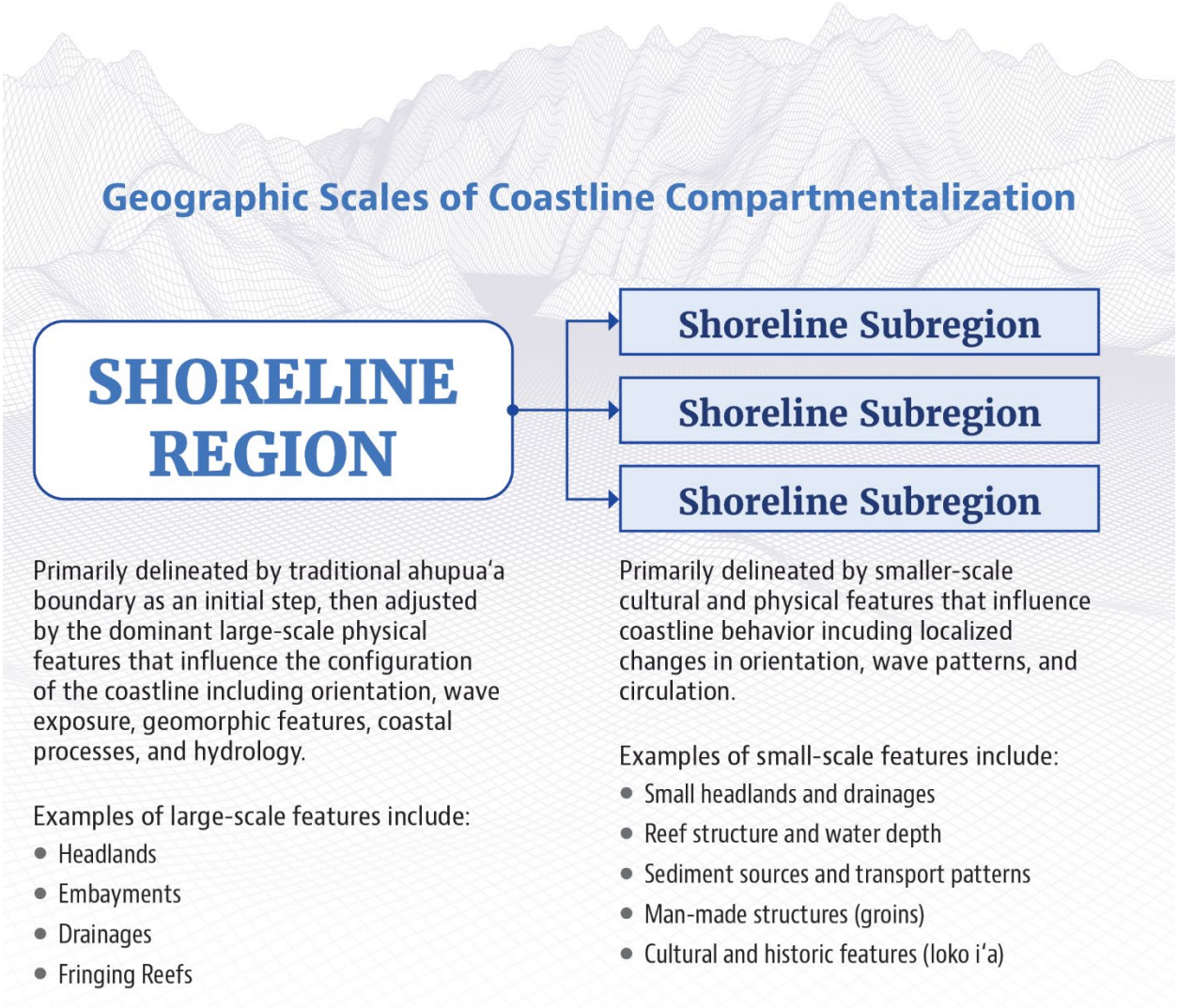


Chapter 2 summarizes examples of methodologies used in Hawai'i, other states, and internationally to compartmentalize shorelines. These examples provided input to the recommended methodology to delineate shoreline regions and subregions.

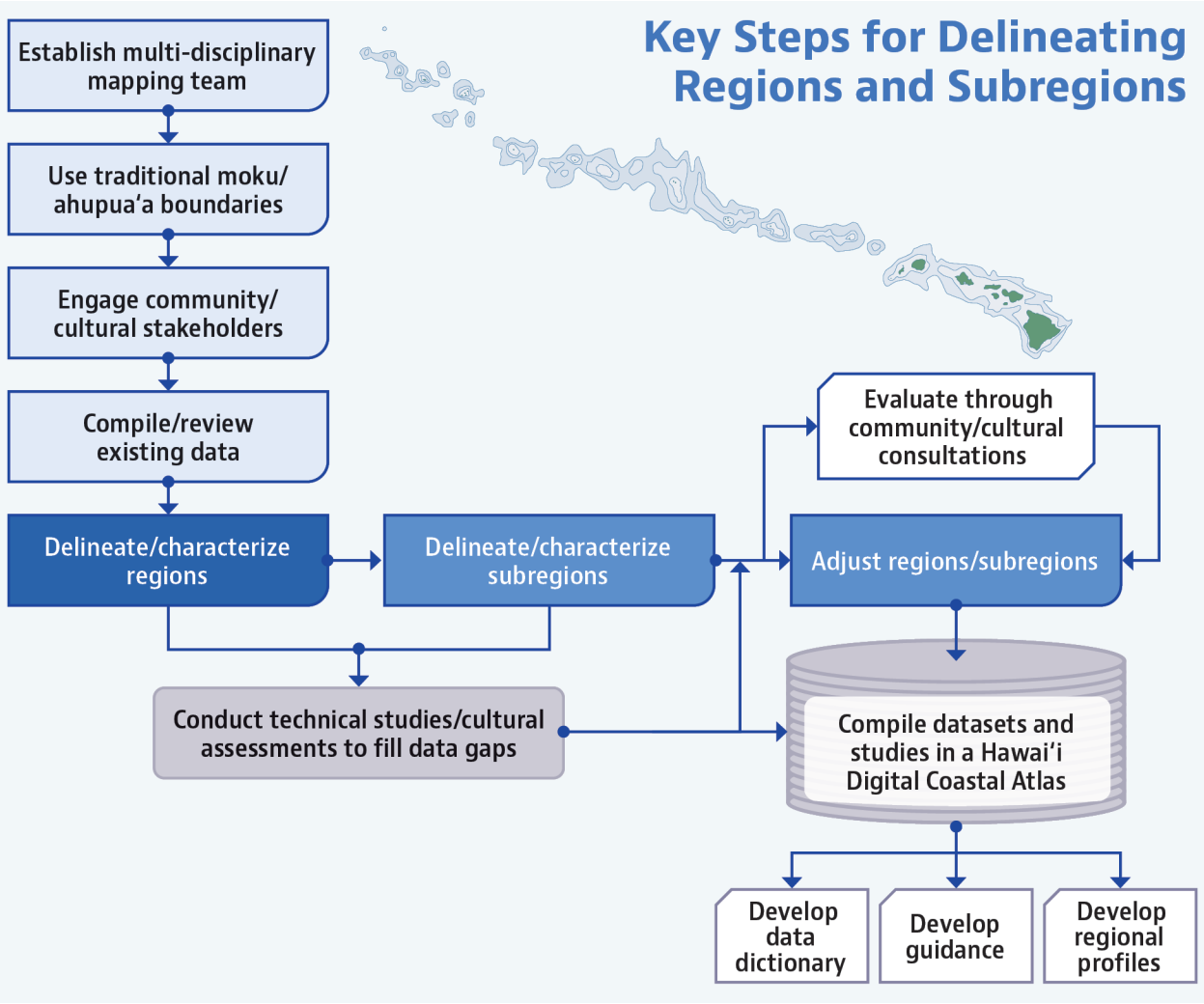
Chapter 3 describes the recommended methodology to delineate shoreline regions and subregions. A shoreline region refers to a specific segment of the coastline that is initially established by traditional

moku and ahupua‘a boundaries and then further refined based on a combination of physical features and processes. A region may consist of multiple ahupua‘a, or a portion of an ahupua‘a, as well as different shoreline types, and may include a combination of natural shorelines and man-made structures and facilities. A region may span one or more littoral cells, which are coastal compartments that contain a complete cycle of sedimentation, including sources, transport paths, and sinks.

A shoreline subregion refers to a specific reach of shoreline in a region whose physical and environmental features and/or processes differentiate it from the remainder of the region. The delineation of subregions allows for more detailed understanding of localized coastal processes and the physical, ecological, cultural, and social complexity of the backshore, foreshore, and nearshore environments. The delineation of subregions also allows for consideration of hazard exposure and vulnerability at finer scales (e.g., sections of a beach that may be subject to more intense erosion than adjacent shorelines).



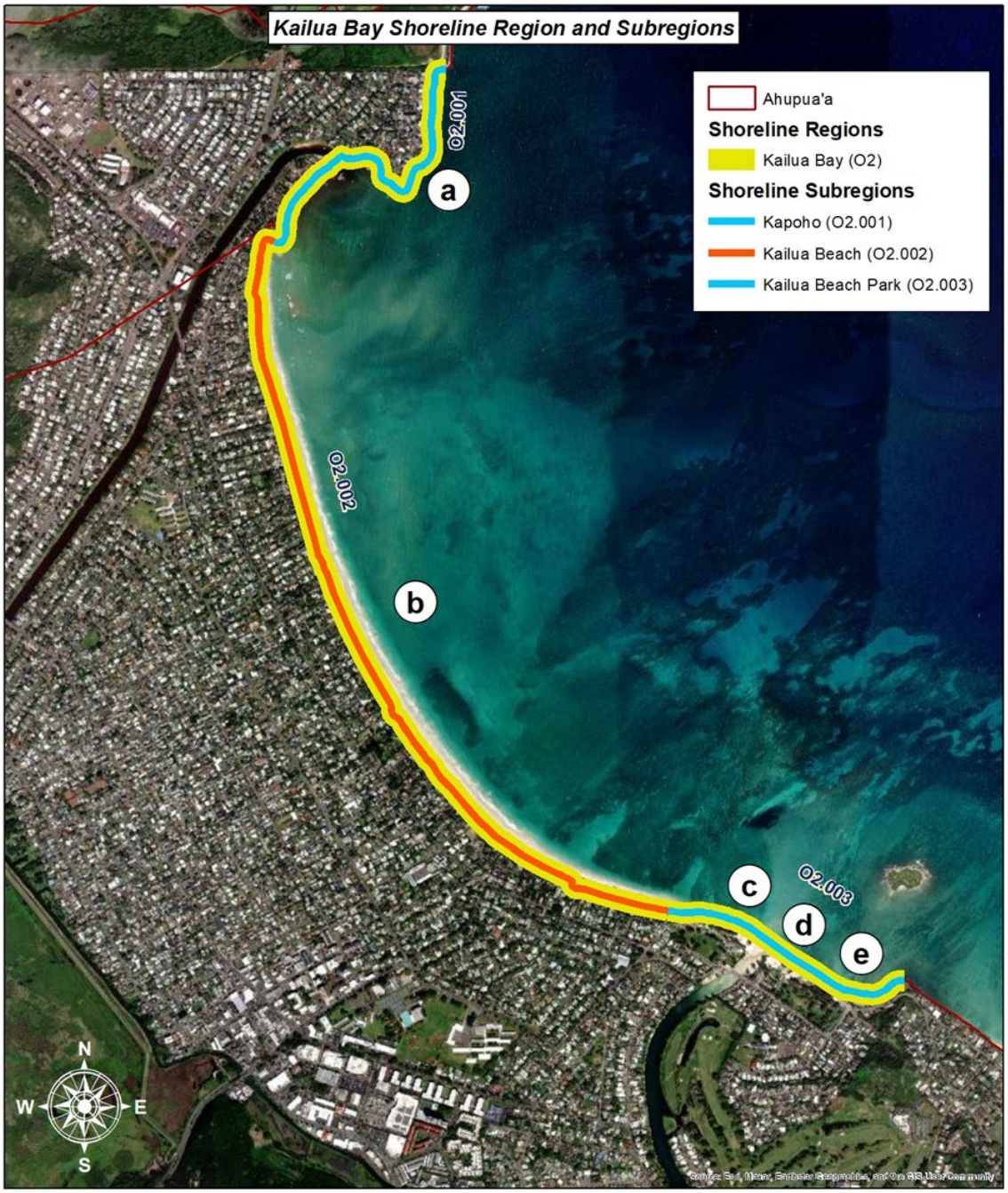
The recommended process for compartmentalizing Hawaii's coastline into discrete shoreline regions and subregions will require an iterative, systematic mapping process that is primarily based on subject matter expertise, professional interpretation, and place-based traditional ecological knowledge. Traditional Hawaiian moku and ahupua'a boundaries would be the basis for an initial mapping effort. This methodology for mapping the shoreline statewide outlines key information and data requirements and an inclusive multi-stakeholder process. The development of a Hawai'i Digital Coastal Atlas is recommended to serve as a clearinghouse for data, guidance, documents, and other information to support regional shoreline management planning.



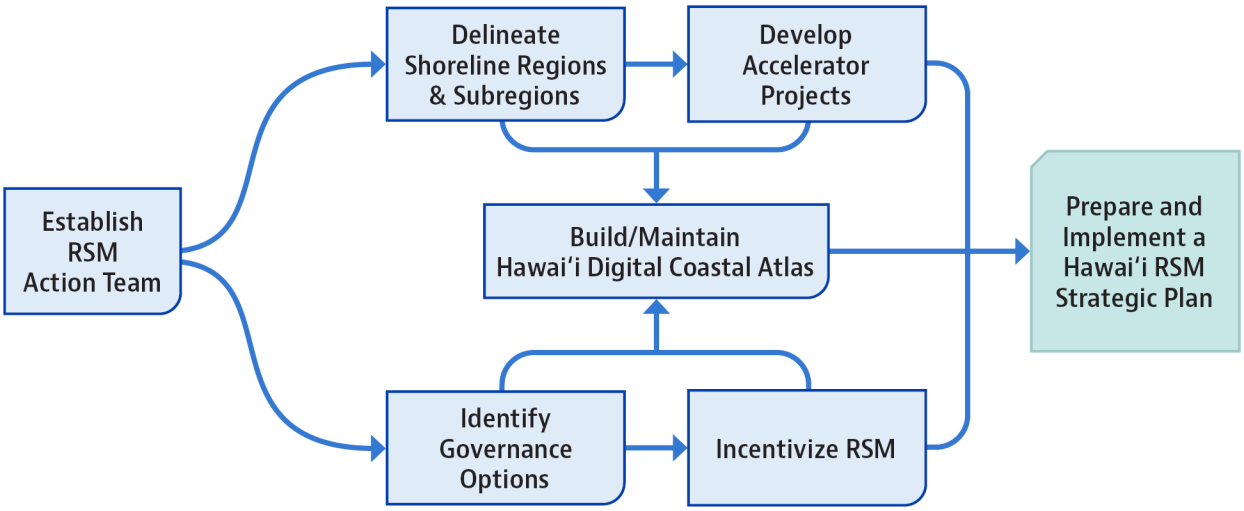
Chapter 4 demonstrates the application of this methodology for selected coastlines on the islands of Maui, O'ahu, and Kaua'i. The shoreline of Kailua, Oahu is one example of the delineation of shoreline region and three subregions. This initial mapping of shoreline regions and subregions would need to undergo the process mapping and stakeholder consultation described in the methodology.

Chapter 5 proposes a 5-year roadmap toward establishing a regional shoreline management approach. The mapping of shoreline regions is considered a catalytic first step. The roadmap is envisioned as a deliberate progression of outputs achieved and lessons learned over a 5-year period toward realizing multiple outcomes detailed in the theory of change.

Chapter 6 is a call to action for an infusion of human and financial resource capacity, commensurate with the social, economic, and ecosystem services provided by Hawaii's shoreline, at both State and county levels to catalyze a proactive regional shoreline management approach rather than a reactive parcel-by-parcel approach. The call to action also requires that State and county government entities with shoreline-related responsibilities engage and collaborate in earnest and with urgency to meet the increasing challenges of shoreline management.



5-Year Roadmap Toward a Regional Shoreline Management (RSM) Approach for the State of Hawai'i



Acronyms

CDP	Community Development Plan
CWA	Clean Water Act
CWB	DOH Clean Water Branch
DLNR	State of Hawai‘i Department of Land and Natural Resources
DOH	State of Hawai‘i Department of Health
GIS	Geographic Information System
HRS	Hawai‘i Revised Statutes
MACZAC	Marine and Coastal Zone Advocacy Council
NGO	Non-governmental Organization
OCCL	DLNR Office of Conservation and Coastal Lands
OPSD-CZM	Department of Business, Economic Development &Tourism Office of Planning and Sustainable Development, Coastal Zone Management Program
ORMP	Hawai‘i Ocean Resources Management Plan
SMA	Special Management Area
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey


O'ahu, Hawai'i

1. Introduction

The State of Hawai'i has identified key challenges and improvement opportunities related to its ability to mitigate risks from coastal hazards, which are exacerbated by sea level rise. These challenges and opportunities are outlined in the State's federally approved Section 309 Assessment and Strategy for FY2021-2025, which was prepared by the Coastal Zone Management Program (CZM) of the Department of Business, Economic Development and Tourism's Office of Planning and Sustainable Development (OPSD). The Hawai'i Ocean Resources Management Plan (ORMP) is the implementing mechanism for the CZM Program's 309 Strategy and serves as a guiding document for agencies with responsibilities relating to marine and coastal zone management. As the lead agency to coordinate implementation of the ORMP, the OPSD-CZM Program brings together a diverse group of stakeholders and experts to collaboratively address management gaps at a statewide level that are presently unaddressed or insufficiently addressed through existing resources and actions.

The 2020 update of the ORMP established three focus areas. This Regional Shoreline Management Scoping Study (Scoping Study) directly implements actions towards the goal of Focus Area 1 – Development and Coastal Hazards to "Develop a statewide integrated shoreline management strategy to address the compounding impact's to Hawaii's shorelines of coastal development, climate change and sea level rise, erosion, and other chronic coastal hazards". The ORMP working group and county and state coordination meetings have been instrumental in identifying the current challenges of reactive decisions in coastal zone management and stimulating discussion on the need to identify a suitable geographic scale for shoreline adaptation planning based on coastal processes. In response, this Scoping Study was prepared to recommend a methodology for compartmentalizing the shoreline into regions and subregions. This study is part of an initiative to facilitate the planning and implementation of adaptation and management interventions at a more appropriate scale than parcel-by-parcel decision making. The Scoping Study also proposes steps toward development of a regional shoreline management approach specific to a Hawai'i context.

1.1. Problem Statement

Damaged pavilion at Baldwin Beach Park, Maui following high surf in August 2020
Source: Maui County Department of Parks and Recreation

Over 70% of Hawai'i's shorelines are eroding. As sea level rises due to climate change and more damaging wave events transform the coastal environment, homes and infrastructure, beaches, dunes, and other coastal ecosystems, and cultural resources and practices located along the coast are being threatened and lost. Climate change is also resulting in more severe rainfall events causing coastal flooding that can alter the shoreline. Numerous shoreline management issues exacerbated by sea level rise are challenging the State's ability to effectively achieve the Hawai'i Coastal Zone Management Program's objectives (see Appendix 1) which include protecting beaches, dunes and public shoreline access and reducing coastal hazard threats to life and property.

Hawai'i's coastline is a dynamic and changing environment that separates land and sea. Landward of the shoreline, county-designated shoreline setbacks and Special Management Area (SMA) permits are the primary tools used to regulate land use and manage development. The establishment of shoreline setbacks provides a buffer zone so that structures are built outside of hazard prone areas. They also preserve public access and use of the publicly owned shoreline and beaches. Such setbacks are established on a parcel-by-parcel basis. While this regulatory tool is important and needed, it may not be adequate to capture dynamically changing coastal areas in a way that addresses the increasing vulnerability of Hawaii's shoreline.

A county's shoreline setback may incorporate considerations of sea level rise and buffers for uncertainty, but other factors—such as severe wave events, the issuance of hardship variances, temporary shoreline protection, and shoreline hardening—erode the efficacy of shoreline regulations. Further, the current parcel-by-parcel approach is not conducive to larger-scale, multi-parcel, or regional-scale shoreline adaptation strategies and management interventions. Without regional shoreline management plans, regulators and landowners cannot easily account for larger-scale considerations of shoreline types and conditions, ecosystem services, and existing development. The result is a fragmented approach where decisions are made without considering cumulative impacts, long-term trends, or place-based characteristics[1].

With its regulatory process establishing shoreline setbacks for development, Hawai‘i is one of the most progressive states in the United States in terms of regulating shorelines but lacks a comprehensive and coordinated approach for regional shoreline management in a changing climate. The term “shoreline management” is not referenced or defined in the existing laws, statutes, administrative rules, or ordinances in Hawai‘i. No State agency or department is specifically tasked with shoreline management in Hawai‘i. Furthermore, the current parcel-based regulatory process employed by counties is inadequate for proactive, innovative, efficient, and effective shoreline management in the face of a changing climate, especially with sea level rise.

The challenges for implementing a regional shoreline management approach are numerous but so are the opportunities (Figure 1 and Appendix 2). Despite limitations posed by the existing regulatory framework, there are examples of regional shoreline management projects in Hawai‘i, many of which are being implemented by private landowners through co-management arrangements with State and county agencies (see examples in Appendix 3 and 4).

Figure 1. Word art of various shoreline management issues

A fundamental element of these examples is that the shoreline is compartmentalized into regions and subregions for management purposes. Information and data on geomorphology, coastal processes, and other environmental factors are used to delineate regions and subregions, and projects are designed considering the cumulative effects and place-based interventions appropriate for these areas.

Currently, the information and data needed to design a regional shoreline management project is fragmented and incomplete, scattered across multiple data platforms, technical studies, and other information sources. Project proponents hire consultants to compile and analyze data, conduct technical studies to address data gaps, and gather place-based knowledge from cultural practitioners and community stakeholders. Information and data generated through these parcel-specific studies are not catalogued or readily accessible for future use. Many datasets generated through these efforts—most notably shoreline certification surveys—are not required to be provided in geospatial format that could contribute to the development of a state-wide shoreline database.

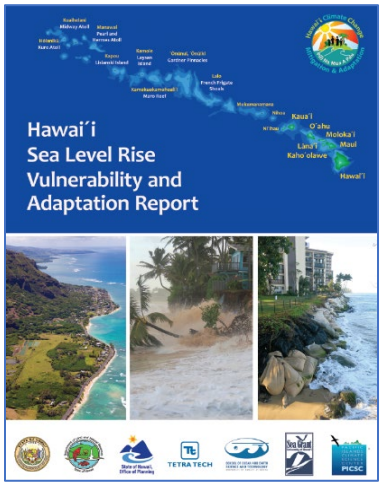
1.2. Theory of Change

A key output of this Scoping Study is a recommended methodology to compartmentalize Hawaii's shoreline into regions and subregions statewide. Considering such an endeavor raises questions such as:

- How will delineating shoreline regions and subregions address the problem statement?
- What outcomes are expected from this effort?
- Does the current governance framework accommodate regional shoreline management?

These are valid questions that cannot be fully addressed in this Scoping Study; however, the statewide assessment of sea level rise, funded by the Hawai'i State Legislature and with coordination through the Hawai'i Climate Change Mitigation and Adaptation Commission, offers a vision of the future. Foundational data on sea level rise, made it accessible to planners, policy makers, private sector, nongovernmental organizations, and the public lead to discrete actions in planning and decision-making.

The Hawai'i State Sea Level Rise Vulnerability and Adaptation Report[2] and companion Hawai'i State Sea Level Rise Viewer are excellent examples of the transformative power of developing foundational geospatial data and making it accessible on one platform (Figure 2). The Sea Level Rise Exposure Area (SLRXA) is a composite of chronic coastal hazards associated with sea level rise, used to assess vulnerability statewide. It has become a driving force in planning and policy formulation since it was made accessible to the public, planners, consultants, and practitioners through the Hawai'i State Sea Level Rise Viewer. The Viewer enables users to download datasets and overlay different features to understand the potential impacts of sea level rise under different scenarios, down to the parcel level. This powerful planning tool has dramatically transformed the public conversation regarding sea level rise from *if* action is needed to *what* actions are needed. The evidence of the catalytic impact of these two products is documented in the 5-year review and update, which reports revisions to State laws, county policies and plans, and many other initiatives statewide to address sea level rise.



2014 – 2017 (4 years)

- Hawaii Climate Adaptation Initiative (Act 83 2014)
- Hawaii State Sea Level Rise Vulnerability and Adaptation Report
- Hawaii State Sea Level Rise Viewer

2018 – 2022: (5 years)

- New guidance documents and tools developed
- New/revised state laws adopted
- New/revised county policies and plans adopted/prepared
- Hawaii Sea Level Rise Vulnerability and Adaptation Report 5-year review and update completed

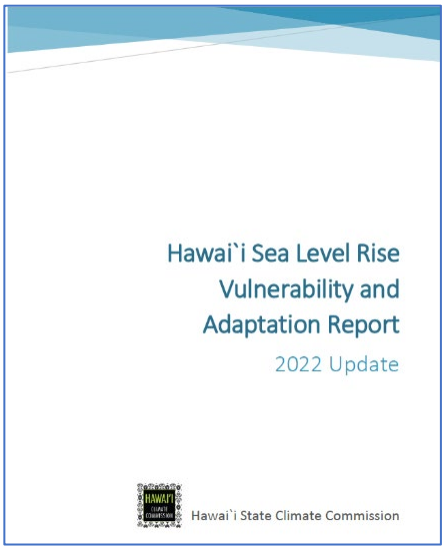


Figure 2. Products associated with the Sea Level Rise Exposure Area (SLRXA)

It is this story of SLRXA and associated products that inspired a Theory of Change for regional shoreline management. A Theory of Change outlines the cause-and-effect linkages and outcomes of an initiative in terms of *if/then* statements. What can be learned from these examples and how can they be expanded to facilitate regional shoreline management in Hawai'i? Regional shoreline management, when planned and implemented at larger geographic scales appropriate for proactive coastal adaptation, would support policy objectives for coastal zone management in Hawai'i and provide the overarching framework to support a parcel-by-parcel regulatory approach. The development of a methodology for delineating and characterizing shoreline regions and subregions is an important first step. The Theory of Change shown in Figure 3 is offered for testing over the next 5 to 10 years.

Theory of Change toward a Regional Shoreline Management Approach in Hawai'i

IF Hawai'i's shoreline is delineated into regions and subregions using an established methodology, the best available information and data, and with local and traditional ecological knowledge from stakeholders *(Chapters 3 and 4, Section 5.2)*;

and if a state-wide data management platform consolidates and updates information and data by region and serves as a resource center for regional profiles, guidance, case studies, and other educational products *(Sections 3.9 and 5.4)*;

and if accelerator projects and incentives advance and inform regional shoreline management *(Sections 5.3 and 5.6)* **...**

Assumptions

State and county government entities with shoreline-related responsibilities will engage and collaborate in earnest and with urgency to meet the increasing challenges of shoreline.

New financial and human resource capacity at State and county levels is dedicated to supporting regional shoreline management.

A regional shoreline management approach can be implemented under the existing or modified governance framework.

THEN

the following outcomes are expected to catalyze regional shoreline management in Hawai'i over the next 5–10 years:

OUTCOMES

- The public, with greater access to information and data, will become more aware of the processes that shape Hawai'i's complex shoreline and advocate for a regional shoreline management approach;
- Adjacent landowners will work together to address shoreline issues as a unit rather than as individual property holders;
- Environmental impact reviews will incorporate more detailed analyses of the cumulative impacts of a shoreline project;
- State and county regulators will make parcel-based decisions within a regional context;
- New co-management arrangements will be established inclusive of a greater variety of entities (nongovernmental organizations, community and cultural groups, private sector) to develop regional shoreline management plans and projects;
- State and counties will advance a regional shoreline management approach in plans and policies;
- State and county investment in regional shoreline management will increase with greater recognition of the importance of managing shorelines;
- The existing shoreline governance framework will be revised based on grounded experiences and lessons learned in applying regional shoreline management; and
- Hawai'i will be better prepared to proactively address the impacts of sea level rise and climate change on the shoreline in the long-term.

Figure 3. Theory of change toward a regional shoreline management approach in Hawai'i

1.3. Scoping Study Approach

This Scoping Study is an exploratory step toward implementing a regional shoreline management approach for Hawai'i. Two key questions addressed in the Scoping Study are:

1. How can Hawaii's shoreline be compartmentalized into regions and subregions to support a regional shoreline management strategy?
2. What are potential steps for implementing a regional shoreline management approach in Hawai'i?

A recommended methodology (Chapter 3) for delineating shoreline regions and subregions was developed to address the first question based on literature review, technical knowledge and expertise, and stakeholder input. Existing methodologies from coastal areas of Hawai'i and around the world were reviewed to provide insight on a methodology for delineating regions and subregions that could be appropriate for Hawai'i's complex shoreline. The results of this review are provided in Chapter 2 and Appendices 3 and 4.

A 5-year roadmap is proposed, with steps for applying the methodology and implementing a regional shoreline management approach. A summary of the existing shoreline management framework (Appendix 1) and challenges and opportunities for implementing regional shoreline management approach (Appendix 2) served as input to the roadmap.

Input was obtained throughout this Scoping Study primarily from stakeholders with technical expertise, especially coastal scientists, engineers, and planners from the State, counties, and private sector involved in planning and implementing shoreline management plans, policies, and projects. A variety of mechanisms were used to gather input for this Scoping Study including the following:

- **Focus group discussions** were held by the OPSD to gather initial feedback from key stakeholders in advance of this project. Participants included State and county planners from all islands.
- **Presentations** were made to the Marine and Coastal Zone Advocacy Council (MACZAC), the Hawai'i Ocean Partnership, the Council on Ocean Resources, and the Department of Land and Natural Resources (DLNR) Fishers Group.
- **Wiki surveys** were sent to 88 individuals from federal, State, county, academic, private sector, and non-governmental entities to gather input on challenges and opportunities and recommendations throughout the project. The results of the wiki surveys are provided in Appendix 2.
- **Virtual workshops** were held to solicit feedback on draft and final recommendations. Workshop participants included coastal scientists, engineers, and planners from the State, counties, and the private sector and representatives from the Aha Moku Advisory Committee and State of Hawai'i Department of Hawaiian Home Lands. Approximately 20 to 25 participants attended each workshop. Presentations were given and written feedback on specific topics was obtained using Google Jamboards. This input was entered into an Excel spreadsheet to facilitate and track revisions.
    - **Workshop #1** was held in July 2022 to solicit feedback on the draft methodology for delineating shoreline regions and subregions. Participants helped to identify challenges and opportunities for applying the methodology. The presentation included examples of regional approaches from Hawai'i and elsewhere. The following discussion and polling questions focused on whether littoral cells and coastal hazard areas should be used to

define shoreline regions. Subregion discussions included looking at backshore, foreshore, and nearshore features that could be used to help delineate smaller subregions.

- **Workshop #2** was held in October 2022 after the draft methodology was developed. The workshop solicited feedback on the draft methodology, the next steps for delineating shoreline regions and subregions, and a phased approach for establishing a regional shoreline management approach. The rationale and draft methodology were presented for three case studies—in southwest Kaua‘i, southeast O‘ahu, and west Maui. When the participants were polled about their level of support, all respondents were either moderately or highly supportive of the draft methodology. The final hour of the workshop included a robust discussion and visioning exercise on operationalizing a regional shoreline management approach.
- **Workshop #3** was held in December 2022 after the Ocean Resources Management Plan (ORMP) Action Team review of the draft report. The workshop presented the draft final methodology and roadmap for establishing a regional shoreline management approach in Hawai‘i.

This Scoping Study is a technical document developed primarily by and for coastal scientists, engineers, and planners to support regional shoreline management. Consultations and outreach to a broader range of stakeholders are planned based on the key outputs and findings of the report.

1.4. Key Terms Used in This Study

For the purposes of this Scoping Study, the following definitions apply.

Regional shoreline management refers to the process of planning and implementing shoreline adaptation strategies and management interventions to achieve the State of Hawaii’s coastal zone management policy objectives at a geographic scale that accounts for coastal features and processes, historical trends and future conditions, place-based and traditional ecological knowledge, and cumulative impacts.

Shoreline region refers to a specific segment of coastline that is initially established by traditional moku and ahupua‘a boundaries, and then further refined based on a combination of physical features and processes. A region may consist of multiple ahupua‘a, or a portion of an ahupua‘a, as well as different shoreline types and may include a combination of natural shorelines and man-made structures and facilities. A region may span one or more littoral cells, which are coastal compartments that contain a complete cycle of sedimentation including sources, transport paths, and sinks. Shoreline regions are delineated to characterize the regional coastal setting and establish the geographic and physical boundaries for shoreline management that extend along the coastline and landward and seaward of it.

Shoreline subregion refers to a specific reach of shoreline within a region that is characterized by a unique combination of physical and environmental features and/or processes that differentiate it from the remainder of the region. The delineation of subregions allows for more detailed understanding of localized coastal processes and the physical, ecological, cultural, and social complexity of the backshore, foreshore, and nearshore environments. The delineation of subregions also allows for consideration of hazard exposure and vulnerability at finer scales (e.g., sections of a beach that may be subject to more intense erosion than adjacent shorelines).

Shoreline adaptation strategies refer to strategies to manage and adapt to existing and future conditions along the shoreline, considering both private and public lands. Typical shoreline adaptation strategies are shown in Table 1**.**

Table 1. Shoreline adaptation strategies

Strategy	Description
Protection	Hold the line by developing new hardened structures or fortifying existing ones to prevent shoreline retreat and reduce coastal flooding
Accommodation	Allow flooding by elevating structures and developing green and blue ways
Realignment	Reconfigure shoreline above and/or away from hazard-prone areas
Managed Retreat	Move away from the coast by relocating structures outside of hazard-prone areas or prohibiting new development within hazard-prone areas
Ecosystem-based adaptation	Enable natural coastal ecosystem responses
Advance	Build a buffer out into the ocean

Shoreline management interventions refer to techniques for maintaining, restoring, protecting, and/or preserving the shoreline. Typical shoreline management interventions are shown in Table 2.

Table 2. Shoreline management interventions

Natural (Green)	Man-Made (Gray)	Hybrid (Gray-Green)
Sand pushing	Seawalls	Living shorelines
Sand backpassing	Revetments	Living wave attenuation units/artificial reefs
Beach nourishment	Groins	Rock sill & sedge
Beach restoration	Boulders/rubble mounds	Fishponds (loko I‘a)
Dune restoration	Breakwaters	Beach nourishment with retaining structures
Reef restoration	Marinas	
	Harbors	
	Offshore wave attenuation units	

Examples of shoreline management interventions include facility management (e.g., ports, harbors, and water facilities), cultural asset management (e.g., fishponds), asset protection (e.g., shore protection structures), accommodation (e.g., shoreline setbacks and freeboard), retreat (e.g., managed retreat or strategic realignment), and nature-based solutions (e.g., beach nourishment, dune restoration). The initial assessment of a shoreline region recognizes the traditional moku and ahupua‘a boundaries and in doing so, acknowledges the traditional ecological knowledge of a region and what cultural resources and practices are to be perpetuated or revitalized to complement contemporary shoreline management interventions. In some cases, a combination of shoreline management interventions may be required to

effectively manage the shoreline. Not all management interventions are suitable or feasible for all types of shorelines and there are advantages, disadvantages, and tradeoffs associated with each. Hybrid solutions are becoming more widely used where man-made structures, including facilities such as traditional fishponds, for example, are enhanced using designs and materials that provide living surfaces and enhance natural habitat.

Co-management (in the context of regional shoreline management) refers to the practice of sharing of rights and responsibilities among government and other stakeholders (e.g., non-governmental, private sector, and researchers) in the pursuit of a shared set of management goals and plans that are applied at a larger geographic scale (e.g., shoreline region or subregion) to facilitate a coherent and effective action. In practice, co-management covers a broad spectrum of management arrangements that may be instructive, consultative, advisory, informative, and cooperative. Examples of co-management arrangements for shoreline management in Hawai‘i are discussed in Section 5.5 and Appendices 2, 3, and 4.

Coastline refers to the general boundary between land and sea. This term is used instead of “shoreline” which has a legal definition under Hawai‘i Revised Statute (HRS) §205A-1.

Shoreline is legally defined under HRS §205A-1 as “the upper reaches of the wash of the waves, other than storm and seismic waves, at high tide during the season of the year in which the highest wash of the waves occurs, usually evidenced by the edge of vegetation growth, or the upper limit of debris left by the wash of the waves.”

Traditional ecological knowledge is a place-based system of cultural knowledge and practice amassed over millennia, which has been transferred orally and observationally from one generation of cultural practitioners to the next. Traditional ecological knowledge is valuable as it recognizes the established cultural overlay to shoreline regions as a means to preserve and perpetuate but also informs and has great potential to complement modern science-based shoreline management planning and interventions.

Ahupua‘a is the traditional Hawai‘i land management system, with boundaries that extend from the uplands to the shoreline and into the ocean. It generally includes one or more complete watersheds and the nearshore resources. Ahupua‘a are grouped by district, or moku (Figure 4). Each ahupua‘a contained a cross section of resources necessary for survival and were managed in a complex social system. These traditional boundaries serve as a starting point for delineating shoreline regions and subregions presented in this Scoping Study.

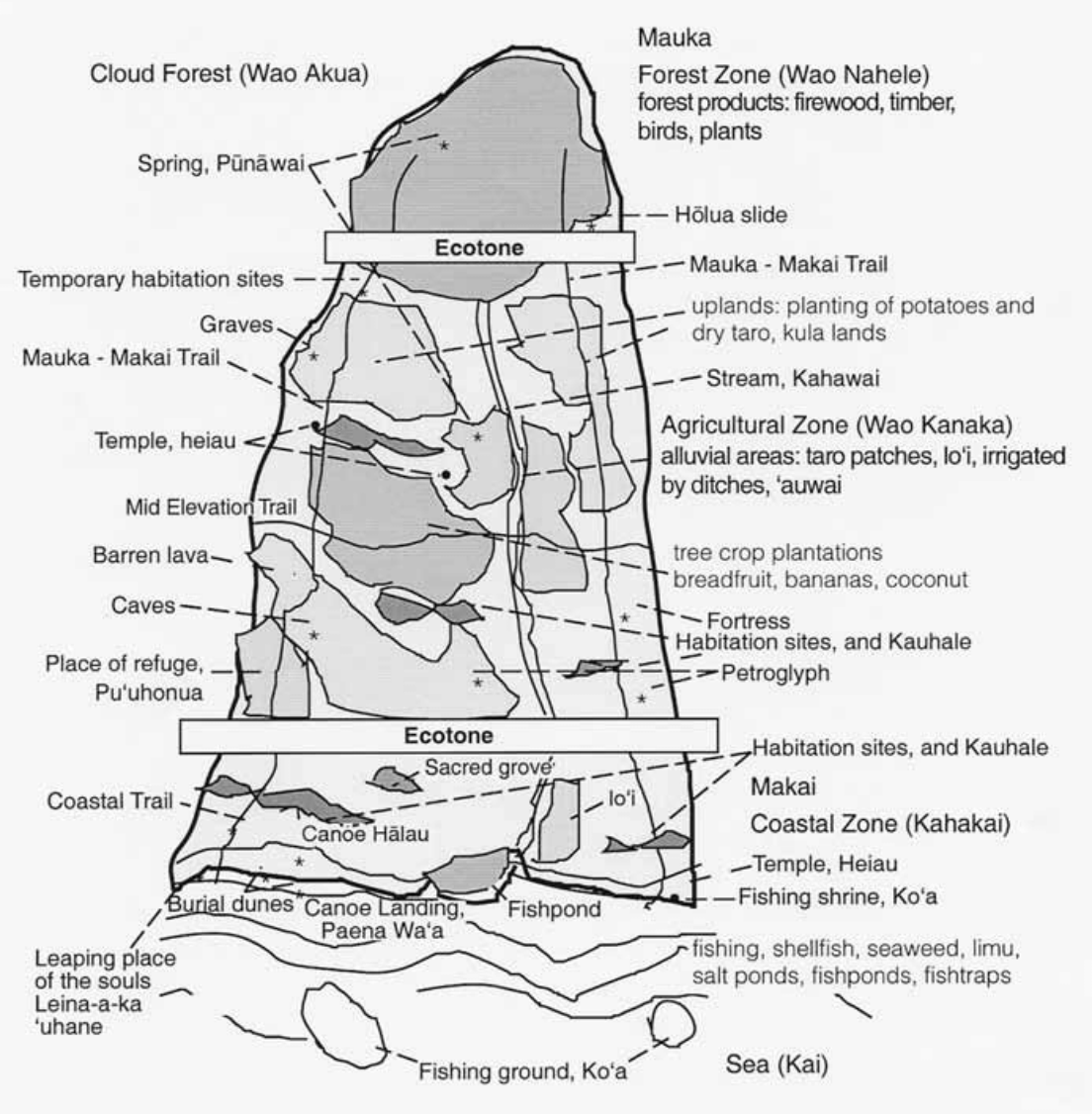


Figure 4. Ahupua'a model of traditional land division[4]

Littoral cells are coastal compartments that contain a complete cycle of sedimentation, including sources, transport paths, and sinks (Figure 5).[5] The cell boundaries delineate geographical areas within which the budget of sediment is balanced, providing a framework for quantitative analysis of coastal erosion and accretion. Sediment sources are commonly streams, sea cliff erosion, onshore migration of sand banks, and material of biological origin such as shells, coral fragments, and skeletons of small marine organisms. The usual transport path is along the coast by waves and currents (longshore transport, longshore drift, or littoral drift). Cross-shore paths may include onshore paths (e.g., aeolian (windblown) sand and overwash deposits) or offshore paths (e.g., channels). Sediment sinks are usually offshore losses through submarine geomorphological features, shoals or onshore dune migration, rollover, or deposition in bays and estuaries. The presence of sand on a beach depends on the transport of sand within the cell. Therefore, the littoral cell and its budget of sediment are essential planning tools for regional shoreline management.

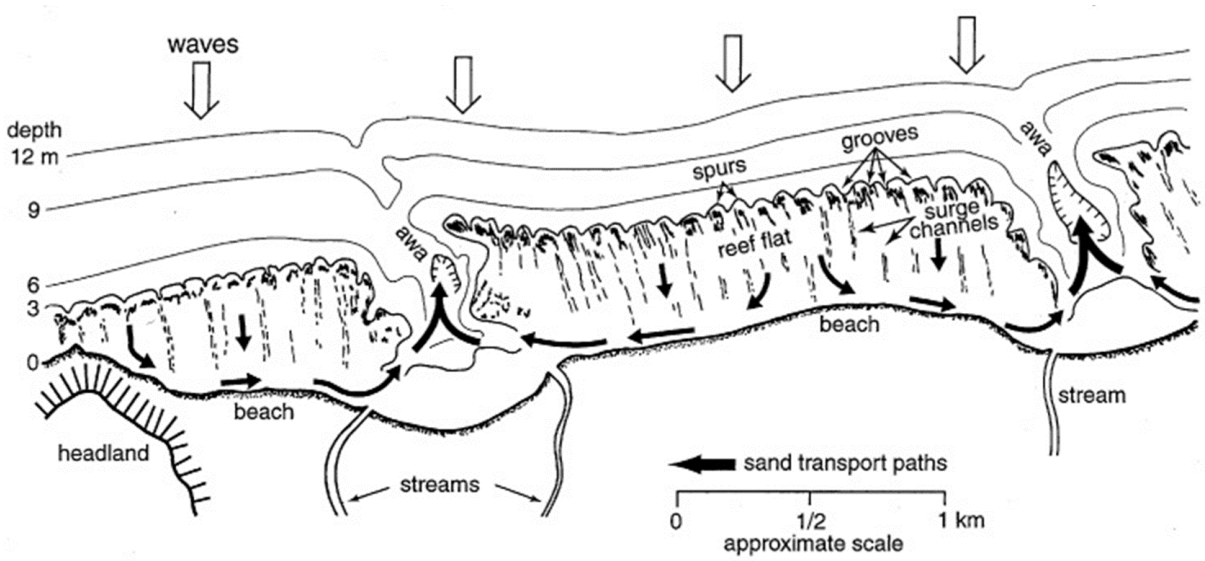


Figure 5. Schematic diagram of coastal features and processes within a littoral cell[6]

Backshore refers to the area landward of the high tide line that is only exposed to wave action during high wave and storm events (Figure 6). For the purposes of this Scoping Study, the backshore extends inshore to the 50-foot elevation contour to capture the primary physical features and processes that characterize the terrestrial environment (e.g., existing development, hydrologic features, terrestrial sediment sources, coastal hazard exposure, and shoreline setbacks).

Foreshore refers to the area seaward of the backshore, between the high and low water marks (e.g., beaches) (Figure 6). This is the portion of the shoreline that is frequently subjected to waves and currents. For the purposes of this Scoping Study, the foreshore extends seaward from the backshore to the beach toe (the low water mark along sandy coastlines) or the beginning of predominantly benthic substrate (e.g., reef).

Nearshore refers to the area seaward of the foreshore that is subject to dynamic waves and currents (e.g., surf zone, breaking waves, shoaling) (Figure 6). For the purposes of this Scoping Study, the nearshore extends seaward from the foreshore to the 100-foot bathymetric contour to capture the primary physical features and processes that characterize the nearshore marine environment (e.g., fringing reefs, channels, sediment transport patterns, and offshore sediment sources).

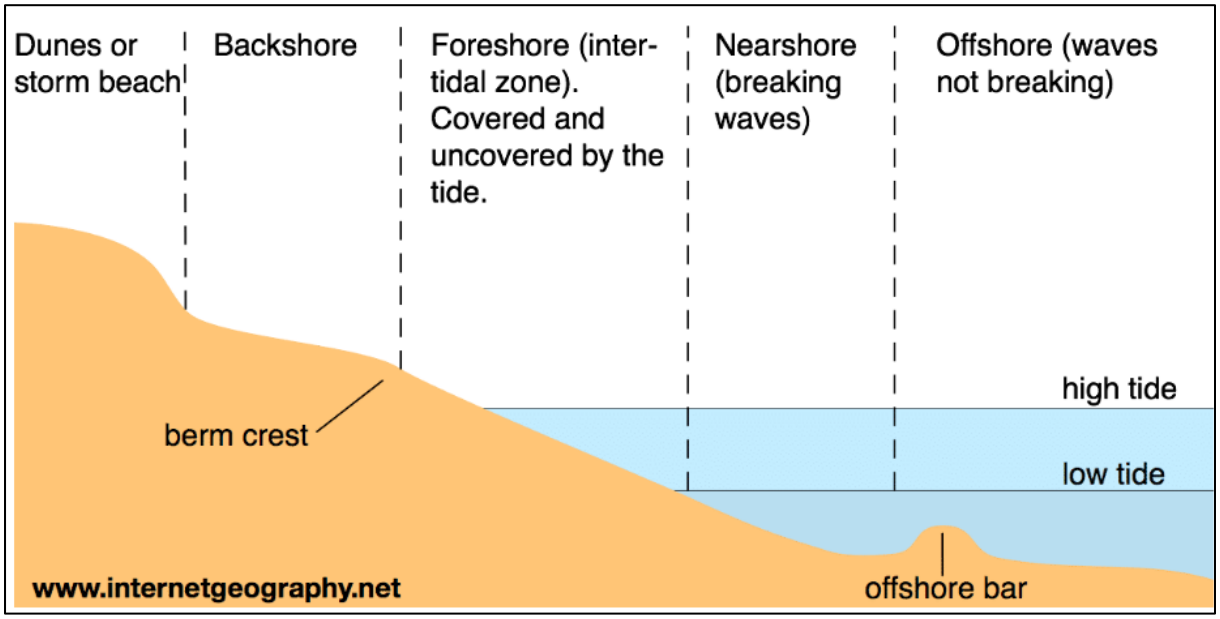


Figure 6. Example cross-sectional profile for a low elevation coastal area

2. Review of Existing Methodologies

The project team evaluated approaches that have been applied in other coastal areas around the world to compartmentalize the coastline into units that support regional shoreline adaptation and management. The review included the U.S. northeast, west, and northwest coasts, Australia, and Hawai'i. The following sections highlight aspects of each methodology that are relevant to Hawai'i's coastline.

2.1. Cape Cod - Zone of Impact

Cape Cod is a peninsula at the southeast corner of Massachusetts that is mostly separated from the mainland by Cape Cod Bay. Cape Cod's 560 miles of coastline is primarily composed of barrier beaches, inlets, spits, tidal flats, and marshes. Its geomorphology consists of glacial landforms that formed through the advance and retreat of the Laurentide Ice Sheet and the associated changes in sea level. Cape Cod is exposed to coastal hazards including erosion, sea level rise, and storm surge.

In 2019, the Cape Cod Commission developed the web-based Cape Cod Coastal Planner as a tool to educate users on the impacts of climate change and coastal hazards, potential adaptation strategies, and implications for local infrastructure and ecosystems. The Cape Cod Coastal Planner is a web-based mapping application that presents data layers such as sediment transport, sea level rise inundation, projected shoreline change, infrastructure vulnerability, and others (Figure 7).

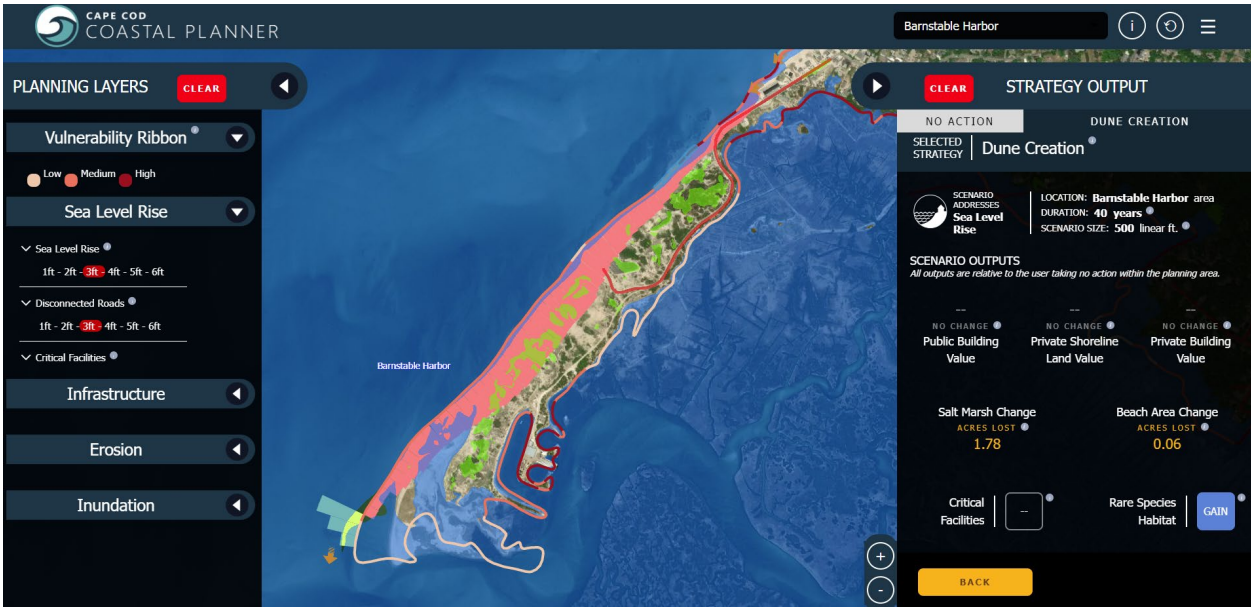


Figure 7. Zone of impact (Cape Cod Coastal Planner)

The Cape Cod Coastal Planner was developed as part of the Resilient Cape Cod project, which was funded by the National Oceanic and Atmospheric Administration (NOAA) Coastal Resilience Grant Program. The project involved a series of community stakeholder workshops to improve understanding of coastal vulnerability and evaluate potential adaptation options to increase community resilience. The project also produced adaptation fact sheets and an adaptation matrix to educate stakeholders and inform decision-making. The Town of Barnstable conducted a pilot test of the Cape Cod Coastal Planner as a tool to advance the town's vulnerability preparedness program.

The Cape Cod Coastal Planner compartmentalizes the coastline into 500-foot segments. Each segment is based on a uniform length, rather than unique physical features or processes that characterize that segments of the coastline. Users can select up to eight contiguous segments for a maximum planning area of 4,000 feet. The planning area extends 500 feet inland, and this area is referred to as a ***zone of impact***. For each zone of impact, users can select potential adaptation strategies based on specific hazard scenarios (e.g., 3 feet of sea level rise).

2.2. San Francisco Bay - Operational Landscape Units

San Francisco Bay is a tidal estuary in California that consists of a group of interconnected bays at the confluence of the Sacramento–San Joaquin River Delta. The Bay has approximately 400 miles of diverse coastline, with beaches, dunes, wetlands, marshes, mud flats, islands, marinas, ports, critical infrastructure, residential neighborhoods, and commercial areas.

San Francisco Bay formed as a result of rising sea levels at the end of the last ice age. As glaciers melted, the Sacramento and San Joaquin rivers carried large volumes of water and sediment down from the Sierra Nevada Mountains. Sea levels rose, and water entering through the Golden Gate flooded San Francisco Bay with seawater. The Bay is sheltered from the open ocean but exposed to a variety of coastal hazards, including tsunamis, erosion, sea level rise, and storm surge.

In 2019, the San Francisco Estuary Institute developed the web-based Resilience Atlas for San Francisco Bay. The atlas provides a science-based framework to identify effective adaptation strategies for building social and ecological resilience to rising sea levels, with an emphasis on nature-based adaptation strategies. Its data layers include shoreline characteristics, habitat types, facilities and infrastructure, shoreline modifications, hazard exposure, and opportunities for nature-based adaptation.

The primary objectives of the project were to facilitate regional planning by providing access to key datasets related to ecosystem resilience and to identify geographic areas with shared physical characteristics that would benefit from being managed as a unit. The project divided the San Francisco Bay shoreline into 30 ***operational landscape units (OLUs)***, which are geographic areas that share common physical characteristics based on natural processes such as tides, waves, and sediment transport (Figure 8). The OLUs encompass the entire San Francisco Bay shoreline, including the land area potentially vulnerable to sea level rise. They represent areas along and adjacent to the shore for which geographically specific and science-based sea level rise adaptation strategies can be developed.

The OLU framework has been used for a variety of purposes, including education and outreach, adaptation planning, and habitat connectivity analysis. The San Francisco Bay Shoreline Adaptation Atlas is a report that provides recommendations for how to apply the OLU framework and additional research

to address critical data gaps. The OLU framework is currently being utilized to support sea level rise adaptation planning in Marin and San Mateo Counties.

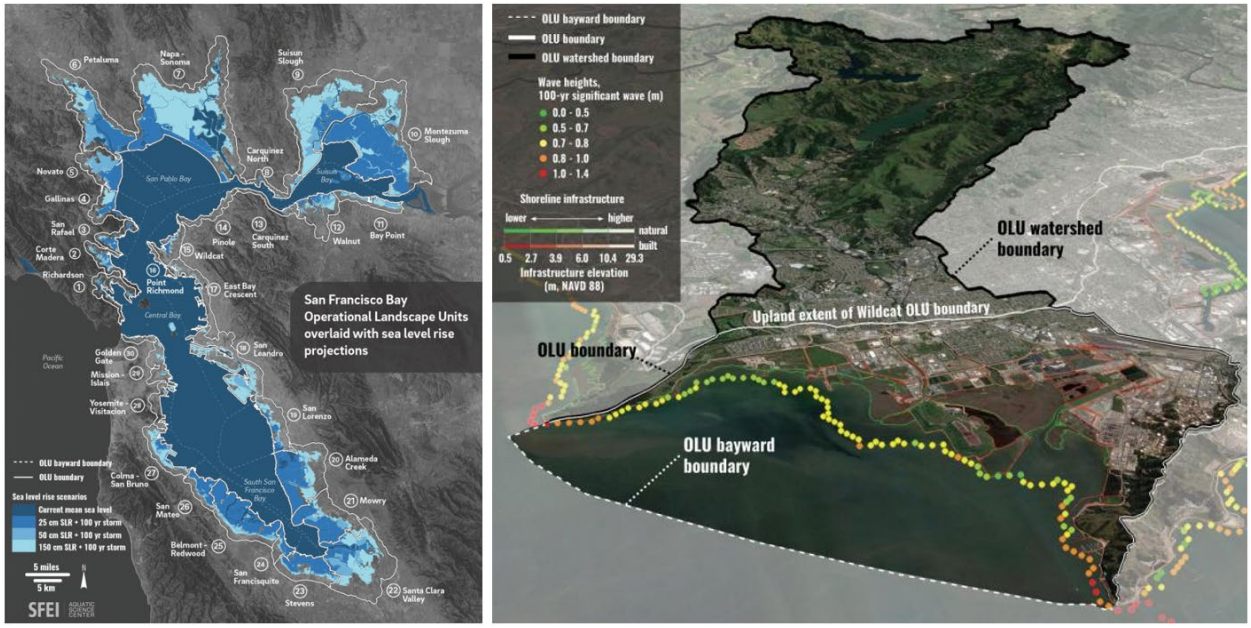


Figure 8. Operational landscape units (San Francisco Bay Resilience Atlas)

2.3. Pacific Northwest - ShoreZone Inventory

The ShoreZone Inventory approach was originally developed in British Columbia and later expanded to the states of Alaska, Washington, and Oregon. The existing ShoreZone inventories cover approximately 84,000 miles of coastline that consists of a diverse range of coastal environments including open-ocean coastlines, embayments, straits, sounds, estuaries, and islands. This Scoping Study focused on the ShoreZone Inventory for Washington State.

Washington State has one of the longest and most diverse coastlines in the United States, with 3,085 miles of coastline, including Puget Sound, the San Juan Islands and Georgia Straight, the Strait of Juan de Fuca, and the open ocean coastline from Cape Flattery to the Columbia River mouth. Nearly every type of shoreline can be found along Washington's coast.

In the late-1990s, the Washington State Department of Natural Resources inventoried Washington's saltwater shorelines to describe the physical and biological characteristics of intertidal and shallow subtidal areas. The coastline was systematically characterized based on shoreline morphology, substrate, wave exposure, and biota. The ShoreZone Inventory divided the shoreline into homogenous stretches called ***units***, which are alongshore stretches of shoreline with similar geomorphological characteristics. Within each unit, the shoreline was further divided into a series of cross-shore ***components***, which are stretches of shoreline that exhibit cross-shore variation in sediment composition and morphology.

Shoreline units and components were delineated based on physical processes and features and are characterized by over 50 individual attributes. Cross-shore component data was designed to capture details about the cross-shore variation. For example, along a stretch of beach, the backshore seawall may consist of concrete while the beach berm consists of logs and sand, the beach face consists of sand and pebbles, and the tidal flat with channels consists of sand and mud.

In 2014, the Washington ShoreZone Inventory was updated to provide a more detailed means of categorizing shorelines based on wave exposure and sediment types. The entire coastline was further compartmentalized into 60 unique ***shoreline classifications*** based on primary substate, secondary substrate, substrate stability, and wave exposure. ***Shoreline classifications*** include information regarding coastal landforms, shoreline modifications, shoreline armoring, slope stability, and sea level rise exposure.

Washington ShoreZone Inventory data is published in the Washington State Coastal Atlas, and individual GIS datasets are available to download (Figure 9). Washington ShoreZone Inventory data has been used for a variety of purposes including ecosystem services mapping, nearshore habitat monitoring, biotic community monitoring, eelgrass and kelp monitoring, informing habitat restoration projects, cataloging shoreline modifications (bulkheads, seawalls, boat ramps, etc.), and quantifying anthropogenic impacts along the shoreline (e.g., armoring, fill, loss of riparian vegetation). Washington ShoreZone Inventory data has also been used to identify opportunities and options for shoreline conservation, restoration, and enhancement.

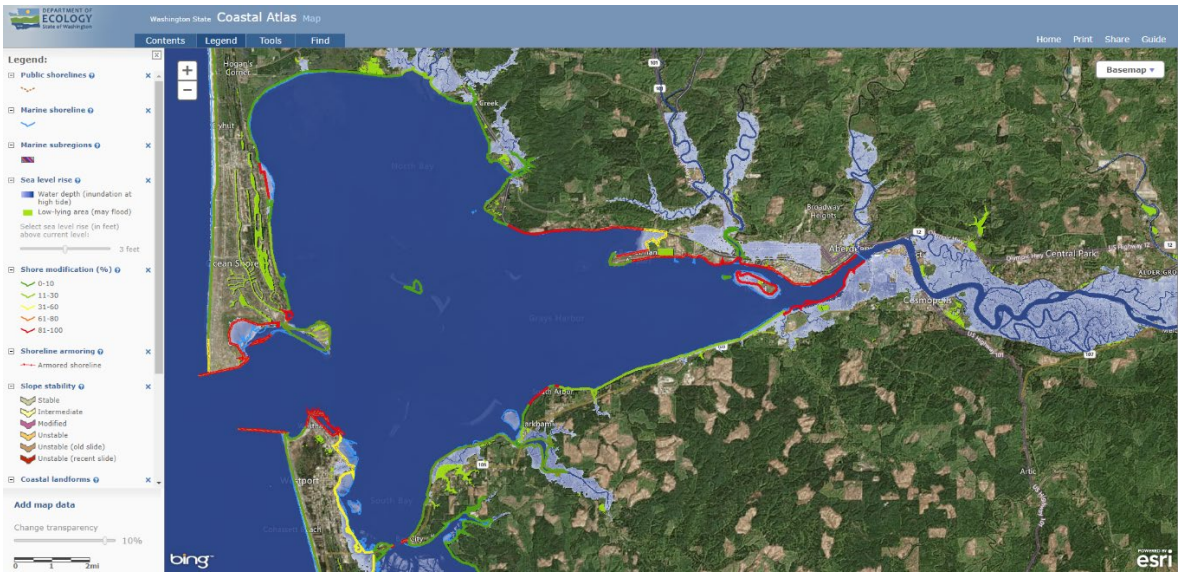


Figure 9. Washington ShoreZone Inventory data (Washington State Coastal Atlas)

2.4. U.S. Army Corps of Engineers - Regional Sediment Management

The U.S. Army Corps of Engineers (USACE) Regional Sediment Management Program is a nationwide program that conducts research to inform management decisions and develops demonstration projects to improve sediment management activities. The Regional Sediment Management Program has been active in Hawai‘i since 2008, and nine regional sediment management plans have been developed on the islands of Kaua‘i, O‘ahu, and Maui (Table 3).

Table 3. Coverage of USACE Regional Sediment Management Program in Hawai‘i

Island	Regional Sediment Management Planning Area	Length (miles)	Littoral Cells or Shoreline Reaches
Kaua‘i	Po‘ipū (Lāwa‘i to Shipwreck Beach)	5.5	8
	Kekaha (Kokole Point to Waimea River)	3.5	3
O‘ahu	Diamond Head to Pearl Harbor (‘Ewa Beach to Black Point)	18	6
	Southeast O‘ahu (Mōkapu Point to Makapu‘u Point)	12	9
	Hale‘iwa (Pua‘ena Point to Kaiaka Point)	2	5
	Sunset Beach (Ke Iki Beach to Velzyland)	3	3
Maui	Kahului (‘Īao Stream to Ho‘okipa Beach)	9	7
	West Maui (Hanaka‘ō‘ō to Honolua Bay)	10	12
	Kīhei (Mā‘alaea to Keawakapu Point)	7	7
	TOTALS	**70**	**60**

Regional sediment management plans have focused on areas with documented shoreline management issues and needs, including densely developed areas (e.g., Kīhei, Sunset Beach), resort areas (e.g., Waikīkī, West Maui), and commercial areas (e.g., Kahului, Hale‘iwa). While the Hawai‘i Regional Sediment Management Program spans approximately 70 miles, which represents less than 10 percent of Hawai‘i’s 750-mile coastline, the information gathered and generated through these projects can be useful to inform shoreline management decisions.

The Regional Sediment Management Program is not prescriptive and does not adhere to a specific methodology. However, projects typically rely on key datasets to inform the analysis of regional sediment management needs and development of recommendations and potential demonstration projects. Various scientific datasets are utilized to compartmentalize the coastline for the purposes of understanding regional sediment transport and identifying regional sediment management needs.

Regional sediment management projects typically utilize a combination of professional expertise, quantitative data (e.g., historical shoreline change, numerical modeling of waves, currents, and circulation patterns), and field observations to identify littoral processes, sediment transport patterns, sediment budgets, and shoreline change at the regional scale. These projects compartmentalize the coastline at various scales including regions, littoral cells (Figure 10) and shoreline reaches (Figure 11).

Data is published on the USACE Regional Sediment Management in Hawai‘i website. While data is available to download in the form of maps, reports, and presentations, there are no web-based mapping

applications or GIS data available for download. In some cases, regional sediment management data may need to be reviewed for accuracy or updated to account for changing conditions.

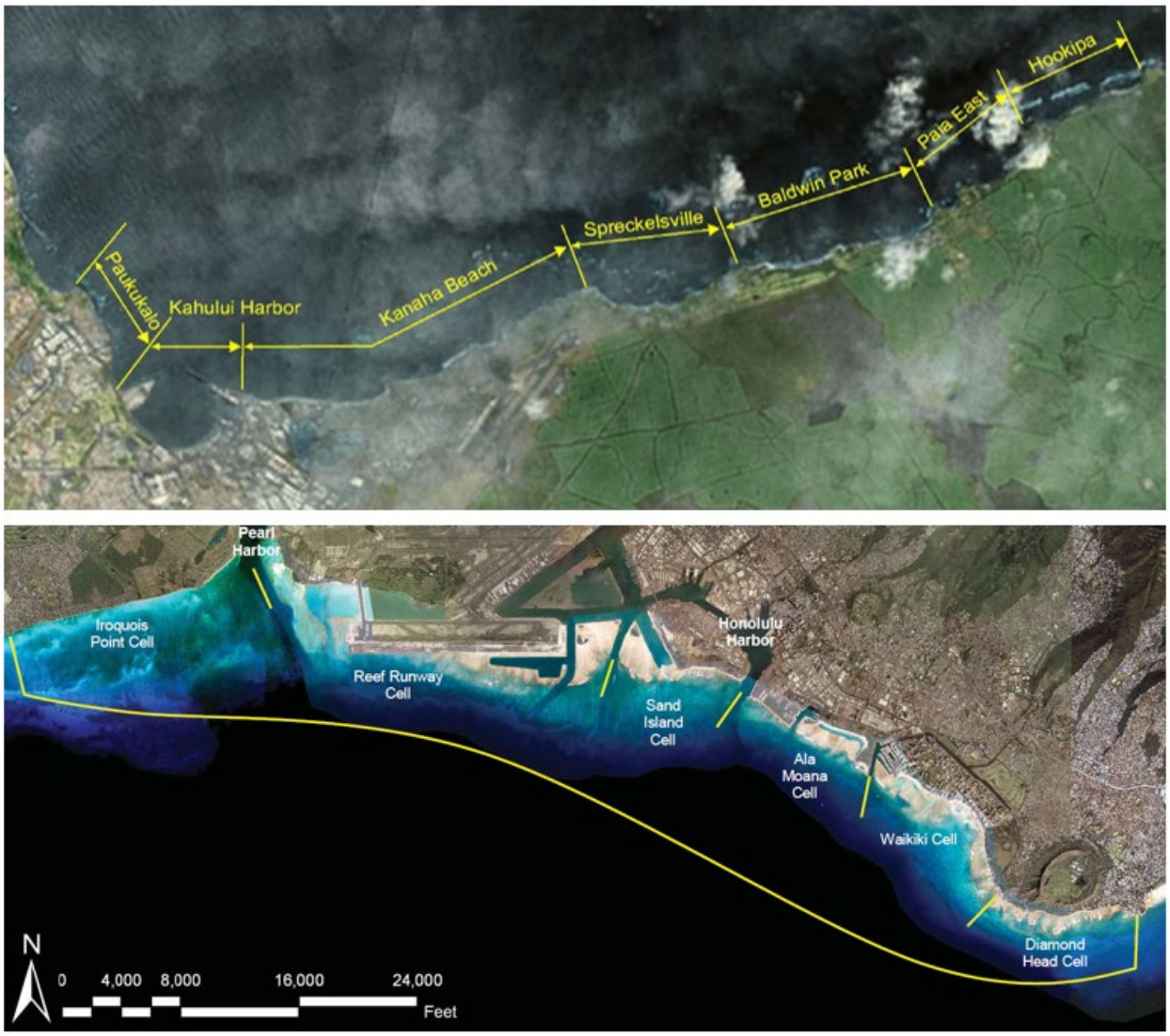


Figure 10. Littoral cells at Kahului, Maui (top) and South Shore, O'ahu (bottom) (USACE)

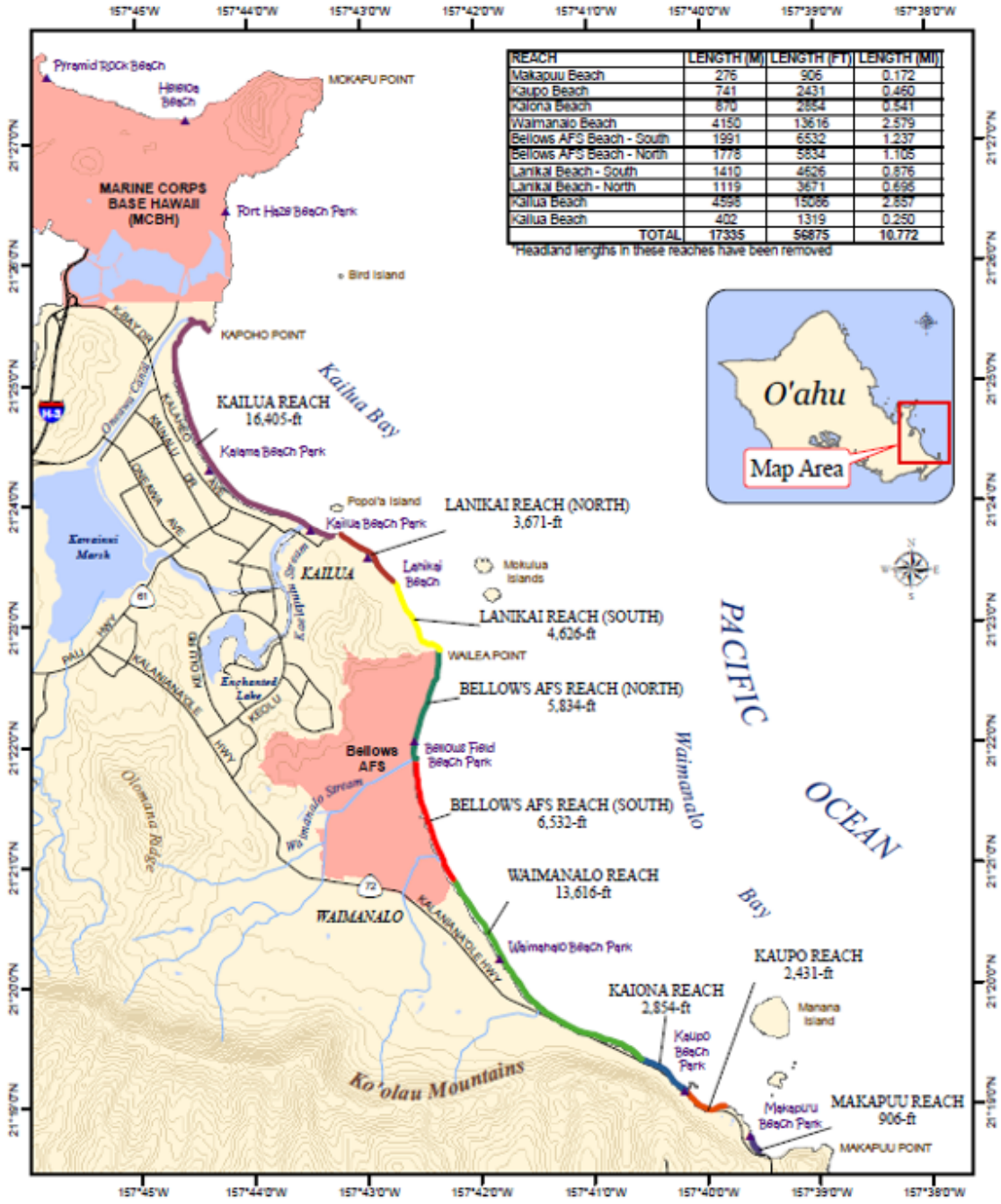


Figure 11. Shoreline reaches from Mōkapu Point to Makapu'u Point, O'ahu (USACE)

2.5. Australia - CoastAdapt

Australia is an island continent that is separated from Asia by the Arafura and Timor seas, with the Coral Sea lying off the Queensland coast, and the Tasman Sea lying between Australia and New Zealand. The coastline of Australia is exposed to wave energy from all directions. The southern half of Australia is exposed to larger waves that are generated by sub-tropical and temperate low-pressure systems. The northern half of Australia is mostly influenced by less energetic equatorial and tropical weather systems with seasonal variations in wave height related to the southeasterly trade winds (May-November) and monsoons (December-April). The Australian coastline extends approximately 21,000 miles (excluding all small offshore islands) and includes more than 1,000 estuaries.[7] The coastline consists of a diverse range of shoreline types that are characterized by a variety of attributes, including wave exposure, substrate, profile (slope), and erodibility.

In 2015, Geoscience Australia compartmentalized the entire coastline of Australia into discrete spatial units at multiple spatial scales. The objective of the project was to improve understanding of sediment transport processes and the potential impacts of sea level rise to inform shoreline adaptation planning and management. The project developed a comprehensive process-based coastal classification system as a framework to support coastal management at various scales.

The Australian coastline was divided into two large geographic realms, six regions, and 23 divisions. The divisions were further divided into 100 primary compartments and 359 secondary compartments to accommodate a range of management scales and timeframes (Figure 12). ***Divisions*** were defined based on the predominant orientation of the coastline, major geological features and processes, and recurring patterns of landform and geology. ***Primary compartments*** and ***secondary compartments*** were defined based on smaller-scale lithological/geological changes, geomorphic (topographic) features and landforms, and changes in the orientation of the coastline at different geographic scales (e.g., 1:250,000 versus 1:25,000). The landward and seaward boundaries for both primary and secondary compartments were chosen arbitrarily based on specific topographic and bathymetric contours. Data is published through the CoastAdapt Shoreline Explorer and is available to download as individual GIS files.

Figure 12. CoastAdapt divisions (left), primary compartments (center), and secondary compartments (right)

2.6. Key Takeaways

The methodologies reviewed as part of this Scoping Study exhibited common themes, which were considered fundamental to the development of a recommended methodology to delineate shoreline regions and subregions in Hawai‘i. Common themes from these methodologies include the following:

- Compartmentalize the coastline into discrete units at various geographic scales.
- Compartmentalize the coastline based on physical features and processes.
- Identify coastlines with unique wave exposure, geomorphology, and management needs.
- Characterize areas landward and seaward of the coastline.
- Include data delivery methods such as web viewers and downloadable data.
- Improve knowledge of coastal processes, coastal hazards, and shoreline behavior.
- Inform planning and decision-making for specific management purposes such as sea level rise adaptation, sediment management, and habitat management.
- Improve awareness of adaptation and management options.
- Increase resilience to coastal hazards and sea level rise.

The methodologies reviewed relied on available data and professional interpretation to compartmentalize the coastline into various geographic units (e.g., zones of impact, operational landscape units, littoral cells, shoreline reaches, and coastal compartments) based on unique physical characteristics and processes. The process of compartmentalizing the coastline produced comprehensive datasets that provided a more detailed understanding of coastal processes and shoreline behavior. Applying a similar approach in Hawai‘i would provide a foundational baseline dataset to inform planning and decision-making for shoreline adaptation and management at the regional and subregional scales.

The recommended methodology (Chapter 3) incorporates elements of the Australia CoastAdapt approach by compartmentalizing the coastline into ***regions,*** based on the predominant orientation of the coastline, major geological features and processes, and recurring patterns of landform and geology, and ***subregions,*** based on smaller-scale lithological/geological changes, geomorphic (topographic) features, and landforms. The recommended methodology also includes a ***cross-shore characterization*** similar to that which was utilized in the Washington ShoreZone Inventory approach. Building on the Cape Cod and San Francisco Bay examples, the recommended methodology emphasizes the role of coastal hazards exacerbated by climate change in characterizing regional and subregional shoreline segments. Lastly, the recommended methodology incorporates aspects of the Hawai‘i Regional Sediment Management approach by emphasizing the use of data relating to coastal processes (e.g., wave exposure, currents, circulation, and sediment transport patterns) and shoreline behavior (e.g., historical and projected shoreline change).

A primary difference between the reviewed methodologies and the recommended methodology is the incorporation of place-based traditional ecological knowledge as the first consideration of delineating shoreline regions and subregions, as well as its recognition of community and cultural assets and uses as well as community and cultural values.


Maui, Hawai‘i

3. Recommended Methodology for Delineating Shoreline Regions and Subregions in Hawai‘i

3.1. Overview of Recommended Methodology

This Scoping Study has identified a recommended methodology for delineating shoreline regions and subregions based on the following:

- A comprehensive review of challenges and opportunities for regional shoreline management (Appendix 2)
- Examples of regional and subregional shoreline management approaches in Hawai‘i and other locations around the world (Chapter 2, Appendix 3 and 4)
- Initial mapping of regions and subregions for selected shoreline shorelines in Hawai‘i (Chapter 4)
- Feedback from the ORMP Action Team, wiki surveys, and workshops.

The recommended geographic scales for shoreline compartmentalization are summarized in Figure 13. Examples of applying the methodology for delineating shoreline regions and subregions are described in further detail in Chapter 4.

Shoreline Regions and Subregions

A shoreline region refers to a specific segment of the coastline that is initially established by traditional ahupua‘a boundaries and further refined based on a combination of physical features and processes. A region may consist of multiple ahupua‘a, or a portion of an ahupua‘a. It may include different shoreline types, as well as a combination of natural shorelines and man-made structures and facilities. A region may span one or more littoral cells. Shoreline regions are delineated to characterize the regional coastal setting and establish the geographic and physical boundaries for shoreline management that extend along the coastline and landward and seaward of it.

A shoreline subregion refers to a specific reach of shoreline within a region that is characterized by physical and environmental features and/or processes that differentiate it from the remainder of the region. The delineation of subregions allows for more detailed understanding of localized coastal processes and the physical, ecological, cultural, and social complexity of the backshore, foreshore, and nearshore environments. The delineation of subregions also allows for consideration of hazard exposure and vulnerability at finer scales (e.g., sections of a beach that may be subject to more intense erosion than adjacent shorelines).

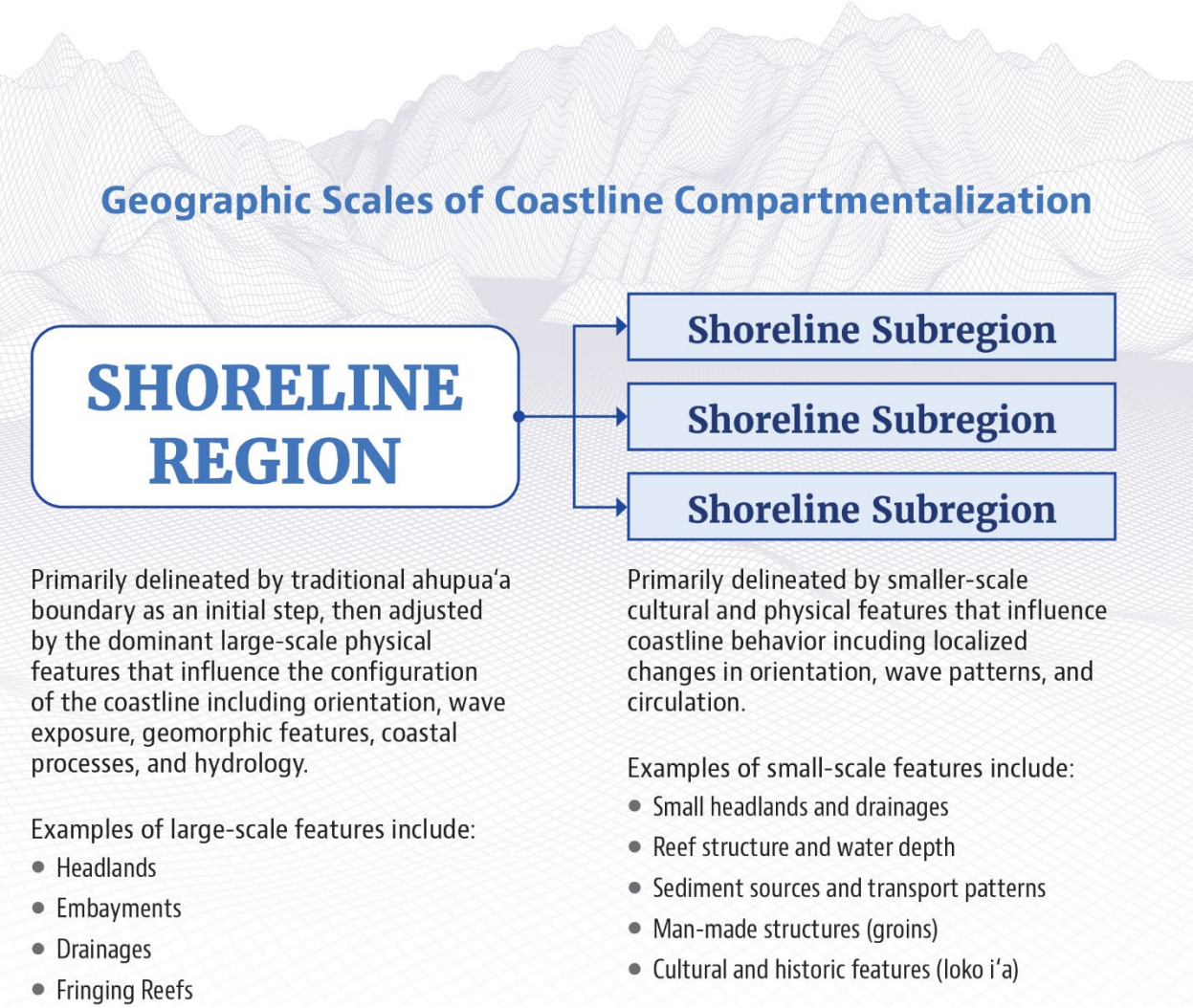


Figure 13. Geographic scales of coastline compartmentalization

Information Sources for Shoreline Delineations

The shoreline region and subregion boundaries and characterizations are based on a combination of quantitative and qualitative data. The level of confidence in the output data will vary based on the accuracy and precision of the input data used in the mapping process. It is recommended that the mapping team establish a tiered system to describe the confidence level associated with the shoreline region and subregion boundaries and characterizations:

- Confidence levels will be higher along shorelines where data availability and quality are high, and physical features and processes are well-defined.
- Confidence levels will be lower in areas where data availability or understanding of physical processes are limited. For areas where confidence levels are low, additional technical studies may be required.

Establishing data confidence levels will enable the mapping team to expedite mapping of areas with higher confidence and prioritize research to address critical data gaps in areas with lower confidence.

The Aha Moku system, been handed down in oral tradition and practice, is based on the concept of `ahupua`a, Hawaii's traditional land, and ocean tenure system. While it originated in ancient times, it contains land divisions that can, if properly incorporated, support a place-based community and cultural consultation process. The 2020 Ocean Resources Management Plan considers traditional ecological knowledge an integral part of land as well as shoreline management through the auspices of the ahupua'a system. Place-based traditional ecological knowledge has been amassed over millennia, passed down from one generation to the next through oral transfer of wisdom gained from experience, observation, and trial-and-error. This process has resulted in valuable information from a living culture that continues to evolve.

The integration of Native Hawaiian traditional ecological knowledge with the latest scientific tools and practices provides the best chance for success in regional shoreline management. The traditional, intimate way that native Hawaiians related to the natural world results in a body of traditional ecological knowledge. Such knowledge provides an appropriate and informative foundation to a scientific assessment of the shoreline that serves to protect and perpetuate the living native Hawaiian cultural practices and sacred sites within a shoreline region. A traditional philosophy and practice can be applied to contemporary shoreline management that considers the needs for today as well as the needs of future generations.

Steps in the Delineation Process

The recommended process for compartmentalizing Hawaii's coastline into discrete shoreline regions and subregions will require a systematic mapping effort consisting of multiple steps (Figure 14). The iterative, systematic mapping process will be primarily based on subject matter expertise, professional interpretation, and place-based traditional ecological knowledge. Each step of the process is described further in the sections below.

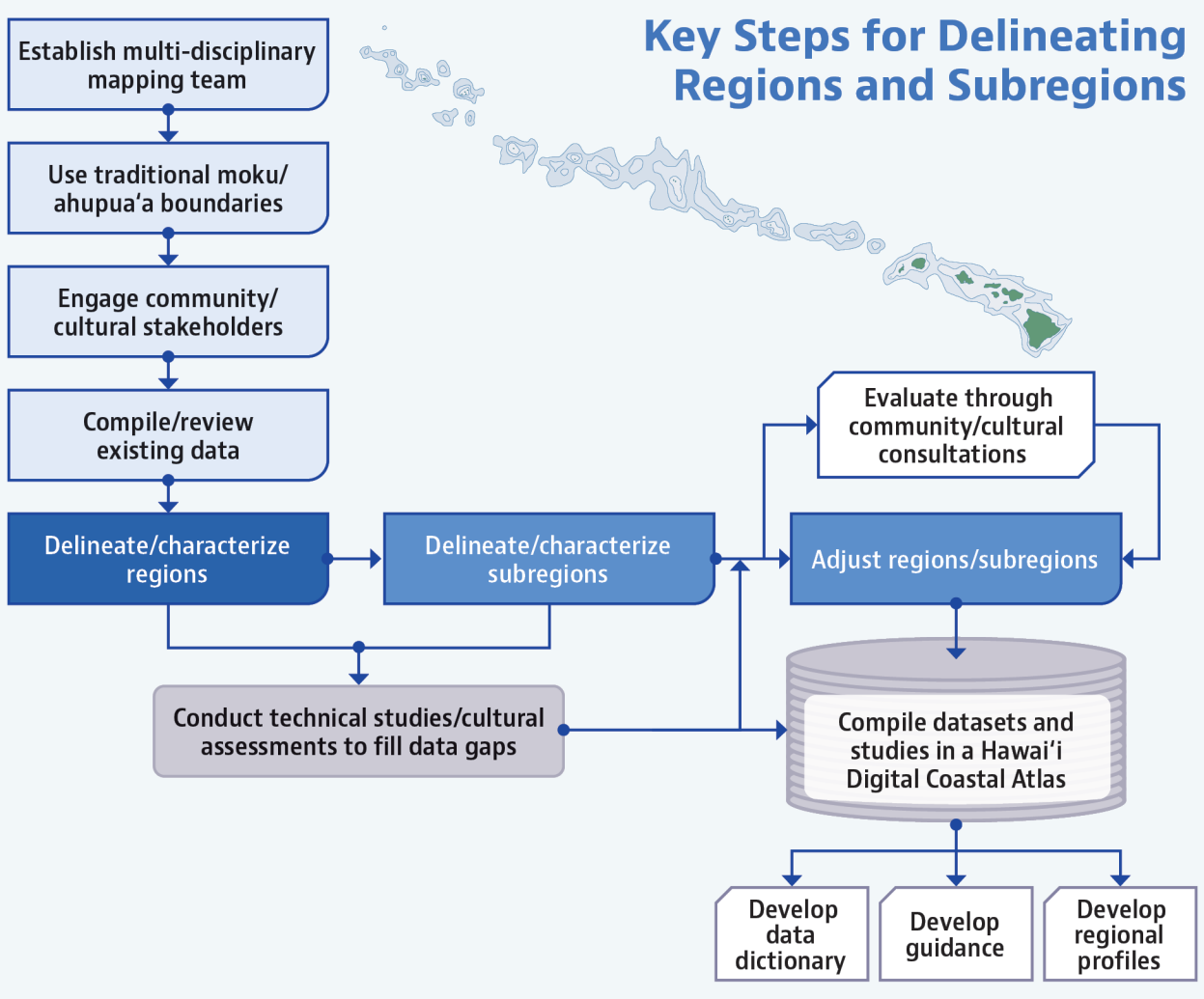


Figure 14. Key steps for delineating shoreline regions and subregions

3.2. Establish a Multidisciplinary Mapping Team

Hawai'i's coastline is characterized by physical processes and features such as orientation, wave exposure, geology, geomorphology, coastal habitat, and hazard exposure. Management of Hawaii's coastline took place for many centuries prior to western contact as a critical segment of native Hawaiian culture through the ahupua'a system and continues through the perpetuation of traditional ecological knowledge. The physical complexity of Hawai'i's coastline is expressed by a diverse range of natural and man-made features and processes. Examples of natural shorelines include sandy beach and dune systems, cobble beaches, marine terraces, rocky shorelines, and steep cliffs (*pali*). In many areas, human interventions have altered the configuration of the coastline and the physical processes and features that influence shoreline behavior. Examples of man-made shoreline features include armored shorelines (e.g., seawalls and revetments), cultural and recreational facilities (e.g., loko i'a (fishponds), marinas and lagoons), and commercial facilities (e.g., ports and harbors).

Hawai'i's coastline is also characterized by diverse and unique coastal ecosystems in backshore, foreshore, and nearshore environments, such as beaches, dunes, anchialine ponds, estuaries, wetlands, intertidal zones, and fringing reefs. These coastal ecosystems contain a multitude of cultural resources

and support a wide range of cultural uses, as well as providing essential habitat that supports endemic and threatened and endangered species, all of which require consideration in shoreline management.

The delineation of shoreline regions and subregions requires in-depth knowledge and understanding of coastal processes and the complex cultural, physical, ecological, and community-related features that characterize individual segments of Hawai'i's coastline. It requires multidisciplinary subject matter expertise, professional interpretation, and input from various cultural and community stakeholders.

A multidisciplinary mapping team is required to systematically delineate Hawai'i's coastline into discrete regions and subregions. The primary objectives of the mapping team would be as follows:

- Establish key parameters and a process for delineating shoreline regions and subregions.
- Establish key parameters and a process for defining unique shoreline typologies.
- Establish naming conventions and data descriptors.
- Identify and compile datasets to support systematic shoreline mapping.
- Identify data gaps and provide guidance for data development.
- Conduct preliminary mapping to delineate shoreline regions and subregions.
- Develop data documentation (e.g., metadata, data dictionary, guidance).
- Identify areas where the methodology is not applicable or appropriate.
- Provide recommendations for mapping in areas that are challenging.
- Review findings with stakeholders to refine shoreline regions and subregions.

A multidisciplinary mapping team should consist of the following subject matter experts:

- **Native Hawaiian Traditional Ecological Knowledge Specialist** – At least one traditional ecological knowledge specialist is required to facilitate the identification of the moku and ahupua'a boundaries recognized by lineal descendants of a particular area as a primary means of delineating shoreline regions and subregions. This role will ensure that cultural resources in the coastal environment are identified and included in regional shoreline management from the onset, that traditional cultural practices are acknowledged and preserved, and that opportunities to integrate traditional ecological knowledge into shoreline planning and interventions where it is practical and advantageous to do so are captured in shoreline datasets and the mapping process.
- ***Coastal Geologist*** – A coastal geologist is needed to identify, analyze, and interpret geologic data (e.g., substrate, soils), geomorphologic features (e.g., headlands, embayments, cliffs), coastal processes (e.g., sediment transport, shoreline change), and other features along the shoreline.
- ***Coastal Engineer*** – A coastal engineer is needed to analyze and interpret data relating to coastal processes including bathymetry, waves, currents, circulation, shoreline change, and sediment transport. A coastal engineer can also identify and characterize man-made structures (e.g., seawalls, revetments, groins, breakwaters) and their influence on coastal processes and shoreline behavior.
- ***Planner*** – A planner is needed to analyze and interpret data related to human uses in the backshore environment such as zoning, land use, land ownership, development, infrastructure, and economics. A planner can help to identify linkages between existing development in the backshore and foreshore environments. A representative from the county planning department should be included for the island being mapped.

- ***Marine Biologist*** – A marine biologist is needed to analyze and interpret data related to the nearshore marine environment, including benthic substrate, benthic habitat, coral reefs, marine flora/fauna, endangered species, essential fish habitat, and water quality. A marine biologist can help to identify linkages between the nearshore and foreshore environments.
- ***Terrestrial Biologist*** – A terrestrial biologist is needed to analyze and interpret data related to the backshore environment, including watersheds, hydrography, terrestrial habitat, terrestrial flora/fauna, vegetation, and water quality. A terrestrial biologist can help to identify linkages between the backshore and foreshore environments.
- ***GIS Analyst*** – A GIS analyst is needed to compile, analyze, interpret, manipulate, develop, and manage digital data. A GIS analyst would be responsible for establishing mapping procedures and techniques, which may include data modeling, geospatial analysis, and data documentation (e.g., metadata, data dictionaries). A GIS analyst may also perform data quality assurance and quality control and may assist with development of data delivery tools.

3.3. Use Traditional Moku and Ahupua‘a Boundaries

Shoreline management has been conducted by passing down of traditional ecological knowledge within each ahupua‘a through numerous generations in Hawai‘i and is still recognized in the present day by lineal descendants that steward and utilize shoreline resources. As a means to capture traditional ecological knowledge about shoreline management that has passed down over millennia, traditional ahupua‘a will serve as a logical grouping for delineating initial boundaries for shoreline regions and subregions. The district-level moku will also be identified as an early step in the process.

A specialist in traditional ecological knowledge will verify that the boundaries associated with available datasets are consistent with boundaries recognized by lineal descendants from within each ahupua‘a. There will likely be disagreement on the traditionally recognized boundaries between ahupua‘a, and resolution of any conflict in this topic will need to be addressed in the cultural assessment phase of the delineation process. Additional conflict resolution steps may be applied as needed to gain consensus. Proper identification of regional boundaries will be followed by adjustments based on community and stakeholder consultation, relevant existing datasets and gaps, and other relevant considerations.

3.4. Engage Community, Cultural, and Other Stakeholders

Once the initial shoreline region is determined based on traditional shoreline management boundaries, the relevant lineal descendants, cultural practitioners, and other keepers of traditional ecological knowledge (such as Hawaiian Civic Clubs, canoe clubs, fishing hui) can be identified and consulted for foundational knowledge about that region. Further consultations—with landowners and representatives of publicly held lands, community-based groups, non-government organizations, commercial entities, and otherwise unaffiliated individuals—can further inform the delineation process and, ideally, involvement in subsequent regional shoreline management, as appropriate. Consultations will also occur through the established community planning areas to connect with other regional planning processes, as well as associated groups and individuals. Connecting local government planners and shoreline managers, specifically at the county level, will be critical to incorporating all jurisdictional considerations in region and subregion delineation.

The consultations conducted at this stage will be revisited once the regions and subregions are delineated through an evaluation process in the latter part of this methodology. Revisiting will allow refinement through a feedback loop that improves the likelihood of stakeholder buy-in and therefore the ability to successfully implement regional shoreline management in Hawai‘i.

3.5. Compile Existing Datasets

Delineation of the coastline into regions and subregions will be based primarily on existing data including but not limited to the following:

Moku and Ahupua‘a Boundaries– In the traditional Hawaiian culture, each island was divided into moku, the largest units within each island. These were usually wedge-shaped and ran from the mountain crest to the nearshore waters. Each moku was further divided into ahupua‘a, generally narrower wedge-shaped land sections that also ran from the mountains to the sea. Recognizing these traditional boundaries as an initial step includes the range of cultural resources to be protected, as well as the management practices that have evolved over millennia that inform modern shoreline management. In some instances, there are multiple interpretations of where an ahupua‘a boundary may be located, which may need to be resolved as part of the mapping process.

Imagery – A combination of historical and current orthophotographs can be used to analyze the coastline and the surrounding physical environment. High-resolution orthoimagery is a principal dataset that provides insights into the physical features (e.g., shoreline orientation and landforms) and processes (e.g., wave exposure) that have influenced the configuration and evolution of the shoreline over time. Additional observations can be made using oblique aerial imagery (e.g., Pictometry) and ground photographs.

Coastal Hazards – Hawai‘i’s coastline is exposed to a wide range of coastal hazards, including tsunamis, hurricanes, storm surge, coastal and terrestrial flooding, coastal erosion, bluff erosion, and bluff failures. Many of these hazards are being exacerbated by climate change and sea level rise. Hazard analysis is important for understanding both current and future environments (e.g., historical and projected shoreline change, sea level rise, coastal flooding).

Backshore (Terrestrial) Environment – Hawaii’s coastline is characterized and influenced by a wide range of terrestrial features and processes such as cultural resources (e.g., heiau), geomorphologic features (e.g., mountains, headlands), topography (e.g., low-lying coastal plains vs. steep rocky cliffs), substrate (e.g., geologic units and soils), hydrology (e.g., surface water, groundwater, watersheds, drainage systems), and land use and land cover (e.g., forests, wetlands, urban areas). In many cases, the physical features and processes that are present in the backshore (terrestrial) area can directly or indirectly influence shoreline behavior and the feasibility and effectiveness of shoreline adaptation strategies and management interventions.

Foreshore (Shoreline) Environment – Hawaii’s coastline consists of a multitude of unique shoreline types that are influenced by various physical features and processes such as cultural resources (e.g., loko i‘a), geomorphology, substrate, topography, wave exposure, currents and circulation, sediment transport, and the presence of man-made structures. It is important to characterize the foreshore and identify linkages between the backshore and nearshore environments.

Nearshore (Marine) Environment – Hawaii’s nearshore environment is diverse and consists of cultural resources (e.g., fishing grounds), fringing reefs, channels (natural and man-made), alluvial

fans, mud flats, sandbars, and shoals. Complex bathymetry in the vicinity of the coastline influences waves, currents, circulation, and sediment transport patterns. Benthic habitat geography, geomorphology, and biology are also highly variable in the nearshore environment. The physical features and processes in the nearshore environment can directly or indirectly influence shoreline behavior.

Administrative – Implementing shoreline management at a regional scale will necessarily span a multitude of administrative boundaries such as zoning, land use, land ownership (i.e., parcel boundaries), and cultural boundaries. The administrative composition of the backshore environment can directly or indirectly affect the feasibility and effectiveness of shoreline adaptation strategies and management interventions.

Infrastructure – Hawaii's coastline consists of both undeveloped areas where open space is abundant and developed areas where existing development and infrastructure are highly concentrated. In many developed areas, habitable structures (e.g., residential homes), water-dependent facilities (e.g., ports and harbors), economic infrastructure (e.g., hotels and resorts), and critical public infrastructure (e.g., highways, wastewater treatment facilities) are located close to the shoreline or in low-lying coastal areas that are vulnerable to coastal hazards and sea level rise. The presence of existing development and infrastructure is a key determining factor in understanding adaptation needs and evaluating shoreline management interventions.

The primary datasets required for initial mapping of shoreline regions and subregions are listed in Table 4. The multidisciplinary mapping team should determine if any additional datasets are required.

Table 4. Primary datasets to support initial mapping of shoreline regions and subregions

Description	State Coverage	Source
Cultural		
Moku	State-wide	Multiple
Ahupua'a	State-wide	Multiple
Loko i'a	Partial	Multiple
Geographic place names	State-wide	OPSD
Imagery		
Historical aerial photographs	State-wide	Multiple
Current orthophotographs	State-wide	Google Earth
Oblique aerial photographs	Partial	Multiple
Oblique aerial video	Not Available	
Coastal Hazards		
Coastal hazards atlas	State-wide	U.S. Geological Survey (USGS)
Historical shoreline change	Partial	University of Hawai'i Coastal Geology Group (UH-CGG)
Projected shoreline change	Partial	UH-CGG
SLOSH (Sea, Lake, and Overland Surges from Hurricanes)	State-wide	NOAA

Description	State Coverage	Source
Federal Emergency Management Agency (FEMA) flood zones	State-wide	FEMA/DLNR
Tsunami inundation areas	State-wide	Multiple
Sea level rise exposure area	State-wide	University of Hawai'i Pacific Islands Ocean Observing System PacIOOS
1%-annual chance coastal flood with sea level Rise	State-wide	OPSD
Landslide susceptibility (Hawai'i Island)	Partial	Pacific Disaster Center
Terrestrial		
Topography (LiDAR)	State-wide	USACE
Geologic UNITS	State-wide	USGS
Soil Units	State-wide	U.S. Department of Agriculture (USDA)
Hydrography	State-wide	OPSD
Wetlands	State-wide	U.S. Fish and Wildlife Service (USFWS)
Watersheds	State-wide	OPSD
Inland Water Classifications	State-wide	Department of Health (DOH)
Land Use / Land Cover	State-wide	OPSD
Coastal		
Coastline	State-wide	OPSD
Vegetation Line	Partial	UH-CGG
Littoral Cells	Partial	USACE
Shoreline Modifications	Partial	Counties
Facilities	Partial	OPSD
Critical Infrastructure	State-wide	OPSD
Marine		
Bathymetry	State-wide	USACE
Wave Exposure	Partial	UH-CGG
Littoral Cells	Partial	USACE
Currents and Circulation	Partial	USACE
Sediment Transport	Partial	USACE
Benthic Habitat	State-wide	NOAA
Coral Reefs	State-wide	OPSD
Marine Water Classifications	State-wide	DOH
Administrative		
Shoreline Public Access	Partial	Counties
Community Planning Areas	State-wide	Counties
Parcels / Zoning	State-wide	OPSD
Infrastructure		
Roadways	State-wide	OPSD

Description	State Coverage	Source
Harbors	State-wide	OPSD
Bridges	State-wide	OPSD
Utilities	State-wide	OPSD
Parks	State-wide	OPSD

3.6. Delineate and Characterize Shoreline Regions

Shoreline region refers to a specific segment of the coastline that is initially established by traditional moku and ahupua‘a boundaries as established at the shoreline, and further refined based on a combination of distinct physical features and littoral processes. A region may consist of multiple ahupua‘a, or a portion of an ahupua‘a, as well as different shoreline types and may include a combination of natural shorelines and man-made shorelines structures and facilities. A region may span one or more littoral cells. Shoreline regions are delineated to characterize the regional coastal setting and establish the geographic and physical boundaries for shoreline management that extend both along the coastline and landward and seaward of it.

Delineation of shoreline regions allows for consideration of hazard exposure and vulnerability at the regional and community levels. It provides a geographic scale to identify regional shoreline adaptation needs and evaluate potential management interventions. Shoreline regions are the preferred scale for shoreline management. In some cases, an area consisting of multiple shoreline regions could be selected to inform larger-scale planning efforts (e.g., community development plans, regional sediment management plans).

Delineate Shoreline Regions

Shoreline regions are delineated through an iterative systematic mapping process based on four primary factors: traditional cultural management boundaries (e.g., moku and ahupua‘a boundaries), shoreline orientation, wave exposure, and the dominant geomorphologic features along the coastline. Initial mapping is based on subject matter expertise, professional interpretation of aerial photographs, place-based traditional ecological knowledge about coastal and shoreline processes, knowledge of shoreline adaptation needs, and past, present, and proposed management interventions.

The initial delineations are refined based on review of published reports (e.g., environmental assessments, environmental impact statements, cultural impact assessments) and studies (e.g., coastal erosion studies, regional sediment management plans, shoreline management plans, ethnographic and archaeological studies). Shoreline regions are further refined based on feedback obtained through formal and informal review with stakeholders.

The initial step in delineating shoreline regions is to establish a *representative coastline*. For the purposes of delineating shoreline regions, it is important to select a representative coastline that is (a) available statewide, (b) relatively stable, and (c) not dependent on regulatory jurisdiction and/or land ownership. The recommended source for this delineation is the *coastline* dataset available through the Hawai‘i Statewide GIS Program, which is a polyline dataset representing the coastlines of the eight main Hawaiian Islands, derived from USGS Digital Line Graphs. Using the term *coastline* may help to avoid

potential confusion with terminology in existing statutes and administrative rules related to coastal zone management (e.g., *coastal zone*), regulatory jurisdiction (e.g., *shoreline area*), and land ownership (e.g., *certified shoreline*).

The delineation of shoreline regions is based on professional interpretation of aerial photographs, subject matter experience, historical knowledge about coastal and shoreline processes, and knowledge of past/present/proposed shoreline management needs and interventions. At a minimum, the following factors should be considered when delineating shoreline regions:

- ***Orientation*** – Dominant angle of the coastline that determines exposure to wave energy.
- ***Geomorphology*** – Dominant landforms that affect wave patterns and sediment transport (e.g., headlands, embayments).
- ***Hydrology*** – Dominant hydrologic features that influence the configuration and/or behavior of the shoreline (e.g., rivers, streams, watersheds).
- ***Sediment Transport*** – Dominant sediment sources, sinks, mode (direction), volume, and frequency (e.g., tidal, seasonal, episodic).
- ***Bathymetry*** – Dominant features in the nearshore environment that influence wave patterns, wave energy dissipation, currents, and circulation (e.g., water depths, channels, fringing reefs).
- ***Topography*** – Elevation of the backshore environment that affects hazard exposure.
- ***Shoreline Types*** – Dominant shoreline types within a region (e.g., beaches vs. rocky coastline).
- ***Shoreline Change*** – Historical observations and future projections for erosion and accretion.
- ***Shoreline Modifications*** – Presence of man-made structures that influence coastal processes and shoreline behavior (e.g., armored vs. unarmored coastline, groins, breakwaters, seawalls, revetments, facilities).

In order to inform shoreline adaptation and management interventions at a regional scale, it is necessary to characterize the physical environment landward and seaward of the coastline. In Hawai‘i, various terms have been used to reference the boundary between land (*‘āina*) and sea (*kai*). Seaward boundaries of private lands along the coastline were historically described as *ma ke kai* (at or along the sea) or along the *kahakai* (mark of the sea).[8] USACE references the *high-water mark* to establish the limits of federal jurisdiction along the coastline. The University of Hawai‘i references the *beach toe* (i.e., low water mark along sandy coastlines) as a proxy to quantify historical shoreline change (e.g., erosion and accretion). The State of Hawai‘i references the *shoreline*[9] to establish the makai (seaward) limits of private land ownership, establish the jurisdictional boundaries of the Conservation District and the SMA, and provide a baseline for calculating shoreline setbacks. Most of these terms are based on physical features that were identified for specific purposes and have implications related to regulatory jurisdiction and/or land ownership.

Once the *representative coastline* has been established, the mapping team should establish reasonable boundaries within which key datasets should be evaluated and considered. The 50-foot elevation contour should be used as the landward limit for cross-shore characterization. This elevation is considered adequate to capture the primary physical features and processes that characterize the terrestrial environment (e.g., existing development, hydrologic features, terrestrial sediment sources, coastal hazard exposure, and shoreline setbacks). The 100-foot bathymetric contour should be used as the seaward limit for cross-shore characterization. This water depth is considered adequate to capture the primary physical features and processes that characterize the nearshore marine environment (e.g., fringing reefs, channels, sediment transport patterns, and offshore sediment sources).

The recommended landward and seaward boundaries are not intended to limit the geographic scope of the areas that should be considered when evaluating potential shoreline adaptation and management interventions. In some cases, these boundaries may need to be expanded to capture features or processes located further inshore (e.g., hydrologic features, groundwater inundation) or offshore (e.g., offshore sand deposits).

Characterize Shoreline Regions

Shoreline regions are further characterized by their unique physical, ecological, cultural, and community features. Once shoreline regions have been delineated, the next step is to collate existing data and populate attributes (data values) to provide a comprehensive description of each region. The mapping team should identify attributes that provide a level of detail sufficient to analyze and identify the physical linkages between the backshore, foreshore, and nearshore environments. Attributes should cover a wide range of physical processes and features in these environments. The objective of characterizing shoreline regions is to produce a robust and informative dataset that will improve understanding of physical processes at the regional scale.

Examples of attributes that could be used to characterize shoreline regions are shown in Table 5. Additional attributes may be added by the mapping team or through consultations with other subject matter experts and community and cultural stakeholders.

Table 5. Example attributes for characterization of shoreline regions

Attribute	Description
Unique ID	00000000
Moku	Koʻolaupoko
Ahupuaʻa	Kailua
Region (*Kahakai*)	Kailua Bay
Begin	Kapoho Point
Begin_Latitude	21°25'27.28"N
Begin_Longitude	157°44'21.35"W
End	Alala Point
End_Latitude	21°23'46.29"N
End_Longitude	157°43'13.17"W
Length	3.8 miles
Subregions	3
Orientation	NE
Primary Landforms	Headlands, Embayment
Secondary Landforms	Dunes, Streams, Canals
Natural Shoreline	95%
Modified Shoreline	5%
Wave Exposure	Exposed
Fringing Reef	Y
Dominant Sediment Transport Mode	Cross-shore
Dominant Sediment Transport Type	Seasonal; Tidal; Episodic
Dominant Nearshore Type	Fringing Reef; Channel

Attribute	Description
Dominant Foreshore Type	Sandy Beach
Dominant Backshore Type	Dune
Historical Shoreline Change	Accretion (avg X feet/year)
Projected Shoreline Change	Erosion (avg X feet/year)
Sea Level Rise Exposure	Medium
Orthophotograph	<link>

3.7. Delineate and Characterize Shoreline Subregions

Shoreline subregion refers to a specific reach of shoreline within a region that is characterized by a unique combination of physical and environmental features and/or processes that differentiate it from the remainder of the region. The delineation of subregions allows for more detailed understanding of localized coastal processes and the physical, ecological, cultural, and social complexity of the backshore, foreshore, and nearshore environments. The delineation of subregions also allows for consideration of hazard exposure and vulnerability at finer scales (e.g., sections of a beach that may be subject to more intense erosion than adjacent shorelines).

A subregion may be characterized by ahupua‘a boundaries, particularly those that are geographically narrow, or ‘ili (sub-areas to ahupua‘a); a specific shoreline typology; unique physical processes (e.g., currents, circulation, sediment transport); unique physical features (e.g., headlands, drainages, embayments, facilities, structures); or a geographic scale that requires consideration of more site-specific shoreline management strategies. Unique conditions and processes at the subregional scale (e.g., the combination of existing land uses, geology, hazard exposure, elevation, and sediment availability) can affect the feasibility of some adaptation strategies and management interventions. The delineation of subregions improves knowledge of localized coastal processes and shoreline behavior within each region, refines understanding of adaptation needs, and facilitates evaluation of potential shoreline management interventions at the regional scale.

Delineate Shoreline Subregions

The delineation of shoreline subregions is based on professional interpretation of existing data (e.g., aerial photographs, studies, reports, and plans) combined with knowledge of localized coastal processes (e.g., wave patterns, currents, circulation, sediment transport) and the influence of natural features (e.g., stream mouths) and man-made features (e.g., structures and facilities) on shoreline behavior. Shoreline subregions are delineated based on many of the same factors that are used to delineate shoreline regions but with a more detailed investigation to identify and understand the physical features and processes that influence shoreline behavior along smaller segments of the coastline.

A subregion may exist due to subtle changes in shoreline orientation, wave exposure, bathymetry, substrate, or structures. For example, the presence of a physical feature (e.g., headland, fringing reef) can alter wave patterns, which can influence sediment transport and beach stability. Similarly, the presence of a natural feature (e.g., channel, stream mouth) or man-made structure (e.g., groin, fishpond) can create localized sediment transport patterns that are distinct from the predominant mode of sediment transport within a shoreline region.

Characterize Shoreline Subregions

Once shoreline subregions have been delineated, the next step is to collate existing data and populate attributes (data values) to provide a comprehensive description of each subregion. The mapping team should identify attributes that provide a level of detail sufficient to identify and understand smaller portions of coastline (e.g., erosion hot spots, frequently flooded areas) that behave differently than the region as a whole. Attributes should cover a wide range of physical processes and features in the backshore, foreshore, and nearshore environments. The objective of characterizing shoreline subregions is to improve understanding of localized processes that affect individual segments of the coastline and site-specific adaptation needs and to ensure that shoreline management interventions account for localized processes.

A site-specific characterization of each shoreline subregion should provide a detailed description of the components of the backshore, foreshore, and nearshore environments (see Figure 6). Subregions should also be characterized in terms of exposure and sensitivity to coastal hazards and sea level rise, including historical rates and projections for erosion and coastal flooding. Data attributes for each subregion should provide a level of detail that is sufficient to capture the unique features and processes along individual segments of the coastline (e.g., parts of embayments, specific shoreline reaches) and inform management decisions at the subregional and regional scales. Examples of attributes that could be used to characterize shoreline subregions are shown in Table 6. Additional attributes may be added by the mapping team or through consultations with other subject matter experts and community and cultural stakeholders.

Table 6. Example attributes for shoreline subregions

Attribute	Description
Unique ID	00000000
Moku	Koʻolaupoko
Ahupuaʻa	Kailua
Region (Kahakai)	Kailua Bay
Subregion	Kailua Beach Park
Begin	Kalapawai
Begin_Latitude	21°23'56.67"N
Begin_Longitude	157°43'45.61"W
End	Alala Point
End_Latitude	21°23'46.29"N
End_Longitude	157°43'13.17"W
Length	0.7 miles
Orientation	NNE (30 deg)
Wave Exposure	Exposed
Dominant Sediment Transport Mode	Cross-shore
Dominant Sediment Transport Type	Seasonal; Tidal; Episodic
Natural Shoreline	90%
Modified Shoreline	10%
Nearshore Geography	Reef Flat
Nearshore Geomorphology	Pavement
Nearshore Biology	Turf Algae 90-100%

Attribute	Description
Nearshore Depth	Shallow
Nearshore Water Class	AA
Foreshore Type	Beach
Foreshore Substrate	Fine-grain Calcareous Sand
Foreshore ESI Class	3A
Foreshore Erodibility	High
Backshore Type	Dune
Backshore Geologic Unit	Beach and Dune Deposits
Backshore Soil Unit	Jaucus Sand 0-15% slopes
Backshore Erodibility	High
Backshore Zoning	Park
Backshore Land Use Intensity	Low
Historical Shoreline Change	Accretion (X feet/yr)
Projected Shoreline Change	Erosion (X feet/yr)
Sea Level Rise Exposure	Moderate
Flood Zones	N/A
Shoreline Modifications	Boat Ramp
Perpendicular Access	Yes
Lateral Access	Yes
Orthophotograph	<link>
Oblique Aerial Photographs	<link>
Ground Photographs	<link>
Documents	<link>
Comments	e.g., Erosion history, prior shoreline interventions, existing plans

3.8. Evaluate and Refine Through Community and Cultural Consultations

Systematically compartmentalizing Hawaii's coastline into regions and subregions requires an in-depth understanding of coastal processes and the complex cultural, physical, ecological, and community features that characterize segments of the coastline. Preliminary mapping of shoreline regions and subregions should be based on traditional cultural boundaries, subject matter expertise, and professional interpretation. The results should then be refined through engagement with stakeholders.

Traditional moku and ahupua'a boundaries, as well as community planning area boundaries, can be overlaid on a delineated shoreline region to identify cultural practitioners, lineal descendants, landowners, community groups, neighborhood boards, and other stakeholders to engage in regional shoreline management. Community values and policies identified in community development plans should be reviewed, updated as needed, and incorporated into adaptation strategies and shoreline management interventions for a shoreline region or subregion.

Native Hawaiian traditional ecological knowledge of the shoreline includes cultural management and other practices along the shoreline, archaeological sites, burial grounds, and traditional use areas. A

common traditional shoreline management feature is a Hawaiian fishpond (*loko iʻa*), which is a man-made structure along a shoreline that formed part of an integrated food production system within the ahupuaʻa. Many of these features are at risk due to coastal flooding and erosion enhanced by sea level rise.

Lineal descendants possessing traditional ecological knowledge can provide valuable guidance to help refine the shoreline regions and subregions and inform development of adaptation strategies and shoreline management interventions suited to a particular shoreline region. Regional shoreline management plans and interventions should be evaluated early and often as to the applicability and advantages of integrating traditional ecological knowledge concepts that will benefit shoreline management at the regional scale.

3.9. Develop and Maintain a Hawaiʻi Digital Coastal Atlas

Information will be acquired through the process of delineating and characterizing shoreline regions and subregions. A proposed Hawaiʻi Digital Coastal Atlas would serve as digital repository for this information and data, as well as a clearinghouse for guidance documents, studies, and other information that would be made accessible to all.

Establish Administrative Framework for Data Management

Shorelines, by their very nature as the active margin between land and sea, are in a constant state of change. In Hawaiʻi, where the coasts are exposed to high wave energy, periodic storms, rare but destructive tsunamis, and regional fluctuations in sea level combined with the early effects of sea level rise, the shorelines are constantly changing. Routinely updating existing data and periodically revising and improving data sets is critical for preserving the accuracy and usability of the shoreline region and subregion data for management purposes. The initial mapping effort will produce a complete dataset and data management system that is intended to be publicly available. Following the initial mapping effort, successful management of Hawaii's shorelines will require establishing a data management framework that ensures the dataset is maintained and updated periodically.

Key considerations for data administration include the following:

- Identify who will distribute data and determine the required budget
- Identify points of contact for issues with data
- Determine who will be responsible for maintaining data and determine the required budget
- Establish memorandums of understanding or memorandums of agreement with data providers as necessary
- Establish schedule for periodic updates and program budget requirements for each update cycle

Prioritize Data Development

Initial mapping of shoreline regions and subregions will be based primarily on existing data. Additional data will be required to a) refine shoreline regions and subregions, b) fill in data gaps, and c) map shoreline regions/subregions in complex areas.

Priorities for data development may include the following:

- Perform numerical modeling for waves, currents, and circulation patterns.

- Map littoral cells statewide—Littoral cells are delineated by studies that define a coastal compartment by a complete cycle of sedimentation including sources, transport paths, and sinks. A littoral cell may be bounded by two natural headlands, a natural headland and man-made structure, or two man-made structures. Littoral cells have already been delineated by the USACE for some shorelines on Kauaʻi, Oʻahu, and Maui and by other projects such as for Waikīkī Beach and the south shore of Molokaʻi. The littoral cell boundaries have been based on historical shoreline change and sediment transport. These littoral cells can be used as the basis for delineating a region. If a littoral cell has not been delineated, coastal erosion studies conducted by the University of Hawaiʻi can be used as a starting point, together with expert consultation. Mapping of littoral cells should be prioritized to serve as a foundational dataset to inform shoreline management decisions. A littoral cell may be difficult to delineate for some types of shorelines such as long, continuous shorelines with narrow sandy beaches or shorelines with high cliffs and small pocket beaches. These types of shorelines may require additional technical studies to better understand coastal processes to delineate areas for regional shoreline management.
- Conduct aerial video survey statewide.
- Expand aerial Pictometry contract statewide.
- Expand monitoring and documentation of existing coastal hazards, such as high wash of the waves, ephemeral erosion events, mass wasting along steep coastlines, and others as they occur.
- Expand erosion mapping to non-sandy shorelines. This may require a different methodology for shoreline mapping.
- Document existing river and stream mouth dynamics, sediment management strategies such as roadway clearing or stream mouth management that may impact the shoreline, and other activities that affect the position or condition of the coast.

Develop Data Delivery Methods

Once shoreline regions and subregions have been mapped and vetted through engagement with stakeholders, subject matter experts, cultural practitioners, and communities, the data will need to be made available for public use. A variety of data delivery options exist that can support a wide range of potential uses cases. Potential methods may include the following:

- **Level I, Web Viewer**—Simple; users can view and learn from data. Example: Cape Cod Coastal Planner
- **Level II, GIS Data Downloads**—Detailed; users can access raw data and perform more detailed analysis using other software programs (e.g., ArcGIS, QGIS). Example: Hawaiʻi Sea Level Rise Viewer
- **Level III, Integrated Reporting**—Sophisticated; users can generate customized data products without having to download data or use other software programs. Example: Hawaiʻi Flood Hazard Assessment Tool

- **Level IV, Analytical Tools**—Advanced; users can perform detailed analysis (e.g., profile generators, summary statistics).

Publish Data and Supporting Documentation

Once the preferred data delivery methods have been selected, a beta version should be developed. The beta version should include a complementary suite of supporting documentation including detailed metadata, a data dictionary, a summary of potential uses cases, discussion of uncertainties and limitations, and a draft user manual. Beta testing should be conducted with key stakeholders, subject matter experts, and other potential users. The beta version should be updated based on user feedback.

Once the beta testing process is complete, the datasets, tools, and supplemental guidance should be published. Prior to publication, a process should be established to monitor usage and obtain user feedback. These results can direct identification and/or development of new use cases, identification of data gaps and prioritization of data development needs. A schedule should be established to ensure that the datasets and associated tools and documentation are updated periodically (e.g., every 5 years). The update process is particularly important as the shoreline changes with sea level rise and extreme events.

Kaua‘i, Hawai‘i

4. Applying the Recommended Methodology to Selected Shorelines in Hawai‘i

The recommended methodology for regional shoreline delineation (Chapter 3) was applied to selected shorelines on the islands of Kaua‘i, O‘ahu, and Maui. The methodology demonstration areas are shown in Figure 15. Ahupua‘a in each moku were used as a starting point for delineating regions. The sections of this chapter describe all delineated shoreline regions. Although subregions were delineated for each region, the maps and detailed discussions in this chapter present only a subset of the delineated subregions as examples. As described in Chapter 3, initial mapping of shoreline regions and subregions, as performed for these examples, is based on diverse professional subject matter expertise and interpretation of existing data and should be refined through engagement with community and cultural stakeholders that have place-based knowledge of the coastline.

This Scoping Study documented other examples of regional shoreline management projects in Hawai‘i planned and implemented within the context of the working definition provided in Section 1.3 and within the existing regulatory framework. These examples, which include regional sediment management plans, beach and dune management plans, beach maintenance and restoration projects, dune restoration projects, and fishpond restoration projects, are summarized in Appendices 3 and 4.

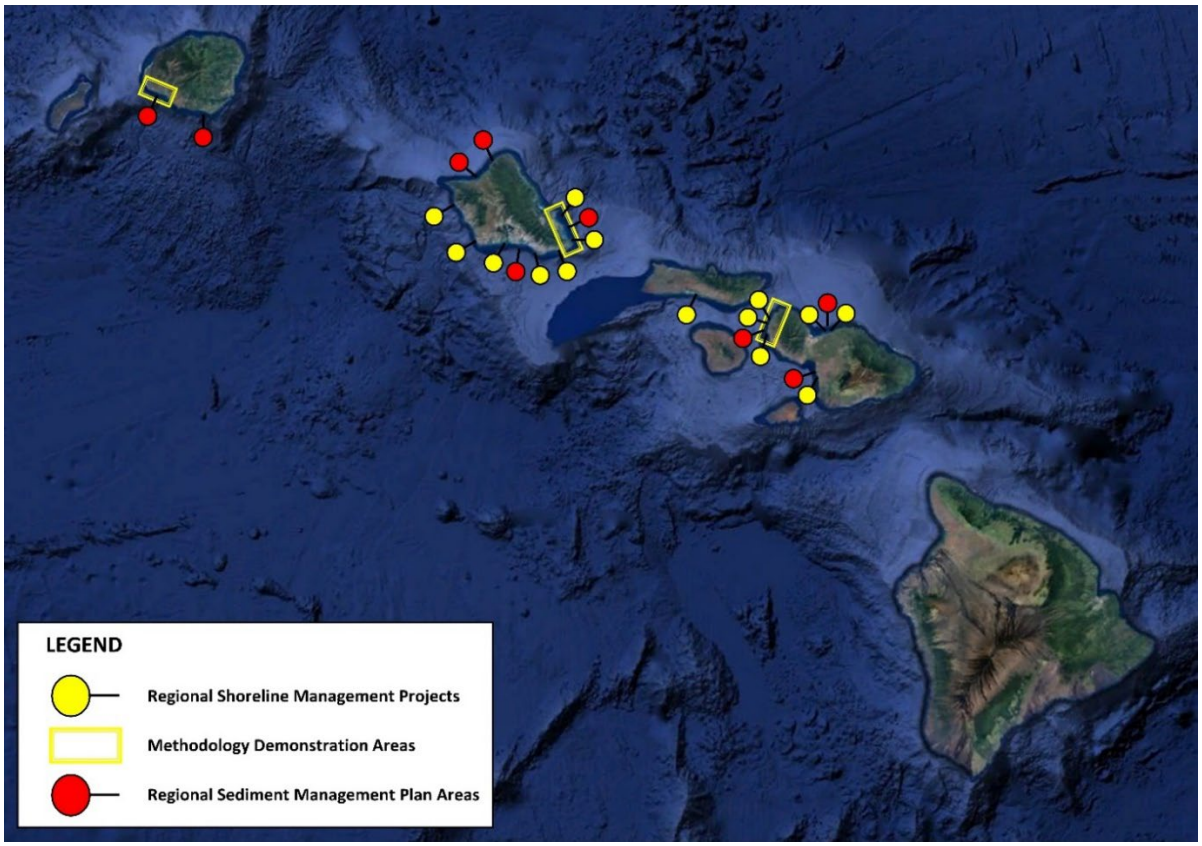


Figure 15. Locations of regional shoreline management plans and projects in Hawai‘i

4.1. Kona Moku, Kaua‘i

General Description

The coastline of Southwest Kaua‘i extends from Lā‘au‘ōkala Point west approximately 9.5 miles to Wai‘eli Drain at the south end of the U.S. Navy Barking Sands Pacific Missile Range Facility. The coastline is predominantly southwest-facing and is primarily exposed to North Pacific swell, South Pacific swell, and occasional Kona storms that approach from the south. All of the shoreline regions along the coastline of Southwest Kaua‘i are located within the Kona moku, the Waimea and Makaweli ahupua‘a, and the West Kaua‘i Community Plan area (see Figure 16).

The coastline is characterized by a series of linear beaches separated by headlands, drainages, and man-made structures. Along the eastern portion of the region, the beaches are composed of terrigenous material that is deposited at the Waimea River mouth and transported alongshore. Along the western portion of the region, the beaches are composed of calcareous sand.

The coastline of Southwest Kaua‘i is the southern portion of a convex promontory known as the Mānā Plain, which is situated between two large-scale features—Mākaha Ridge and Waimea Canyon—that form the western edge of the island of Kaua‘i. The region consists of larger headlands (e.g., Nihole Point, Mānā Point, Kokole Point, and Lā‘au‘ōkala Point); however, unlike many segments of Hawai‘i’s coastline, the size and configuration of these headlands allow for the exchange of sediment (e.g., sand) between

these littoral environments. As a result, the shoreline regions and subregions along the coastline of Southwest Kaua‘i are primarily delineated by changes in shoreline orientation, wave exposure, and currents, circulation, and sediment transport patterns that influence shoreline behavior.

The nearshore environment (seaward of the shoreline) is characterized by a deep fringing reef with variable and complex bathymetry. Shoreline behavior is influenced by variations in reef width, rugosity, and water depths. Wave patterns in this region are highly complex, which influences nearshore littoral processes (e.g., currents, circulation, and sediment transport).

The foreshore environment (along and including the shoreline) primarily consists of linear sandy beaches and coastal dunes situated between rocky headlands and drainages. Portions of the shoreline are armored with engineered shore protection structures (e.g., revetments). In some areas, shoreline behavior is influenced by hydrologic features (e.g., streams, drainages) that bisect the shoreline.

The backshore environment (landward of the shoreline) consists of both developed and undeveloped areas that support a wide range of uses such as residential communities, public beach parks, and military installations (e.g., U.S. Navy Barking Sands Pacific Missile Range Facility). Portions of Kaumuali‘i Highway, the primary vehicular transportation route servicing West Kaua‘i, are adjacent to the shoreline.

Methodology Overview for this Example

Applying the recommended methodology along the coastline of Southwest Kaua‘i results in five shoreline regions and six shoreline subregions. Figure 16 shows the delineated regions and the four subregions presented as examples in this section. Regions are primarily delineated by large-scale geomorphologic and hydrologic features (e.g., headlands, drainages, facilities), and subregions are delineated by subtle changes in shoreline orientation, wave exposure, and sediment transport patterns that affect shoreline behavior.

The primary datasets used to delineate the shoreline regions and subregions included:

- Moku and ahupua‘a boundaries (multiple sources)
- Satellite imagery (e.g., Digital Globe)
- Aerial orthophotographs (e.g., USGS orthophotographs)
- Oblique aerial photographs (e.g., Pictometry)
- High-resolution elevation and bathymetry (e.g., LiDAR)
- Geologic units[10]
- Soil units[11]
- Benthic habitat classifications[12]
- Hydrology (DLNR Division of Aquatic Resources)
- National Shoreline Management Study: Hawai‘i Regional Assessment[13]
- Hawai‘i Sea Level Rise Viewer[14]
- Historical and Projected Shoreline Change[15]

Additional information used to delineate the shoreline regions and subregions included:

- Kekaha Regional Sediment Management Study[16]
- West Kaua‘i Community Vulnerability Assessment[17]

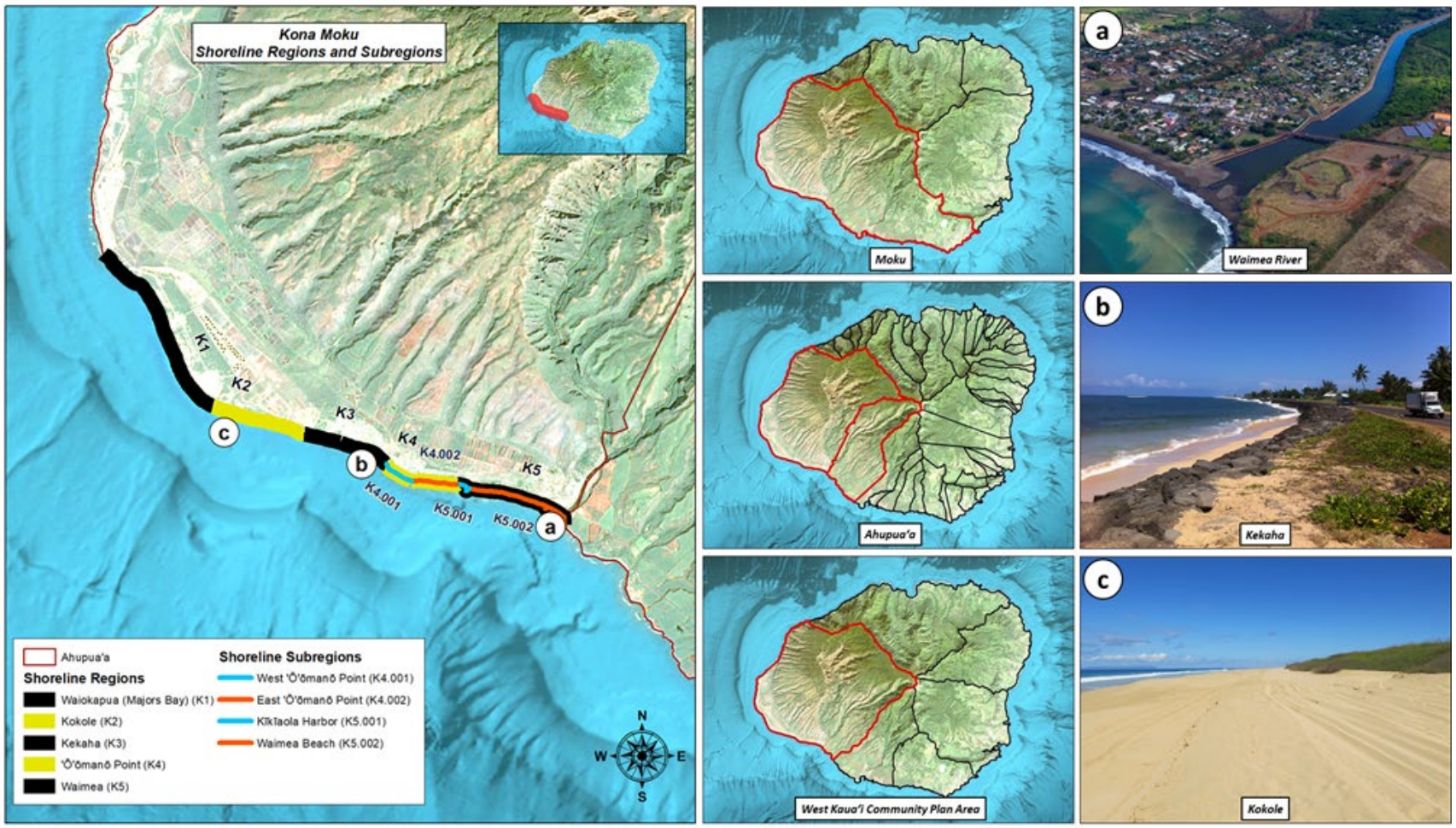


Figure 16. Kona moku example shoreline regions and subregions (Kaua‘i)

Delineated Shoreline Regions

The ***Waiokapua (Majors Bay, K1)*** shoreline region extends from Kokole Point approximately 3.6 miles northwest to Waiʻeli Drain. The shoreline is southwest-facing and consists of a gently embayed sandy beach and dune system. The backshore area is largely undeveloped and consists primarily of facilities associated with the U.S. Navy Barking Sands Pacific Missile Range Facility and the Kauaʻi Island Utility Cooperative. The Waiokapua region is exposed to northwest and westerly swells during the winter and spring, westerly and southwesterly swells during the summer, and persistent tradewinds throughout the year. Unlike most beaches in Hawaiʻi, the beach within the Waiokapua shoreline region has historically been accreting.

The ***Kokole (K2)*** shoreline region extends from Kekaha Beach Park approximately 1.7 miles west to Kokole Point, which is situated between two drainages that bisect the shoreline. Between these drainages, the orientation of the shoreline transitions from south-southwest-facing to southwest-facing. The foreshore is characterized by a sandy beach and dune system. The backshore area consists primarily of agricultural lands and the Mānā Drag Strip. The Kokole shoreline region is exposed to northwest and westerly swells during the winter and spring, westerly and southwesterly swells during the summer, and persistent tradewinds. Due to the combination of shoreline orientation and wave exposure, the shoreline has historically been relatively stable.

The ***Kekaha (K3)*** shoreline region extends from a man-made drainage (ditch) at West ʻŌʻōmanō Point approximately 1.5 miles west to Kekaha Beach Park and consists of two subregions: East Kekaha and Kekaha Beach Park. The eastern portion of the shoreline (East Kekaha) is south-southwest-facing and is characterized by an engineered shore protection structure (rock revetment) that protects Kaumualiʻi Highway and the adjacent residential development. The beach in this area is seasonally variable but is chronically eroding. The western portion of the shoreline (Kekaha Beach Park) is a sandy beach that is also chronically eroding, but to a lesser degree than the adjacent beach to the east. The boundary between the Kekaha and Kokole regions is marked by two drainages that bisect the shoreline. These drainages, like those found at ʻŌʻōmanō Point, are associated with the Waimea Ditch system.

The ***ʻŌʻōmanō Point (K4)*** shoreline region extends from Kīkīaola Harbor approximately 1.7 miles west to Kekaha and consists of two subregions: East ʻŌʻōmanō Point and West ʻŌʻōmanō Point. The eastern portion of the region (East ʻŌʻōmanō Point) is south-facing and characterized by a linear beach composed of terrigenous sediment that is chronically eroding. The backshore area between Kaumualiʻi Highway and the shoreline is lightly developed with residential single-family homes and undeveloped land. West ʻŌʻōmanō Point is situated between two man-made drainages (ditches) that bisect the shoreline. Between these drainages, the orientation of the shoreline transitions from south-facing to south-southwest-facing. The foreshore is characterized by an engineered shore protection structure (rock revetment) that spans approximately 0.75 miles of shoreline and continues west into the Kekaha shoreline region. The backshore area features densely developed residential single-family homes, undeveloped land, and critical infrastructure, including Kaumualiʻi Highway adjacent to the shoreline and a wastewater treatment facility.

The ***Waimea (K5)*** shoreline region extends from Lāʻauʻōkala Point approximately 1.9 miles west to Kīkīaola Harbor and consists of two subregions: Waimea Beach and Kīkīaola Harbor. The eastern portion of the region (Waimea Beach) is south-facing and characterized by a linear beach composed of terrigenous sediment deposited by the Waimea River. Due to the ongoing discharge of sediment at the

river mouth, the beach has historically been accreting. Sediment transport is predominantly east-to-west, resulting in more accretion at the west end of the beach. The rubblemound breakwater at Kīkīaola Harbor inhibits the transport of sediment further to the west. The backshore area between Kaumualiʻi Highway and the shoreline is lightly developed with residential single-family homes (to the east) and mostly undeveloped land (to the west).

Example Shoreline Subregions in the 'Ō'ōmanō Point and Waimea Shoreline Regions

The 'Ō'ōmanō Point shoreline region consists of two subregions: East 'Ō'ōmanō Point and West 'Ō'ōmanō Point (Figure 17).

*The **West 'Ō'ōmanō Point (K4.001)*** shoreline subregion spans approximately 0.9 miles and is bounded by man-made drainages (ditches) at the east and west ends. The shoreline is a southwest-facing linear beach composed primarily of terrigenous sediment that is chronically eroding. The entire length of the shoreline is armored by man-made shore protection structure (rock revetment) that protects Kaumualiʻi Highway. The backshore area (landward of Kaumualiʻi Highway) is densely developed with residential single-family homes. A public cemetery and Saint Theresa's Catholic Church are located adjacent to the shoreline at the west end of the subregion.

*The **East 'Ō'ōmanō Point (K4.002)*** shoreline subregion extends from Kīkīaola Harbor approximately 0.7 miles west to West 'Ō'ōmanō Point. The shoreline is a south-facing linear beach composed of terrigenous sediment that is chronically eroding. The backshore area between Kaumualiʻi Highway and the shoreline is lightly developed with residential single-family homes and undeveloped land.

Prior to the construction of Kīkīaola Small Boat Harbor, the shoreline was relatively linear with a long, wide beach extending from Waimea River to 'Ō'ōmanō Point. Construction of the harbor disrupted the natural sediment transport patterns. The beach updrift (east) of the harbor accreted at an average rate of 2.4 feet per year, while the beach downdrift (west) of the harbor eroded at an average rate of 2.1 feet per year[18]. The erosion would eventually threaten a cemetery located adjacent to the harbor and several residential single-family homes located further to the west. Property owners have implemented both permanent shore protection (e.g., rock revetments) and temporary erosion control measures (e.g., sandbag revetments) to mitigate the erosion. Historical and projected erosion and sea level rise inundation for this area are shown in Figure 18.

In 2014, the Hawaiʻi Department of Land and Natural Resources (DLNR) proposed a sand backpassing project to transfer approximately 80,000 cubic yards of sand from the accreted area east of the harbor to the eroded area west of the harbor. Approximately 20,000 cubic yards of sand was backpassed; however, the project was not completed due to concerns regarding impacts on water quality.

The Waimea shoreline region consists of two subregions: Waimea Beach and Kīkīaola Harbor (Figure 17).

The ***Kīkīaola Harbor (K5.001)*** shoreline subregion consists of Kīkīaola Small Boat Harbor, a light draft harbor that was constructed by the State of Hawaiʻi in 1959. The harbor spans approximately 1,200 feet of shoreline and is bounded by rock rubblemound breakwaters to the east and west. The interior of the harbor includes a loading dock, boat ramp, four light draft moorings (< 3 feet), and ancillary structures (e.g., vessel washdown, restrooms). The harbor provides vessel access for many of the charters and tour boats that provide access to the Nāpali Coast.

The ***Waimea Beach (K5.002)*** shoreline subregion is a south-facing linear beach composed of terrigenous sediment deposited by the Waimea River. Due to the ongoing discharge of sediment at the river mouth, the beach has historically been accreting. Sediment transport is predominantly east-to-west, resulting in more accretion at the west end of the beach. The rubblemound breakwater at Kīkīaola Harbor inhibits the transport of sediment further to the west. The backshore area between Kaumualiʻi Highway and the shoreline is lightly developed with residential single-family homes (to the east) and mostly undeveloped land (to the west).

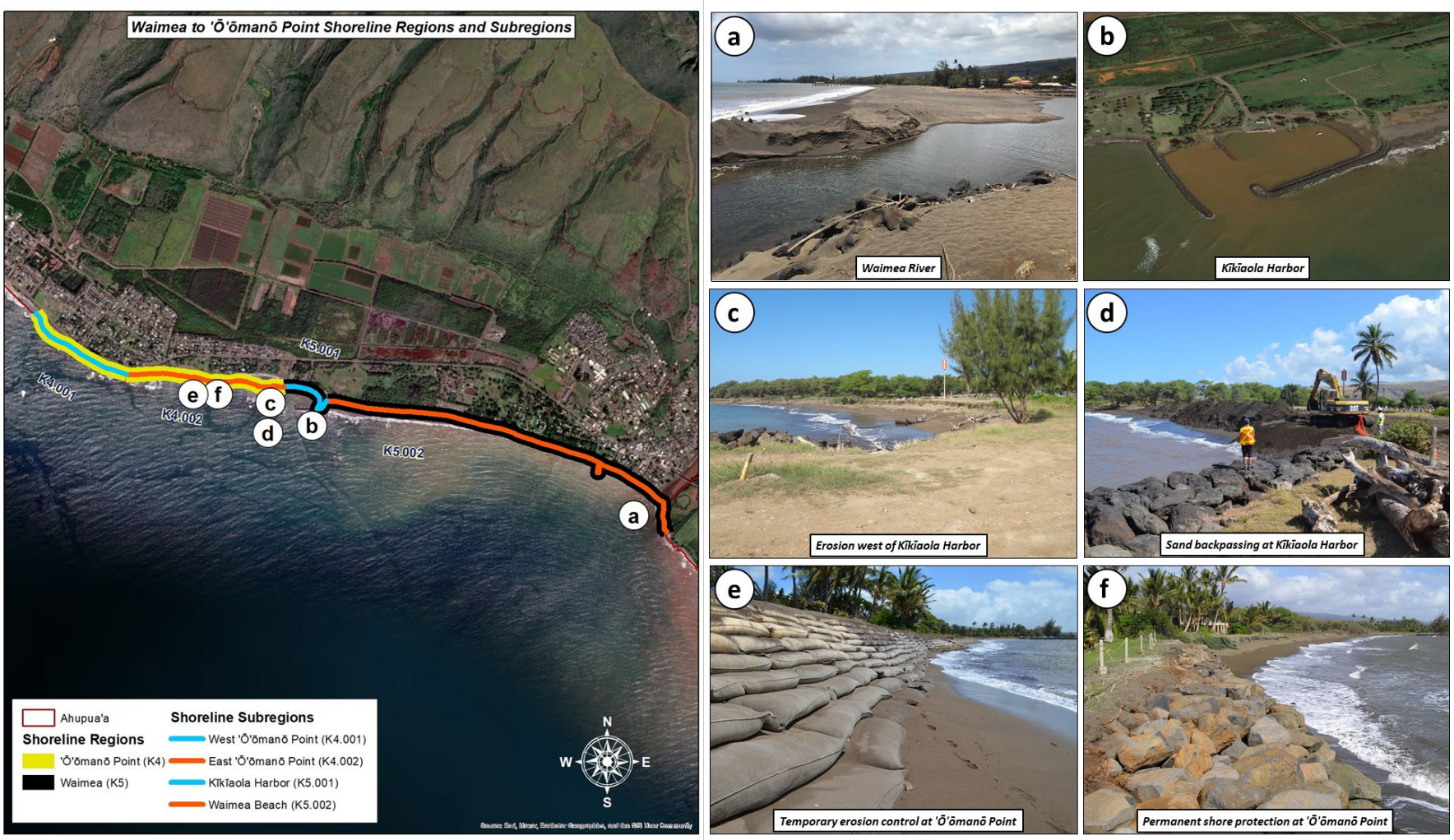


Figure 17. Waimea to 'Ō'ōmanō point example shoreline regions and subregions (Kauaʻi)

Figure 18. (A) Historical shoreline accretion (red) and erosion (blue) rates[15] and (B) future shoreline erosion line (red) and sea level rise exposure area (blue) with 3.2 feet of sea level rise from Waimea to 'Ō'ōmanō Point[14]

4.2. Koʻolaupoko Moku, Oʻahu

General Description

The coastline of southeast Oʻahu extends from Makapuʻu Point (the easternmost point of the island) northwest approximately 17 miles to Mōkapu Point. The coastline is predominantly northeast-facing and is primarily exposed to tradewind waves and North Pacific swell. All of the shoreline regions along the coastline are located within the Koʻolaupoko moku and the Koʻolaupoko Sustainable Communities Plan area (Figure 19).

The coastline is characterized by a series of headlands and embayments that range in size and elevation. The larger headlands (Makapuʻu Point, Mōkapu Point) create distinct physical boundaries that isolate this segment of the coastline from the adjacent segments to the north (Kāneʻohe Bay) and south (Ka Iwi). The size of these headlands prevents the exchange of sediment (e.g., sand) between these littoral environments. Between these large-scale features, the shoreline is further compartmentalized by smaller headlands (Kapoho Point, Alāla Point, Wailea Point) that affect waves, currents, circulation, and sediment transport patterns that influence shoreline behavior.

The nearshore environment (seaward of the shoreline) is characterized by a fringing reef with variable and complex bathymetry. The morphology of the fringing reef is characterized by a variety of features such as beach rock, karst fields, channels, spur-and-groove reef flats, and sand fields. Shoreline behavior is influenced by variations in reef substrate, width, rugosity, and water depths. Waves are depth-limited by the reef as they approach the shoreline, which influences nearshore littoral processes (e.g., wave patterns, wave energy, currents, and circulation) that affect sediment transport.

The foreshore environment (along and including the shoreline) primarily consists of embayed sandy beaches and coastal dunes situated between rocky headlands. In some areas, the shoreline is composed of hard substrate (e.g., basalt and limestone) that is less erodible. Portions of the shoreline have been armored with engineered shore protection structures (e.g., seawalls and revetments).

The backshore environment (landward of the shoreline) consists of both developed and undeveloped areas that support a wide range of uses such as residential communities, public beach parks, and military installations (e.g., Marine Corps Base Hawaiʻi, Bellows Air Force Base). In some areas, shoreline behavior is influenced by hydrologic features (e.g., streams, canals) that bisect the shoreline.

Methodology Overview for This Example

Applying the recommended methodology along the coastline of southeast Oʻahu results in four shoreline regions and 16 shoreline subregions. Figure 19 shows the delineated regions and the three subregions for the Kailua Bay region presented as examples in this section.

Regions are primarily delineated by large-scale geomorphologic features (e.g., large headlands, embayments), whereas subregions are delineated by smaller-scale features (e.g., small headlands, drainages, man-made structures) that create localized conditions that are unique within the larger region. In some cases, subregions are delineated by subtle changes in shoreline orientation, wave exposure, and reef structure.

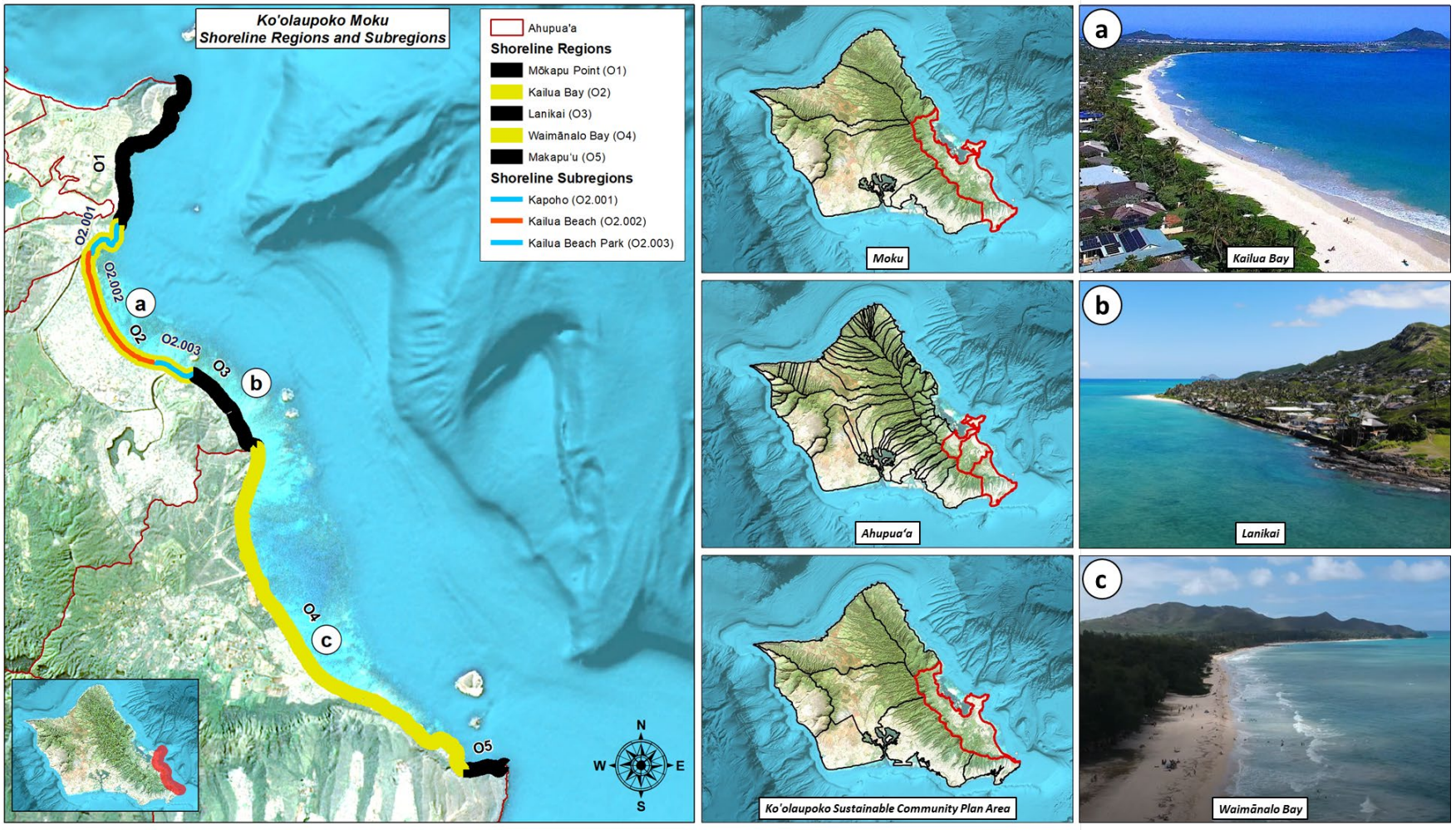


Figure 19. Koʻolaupoko Moku example shoreline regions and subregions (Oʻahu)

The primary datasets used to delineate the shoreline regions and subregions included the same sources listed for Kona Moku, Kauaʻi in Section 4.1. Additional information used to delineate the shoreline regions and subregions included:

- Mōkapu to Makapuʻu Regional Sediment Management Plan[20]
- Kailua Beach and Dune Management Plan[21]

Delineated Shoreline Regions

The ***Mōkapu Point (O1)*** shoreline region extends from Mōkapu Point approximately 3.3 miles south to Kapoho Point and consists of two subregions: East Mōkapu Point and Fort Hase. The northern portion of the region (East Mōkapu Point) is southeast-facing and characterized by an irregular rocky coastline with steep cliffs, marine terraces, and perched beaches. The southern portion of the region (Fort Hase) is east-facing and characterized by sandy beaches, coastal dunes, and intermittent beach rock outcrops. The backshore environment in the Mōkapu Point region is part of Marine Corps Base Hawaiʻi. The Mōkapu Point shoreline region intersects the ahupuaʻa of Heʻeia and Kāneʻohe.

The ***Kailua Bay (O2)*** shoreline region extends from Kapoho Point approximately 3.8 miles south to Alāla Point and consists of three subregions: Kapoho Point, Kailua Beach, and Kailua Beach Park. The north end of the region (Kapoho Point) is a marine terrace with narrow perched beaches. The central portion of the region (Kailua Beach) is an embayed sandy beach and dune system. The southern portion (Kailua Beach Park) is a sandy beach and dune system that is bisected by Ka'elepulu Stream and terminates at Alāla Point. The backshore environment in the Kailua Bay region is primarily residential with several public beach parks. The Kailua Bay shoreline region intersects the ahupuaʻa of Kāneʻohe and Kailua.

The ***Lanikai (O3)*** shoreline region extends from Alāla Point approximately 1.6 miles south to Wailea Point and consists of three subregions: North Lanikai, Central Lanikai, and South Lanikai. The north end of the region (North Lanikai) is an armored shoreline that is fronted by a linear beach rock outcrop that is emergent even during high tides. The central portion of the Lanikai region (Central Lanikai) is a sandy headland beach and dune system that spans approximately 0.5 miles. The southern portion of the Lanikai region (South Lanikai) is a predominantly armored shoreline with intermittent sandy beaches that terminates at Wailea Point. This portion of the shoreline is chronically eroding, and the narrow beach that remains is typically submerged during high tides. The backshore environment in the Lanikai region is primarily residential. The Lanikai shoreline region intersects the ahupuaʻa of Kailua.

The ***Waimānalo Bay (O4)*** shoreline region extends from Wailea Point approximately 7.3 miles south to Makapuʻu Point and consists of eight subregions: North Bellows, South Bellows, Waimānalo Beach, Kaiona, Kaupō, Kalapueo, Makapuʻu Beach Park, and North Makapuʻu Point. The majority of the Waimānalo Bay region consists of an embayed sandy beach and dune system fronted by a wide, shallow fringing reef. The northern portion of the region (North Bellows) is armored by a rock revetment that spans approximately 0.45 miles of shoreline. The southern portion of the region (Kaiona to Makapuʻu Point) is characterized by a variable coastline consisting of strand beaches, rocky shorelines, and man-made structures (seawalls, revetments, fishponds). The backshore environment in the Waimānalo Bay region consists of a combination of residential communities, public beach parks, and Bellows Air Force Base. The Waimānalo Bay shoreline region intersects the ahupuaʻa of Waimānalo.

Example Shoreline Subregions in the Kailua Bay Shoreline Region

The Kailua Bay region extends from Kapoho Point approximately 3.8 miles south to Alāla Point and consists of three subregions: Kapoho Point, Kailua Beach, and Kailua Beach Park (Figure 20).

The ***Kapoho Point (O2.001)*** shoreline subregion is located at the north end of Kailua Bay and consists of a marine terrace that is bisected by Kawainui Canal, which is the primary drainage for the north side of Kawainui Marsh. The nearshore environment consists of shallow reef flats and a dredged channel that provides vessel access to Kawainui Canal. The foreshore environment consists of a marine terrace with narrow perched beaches. Portions of the shoreline are armored with shore protection structures (e.g., seawalls and revetments). The backshore environment consists of the residential communities of Kaimalino (north of Kawainui Canal) and Kailuana (south of Kawainui Canal).

The Kapoho Point subregion is composed primarily of hard substrate (limestone) that is less susceptible to erosion. Portions of the shoreline are armored with shore protection structures (e.g., seawalls and revetments). The backshore environment is relatively low elevation and densely developed with residential single-family homes, so the primary hazard is coastal flooding. As sea levels continue to rise, engineered structures (e.g., flood walls) or accommodation strategies (e.g., freeboard) may be required to protect existing residential development from flooding.

The ***Kailua Beach (O2.002)*** subregion is located in the central portion of Kailua Bay and consists of an embayed sandy beach and dune system that is northeast-facing. The foreshore environment consists of a fringing reef with variable morphologic features including beach rock, karst fields, channels, spur-and-groove reef flats, and sand fields. The backshore environment is primarily residential.

The Kailua Beach subregion is composed primarily of soft substrate (sand) that is susceptible to erosion. Unlike most beaches in Hawai‘i, the beach and dune system has historically been accreting (moving seaward). However, as sea levels continue to rise, it is anticipated that this trend will transition to erosion, which could result in beach loss and potential damage to the coastal dunes. The backshore environment is relatively low elevation and densely developed with residential single-family homes, so coastal flooding is also a concern. Based on projections for erosion and sea level rise, future adaptations or interventions may be required to preserve the beach and coastal dunes.

The *Kailua Beach and Dune Management Plan*[22] provides recommendations to protect the beach, coastal dunes, and surrounding development through a combination of dune restoration, proactive construction standards, managed retreat, education and outreach, and establishing funding and support mechanisms for shoreline management and adaptation planning.

The ***Kailua Beach Park (O2.003)*** subregion is located at the southern end of Kailua Bay. It consists of a sandy beach and dune system that extends 0.6 miles north from Alāla Point and is bisected by Ka‘elepulu Stream, which is the primary drainage for the south side of Kawainui Marsh and Enchanted Lake. The foreshore environment consists of a shallow fringing reef, a paleostream channel with intermittent sand fields, and an islet (Flat Island) located approximately 1,500 feet offshore. The backshore environment consists of a 35-acre public beach park that is managed by the City and County of Honolulu (City). A public boat ramp is located at the south end of the park near Alāla Point.

Figure 20. Kailua Bay example shoreline region and subregions (O‘ahu)

The Kailua Beach Park subregion is composed primarily of soft substrate (sand) that is susceptible to erosion. The backshore environment is relatively low elevation. Its limited development consists of park support structures (e.g., parking lots, changing stations), so coastal flooding is less of a concern in this area. Kawailoa Road, which provides the only vehicular access to the community of Lanikai, is located approximately 500 feet landward of the shoreline. The area landward of Kawailoa Road is densely developed with residential single-family homes.

The primary concern at Kailua Beach Park is seasonal erosion that causes beach narrowing and damage to the coastal dunes. The City previously installed a sandgrabber, which consisted of a concrete block wall that was intended to inhibit cross-shore sediment transport and improve beach stability. The structure eventually failed and was removed. Routine maintenance dredging at Ka‘elepulu Stream is conducted to prevent upstream flooding and improve water circulation. In recent years, the City has conducted sand backpassing, which has consisted of transporting dredged sand from Ka‘elepulu Stream and placing it along the eroded shoreline adjacent to the Kailua boat ramp. This type of beach maintenance can be performed periodically to restore beach width, protect the coastal dunes, and improve lateral shoreline access.

Based on projections for erosion and sea level rise (Figure 21), future adaptations or interventions may be required to preserve the beach and coastal dunes at Kailua Beach Park. Potential options include periodic sand backpassing, beach nourishment, and dune restoration. Most of the park support structures are located landward of the coastal dune, so structural adaptations may not be necessary, at least in the short-term.

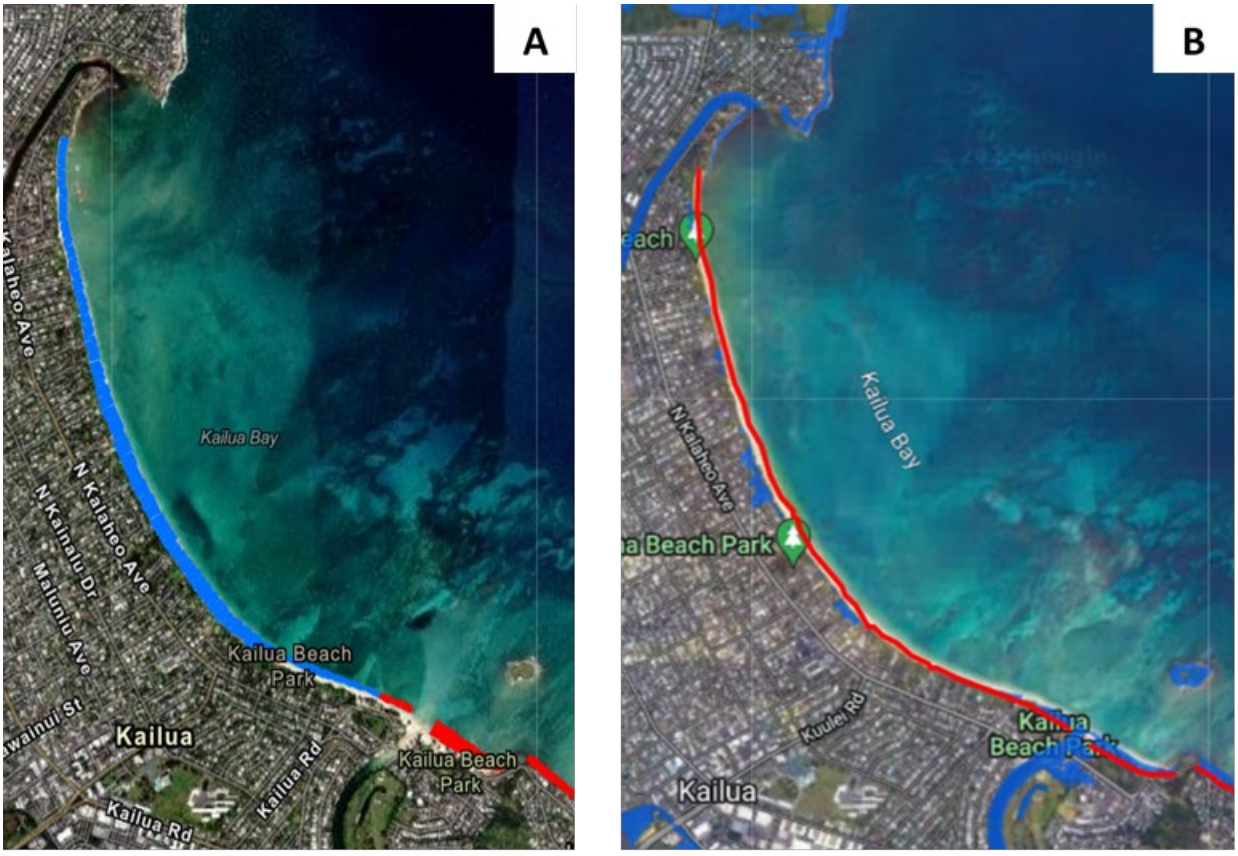


Figure 21. (A) Historical shoreline accretion (red) and erosion (blue) rates[15] and (B) future shoreline erosion line (red) and sea level rise exposure area (blue) with 3.2 feet of sea level rise along the Kailua shoreline region[14]

4.3. Lāhainā and Kāʻanapali Moku, Maui

General Description

The coastline of West Maui extends approximately 10 miles from Puʻunoa Point north to Honolua Bay. The coastline is predominantly WNW-facing and is primarily exposed to North Pacific swell, South Pacific swell, and occasional Kona storms that approach from the south. All of the shoreline regions in West Maui are located within the Lāhainā and Kāʻanapali Moku, and the West Maui Community Plan area (see Figure 22).

The coastline is characterized by a series of headlands and embayments that range in size and elevation. The larger headlands (Puʻunoa Point, Līpoa Point) create distinct physical boundaries that isolate this segment of the coastline from the adjacent segments to the north and south, where the shoreline orientation and wave exposure are substantially different.

Between these large-scale features, the shoreline is further compartmentalized by a series of smaller headlands (e.g., Hanakaʻōʻō Point, Puʻu Kekaʻa, Honokōwai Point, Māhinahina Point, Kaʻea Point, Hāwea Point), many of which align with large-scale hydrologic features (e.g., Honokōwai Stream, Kahana Stream, Nāpili Stream, and Honolua Stream). Between these smaller headlands are a series of embayments (e.g., Kahana Bay, Nāpili Bay, Kapalua Bay, Mokulēʻia Bay, Honolua Bay) that are subject to unique littoral processes (e.g., waves, currents, circulation, and sediment transport patterns) that influence shoreline behavior. Some embayments are completely isolated, whereas others experience some degree of sediment exchange with the adjacent littoral cells.

The nearshore environment (seaward of the shoreline) is highly variable and is characterized by a combination of fringing reefs, channels, beach rock outcrops, and sand fields. Shoreline behavior is influenced by wave exposure, sediment availability, variations in reef substrate, width, rugosity, and water depths, and the presence of man-made structures.

The foreshore environment (along and including the shoreline) is also highly variable and consists of a wide range of shoreline types, including linear sandy beaches, embayed sandy beaches, coastal dunes, rocky shorelines, and basaltic headlands. West Maui is home to several world class sandy beaches including Kāʻanapali Beach, Kahekili Beach, Kapalua Beach, and DT Fleming Beach, some of which are backed by coastal dunes. Kāʻanapali Beach is a world class resort destination and one of the primary economic drivers of the County of Maui. Portions of the West Maui coastline have been armored by shore protection structures (e.g., seawalls and revetments). In some areas, other coastal structures, including breakwaters, groins, and drainage walls, have localized effects on shoreline behavior.

The backshore environment (landward of the shoreline) between Honoapiʻilani Highway and the coastline is intensely developed with large resorts, condominiums, commercial businesses, and residential communities.

Beaches on the island of Maui have the highest rates of erosion in the State of Hawaiʻi with 85 percent of beaches experiencing long-term erosion[23]. Beaches in West Maui exhibit high seasonal variability due to having wave exposure from two directions (north and south). Sand supplies along the West Maui coastline are also limited. West Maui has a history of severe episodic erosion events that have caused beach narrowing, beach loss, environmental damage, and infrastructure damage. The impacts of erosion have been widespread and are being exacerbated by rising sea levels.

Various approaches have been taken to address erosion and beach loss in West Maui. In some areas, the shoreline has been permanently armored with shore protection structures, such as seawalls (e.g., Kahana Beach Resort, Kahana) and revetments (e.g., Mahana Condominiums, Honokōwai Point). In other areas, the shoreline has been temporarily stabilized with various erosion control measures, such as sandbag revetments (e.g., Valley Isle Resort, Kahana), erosion protection skirts (e.g., Kāʻanapali Beach Club, Honokōwai), and sand-filled mattresses (e.g, Kāʻanapali Beach Hotel, Kāʻanapali). To date, there have been no beach nourishment projects completed in West Maui.

Methodology Overview for This Example

Applying the recommended methodology along the coastline of West Maui results in seven shoreline regions and 25 shoreline subregions. Figure 22 shows the delineated regions and the two subregions presented as examples in this section. Regions are primarily delineated by large-scale geomorphologic and hydrologic features (e.g., large headlands, embayments, drainages), whereas subregions are delineated by smaller-scale features (e.g., smaller headlands, drainages, man-made structures) that create localized conditions that are unique within the larger region. In some cases, subregions are delineated by subtle changes in shoreline orientation, wave exposure, and reef structure.

The primary datasets used to delineate the shoreline regions and subregions included the same sources listed for Kona Moku, Kauaʻi in Section 4.1. Additional information used to delineate the shoreline regions and subregions included:

- Beach Management Plan for Maui[24]
- Regional Sediment Budget for the West Maui Region[25]
- Kahana Bay Erosion Mitigation Project Draft Environmental Impact Statement[26]
- Kāʻanapali Beach Restoration and Berm Enhancement Final Environmental Impact Statement[27]

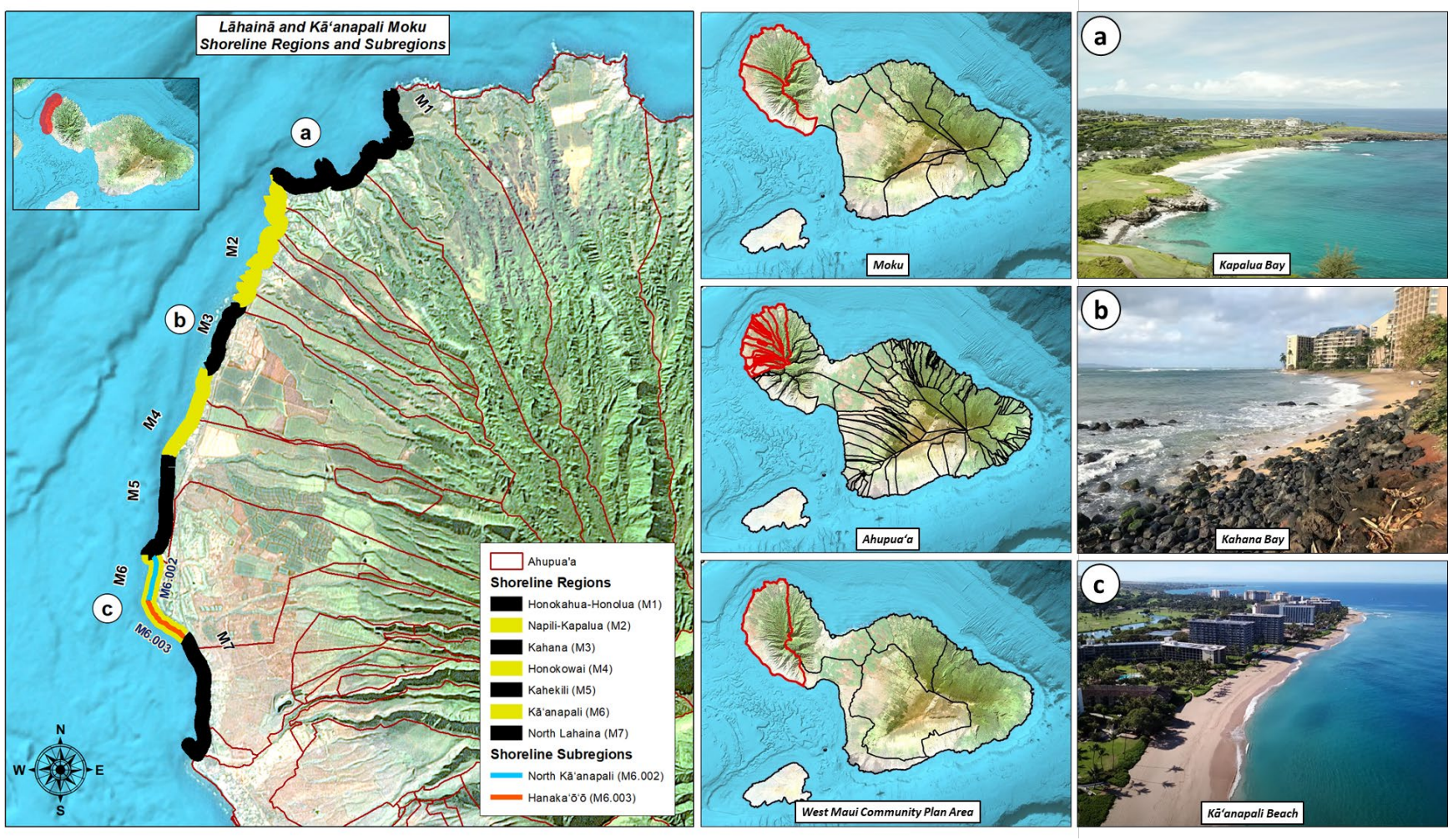


Figure 22. Lāhainā and Kā'anapali example shoreline regions and subregions (Maui)

Delineated Shoreline Regions

The ***Honokahua-Honolua (M1)*** shoreline region extends from Hāwea Point approximately 3.4 miles north to Līpoa Point and consists of 11 subregions: East Hāwea Point, Oneloa Beach, West Makalaupuna Point, East Makalaupuna Point, DT Fleming Beach, Kahauiki, Kahauiki Point, West Mokulēʻia Point, East Mokulēʻia Point, Honolua Beach, and Kulaokaea. The region is compartmentalized into four primary embayments: Oneloa Bay, Honokahua Bay, Mokulēʻia Bay, and Honolua Bay. The region is northwest-facing and exposed to large northerly swells during the winter. The nearshore environment is primarily composed of rocky substrate with intermittent sand fields. The backshore environment is intensely developed with resorts and condominiums. The Honokahua shoreline region intersects the ahupuaʻa of Honokahua and Honolu.

The ***Nāpili-Kapalua (M2)*** shoreline region extends from Kaʻea Point approximately 2.5 miles north to Hāwea Point and consists of eight subregions: Kaʻōpala, Keonenui Bay, ʻAlaeloa, Honokeana Bay, Nāpili Bay, Kapalua Bay, Nāmalu Bay, and West Hāwea Point. The Nāpili-Kapalua coastline is west-northwest-facing and consists of a series of small headlands and embayments, many of which align with hydrologic features (e.g., stream drainages) that intersect the coastline. The foreshore environment is primarily rocky with sandy pocket beaches located in the larger embayments. The sandy pocket beaches located in the Nāpili-Kapalua shoreline region are all experiencing moderate to high erosion. Property owners have implemented both permanent shore protection (e.g., seawalls and revetments) and temporary erosion control measures (e.g., sandbag revetments) to mitigate the erosion. In 2017, the Nāpili Bay and Beach Foundation initiated planning for a beach restoration project at Nāpili Bay. The project is still in the early stages of development. The nearshore environment consists of a discontinuous fringing reef with intermittent channels and offshore sand fields. The backshore environment is densely developed with resorts, condominiums, commercial businesses, and residential single-family homes. The Nāpili-Kapalua shoreline region intersects the ahupuaʻa of Mailepai, ʻAlaeloa, Honokeana, Nāpili 4-5, Nāpili 2-3, and Honokahua.

The ***Kahana (M3)*** shoreline region extends from Māhinahina Point approximately 1.5 miles north to Kaʻea Point. The region is west-northwest-facing and characterized by narrow sandy beaches with an irregular fringing reef with offshore sand deposits. The backshore environment is intensely developed with large condominiums. The Kahana shoreline region intersects the ahupuaʻa of Kahana and Mailepai.

Erosion in the Kahana region has been extensive and well-documented. Property owners have implemented both permanent shore protection (e.g., seawalls and revetments) and temporary erosion control measures (e.g., sandbag revetments) to mitigate the erosion. The Kahana Bay Steering Committee has proposed a plan to restore the beach in Kahana Bay through a combination of beach nourishment and beach stabilizing structures. Approximately 50,000 to 100,000 cubic yards of sand would be recovered from offshore deposits and placed along the shoreline to restore the beach. Seven rock T-head groins and one reinforced rock headland structure would be constructed to stabilize the beach. The Kahana Bay Erosion Mitigation project is currently undergoing environmental review.

The ***Honokōwai (M4)*** shoreline region extends from Honokōwai Point approximately 1.4 miles north to Māhinahina Point and consists of two subregions: North Honokōwai Point and Honokōwai. The southern portion of the region (North Honokōwai Point) is an alluvial headland where the shoreline is armored by shore protection structures (e.g., seawalls and revetments). An isolated sandy beach extends approximately 1,000 feet along the shoreline from Honokōwai Point to Honokōwai Stream. The

northern portion of the region (Honokōwai) is a predominantly armored shoreline with intermittent sandy beaches that are seasonally variable. The nearshore consists of a fringing reef that varies in width and depth. A prominent beach rock outcrop extends approximately 0.95 miles along the interior of the fringing reef. The backshore environment is intensely developed with hotels, resorts, and condominiums. The Honokōwai shoreline region intersects the ahupuaʻa of Honokōwai, Māhinahina, and Kahana.

The ***Kahekili (M5)*** shoreline region extends from Puʻu Kekaʻa approximately 1.4 miles north to Honokōwai Point and consists of two subregions: Kahekili and South Honokōwai Point. The southern portion of the region (Kahekili) is west-facing and characterized by a linear sandy beach and coastal dune system. The northern portion of the region (South Honokōwai Point) is an alluvial headland where the shoreline is armored by shore protection structures (i.e., seawalls and revetments). The backshore environment is intensely developed with resort infrastructure (e.g., hotels and resorts). The Kahekili shoreline region intersects the ahupuaʻa of Honokōwai.

The primary issues at Kahekili are erosion, beach narrowing, and degradation of the coastal dune system. Sediment transport in the Kahekili region is seasonally variable, with southerly swells transporting sand from south to north during the summer, and northerly swells transporting sand from north to south during the winter. During periods when the beach is narrow, the coastal dune is exposed to erosion and wave overtopping.

The properties along this portion of the shoreline were not developed until the early 2000s. When new development was proposed, the availability of open space enabled implementation of more progressive shoreline setbacks and a dune restoration and monitoring program. The program consisted of replacing existing vegetation with native species, installing a continuous lateral walkway along the landward side of the dune, installing a series of dune walkovers to mitigate negative impacts of foot traffic on the dunes, and implementing long-term dune monitoring. The project was and continues to be privately funded by the adjacent landowners.

The ***Kāʻanapali (M6)*** shoreline region extends from Hanakaʻōʻō Beach Park approximately 1.5 miles north to Puʻu Kekaʻa and consists of two subregions: Hanakaʻōʻō and North Kāʻanapali. The southern portion of the region (Hanakaʻōʻō) is southwest-facing and characterized by a linear sandy beach. The Hanakaʻōʻō subregion ends at Hanakaʻōʻō Point, which is both a long-time prominent morphologic feature and exceptionally variable on a seasonal timescale. Hanakaʻōʻō Point accretes (widens) into an expansive sandy beach during the winter and erodes (narrows) during the summer. The northern portion of the region (North Kāʻanapali) is west-facing and characterized by a linear sandy beach that extends from Hanakaʻōʻō Point to Puʻu Kekaʻa. The Kāʻanapali shoreline region intersects the ahupuaʻa of Hanakaʻōʻō.

The ***North Lāhainā (M7)*** shoreline region extends from Pu'unoa Point approximately 2.0 miles north to Hanakaʻōʻō Beach Park. The region is west-facing and characterized by a rocky shoreline with a narrow and irregular fringing reef. The southern portion of the region includes Mala Wharf, which consists of multiple man-made structures (pier, breakwater, groin, boat ramp) located at the mouth of Kahoma Stream and extends north to Wahikuli Park. The backshore area is intensely developed with commercial and residential properties. The northern portion of the region consists of a rocky shoreline that extends from Wahikuli Park to Hanakaʻōʻō Beach Park. In some areas, critical transportation infrastructure (e.g., Honoapi'ilani Highway, Front Street) is located within a few feet of the shoreline. The North Lāhainā shoreline region intersects the ahupuaʻa of Moaliʻi, Wahikuli, and Hanakaʻōʻō.

Example Shoreline Subregions in the Kāʻanapali Shoreline Region

The Kāʻanapali shoreline region extends from Hanakaʻōʻō Beach Park approximately 1.5 miles north to Puʻu Kekaʻa and consists of two subregions: Hanakaʻōʻō and North Kāʻanapali (Figure 23).

The ***North Kāʻanapali (M6.001)*** shoreline subregion is a west-facing linear sandy beach that extends from Hanakaʻōʻō Point to Puʻu Kekaʻa. The backshore environment is intensely developed with resort infrastructure (e.g., hotels, commercial operators, restaurants, pools, and the Kāʻanapali Beachwalk). Wave-induced currents predominate inside the breaker zone, generating both longshore (shore parallel) and onshore/offshore (rip) currents. These nearshore, wave-induced currents drive seasonal sediment transport in the North Kāʻanapali subregion. Summer swells that reach the North Kāʻanapali shoreline break at an oblique angle, creating a longshore current to the north. Winter swells from the north reverse this current.

The State of Hawaiʻi and the Kāʻanapali Operations Association have proposed a plan to restore Kāʻanapali Beach through a combination of beach nourishment and berm enhancement. Beach nourishment is proposed for the Hanakaʻōʻō shoreline region (between Hanakaʻōʻō Beach Park and Hanakaʻōʻō Point), and berm enhancement is proposed for the North Kāʻanapali shoreline region (between Hanakaʻōʻō Point and Puʻu Kekaʻa). The Kāʻanapali Beach Restoration and Berm Enhancement project is currently in the final stages of environmental review.

The ***Hanakaʻōʻō (M7.002)*** shoreline subregion is a southwest-facing linear sandy beach that extends from Hanakaʻōʻō Beach Park to Hanakaʻōʻō Point, which is a long-time prominent morphologic feature that is exceptionally variable on a seasonal timescale. Hanakaʻōʻō Point accretes (widens) into an expansive sandy beach during the winter and erodes (narrows) during the summer. Unlike many of the rocky headlands in West Maui, Hanakaʻōʻō Point is a sandy headland that is dynamic and ephemeral. The seasonal variability of Hanakaʻōʻō Point allows for the exchange of sediment (i.e., sand) between the two adjacent littoral cells.

Severe erosion events in the North Kāʻanapali region typically occur when Hanakaʻōʻō Point is eroded and the beach is narrow. The surrounding bathymetry causes waves to wrap around and form the sand point at Hanakaʻōʻō Point. When the beach is wide, the sandy point dissipates the energy of waves approaching from the south. When the beach is narrow, southerly waves propagate at a high angle along the shoreline, causing rapid sand migration and erosion. During large southerly swells, waves sweep along the shoreline at an oblique angle. These waves often combine with wrapping waves that approach from a more orthogonal direction to form large peaking waves, resulting in very high wave energy along the shoreline. The combination of decreased beach width and increased wave energy at the shoreline typically results in the most dramatic erosion events. Historical and future erosion and sea level rise inundation for this area are shown in Figure 24.

Figure 23. Kā'anapali example shoreline region and subregions (Maui)

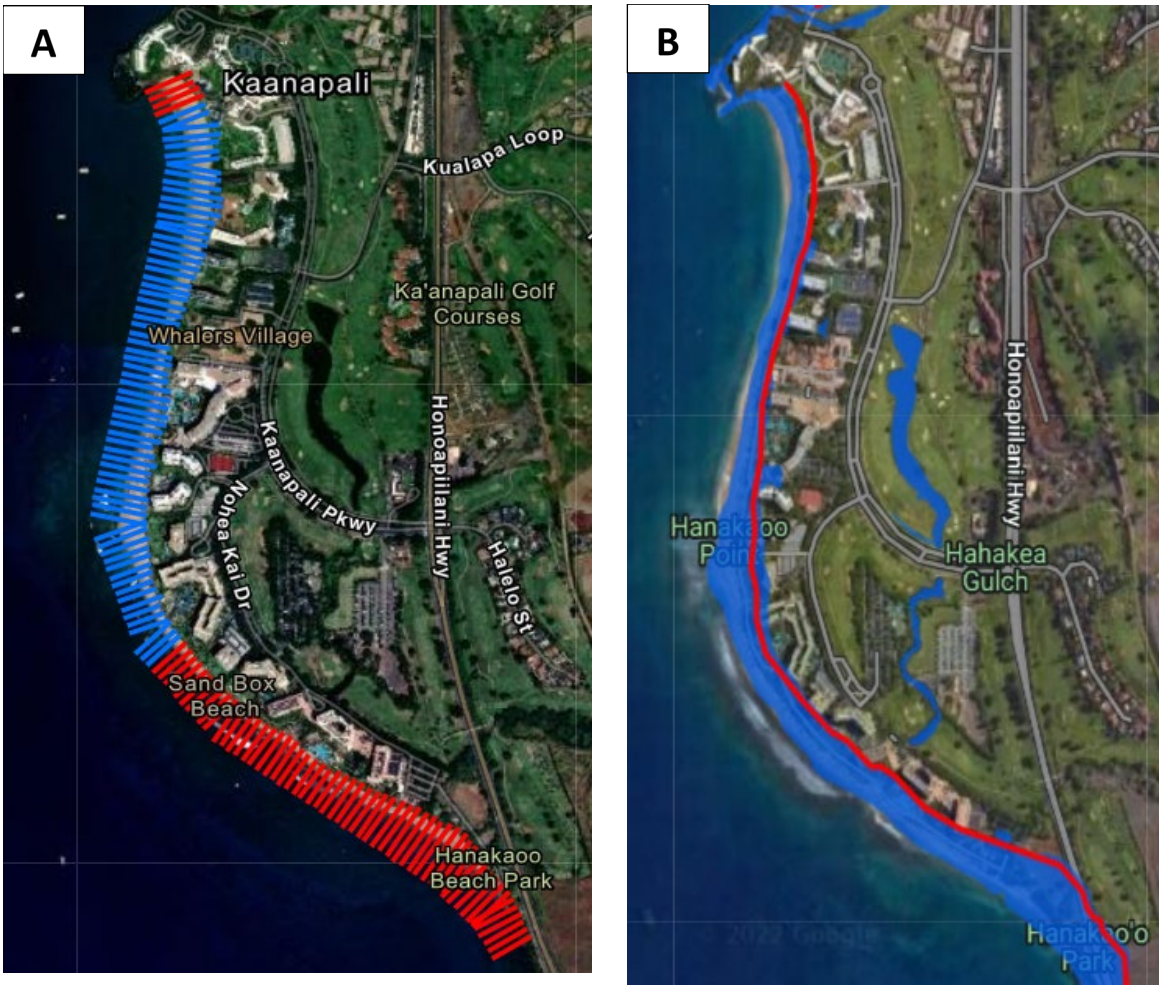


Figure 24. (A) Historical shoreline accretion (red) and erosion (blue) rates[15] and (B) future shoreline erosion line (red) and sea level rise exposure area (blue) with 3.2 feet of sea level rise along the Kā‘anapali shoreline region[14]


The Island of Hawai‘i

5. Proposed 5-Year Roadmap Toward a Regional Shoreline Management Approach in Hawai‘i

A proposed 5-year roadmap toward implementing a regional shoreline management approach is outlined in Figure 25. The roadmap is envisioned as a progression of outputs achieved and lessons learned over a five-year period toward realizing multiple outcomes listed in the Theory of Change (see Section 1.2). Under the ongoing actions of the ORMP, a multi-sector, multi-agency regional Shoreline Management Action Team (Action Team) will be established to guide and provide oversight of the various roadmap steps.

A critical first step in the roadmap will be the delineation of shoreline regions and subregions for each island. The recommended methodology presented in Chapter 3 is ready for testing and refinement. As this is being accomplished, the Action Team will identify and prioritize accelerator projects for priority areas, assessments, or studies.

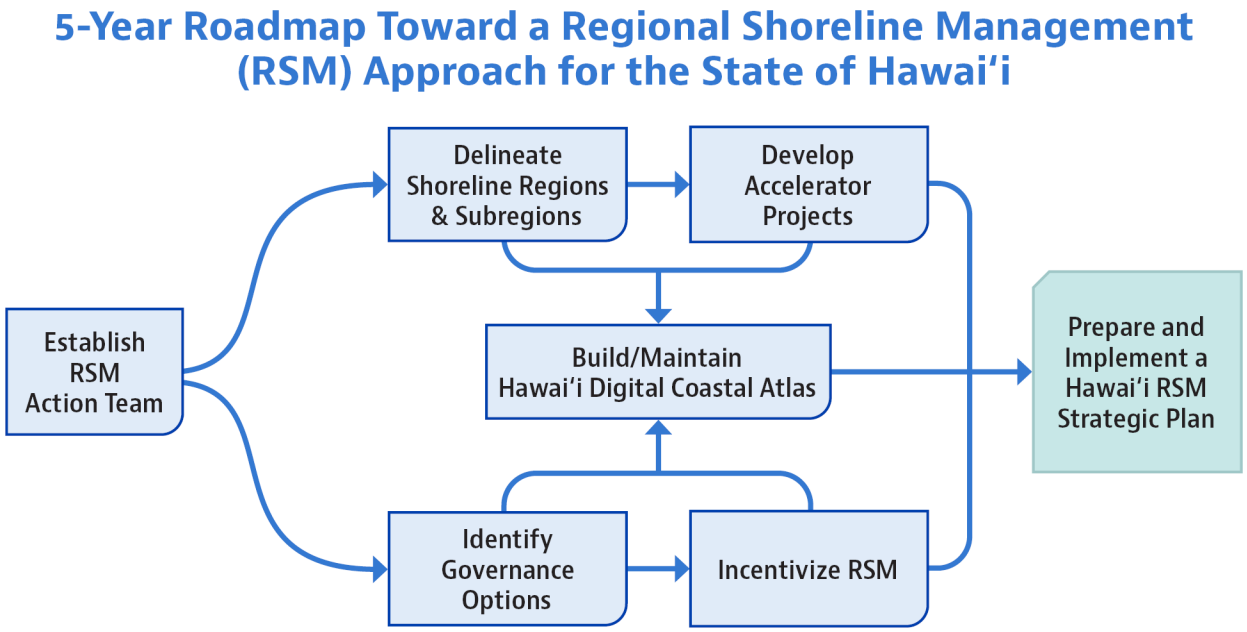


Figure 25. Proposed 5-year roadmap toward a regional shoreline management approach for the State of Hawai‘i

An in-depth assessment of governance options for regional shoreline management will be needed to identify potential revisions to the existing governance framework that can better facilitate regional shoreline management. This assessment will identify and evaluate the need for a new governance framework. A special focus will be placed on developing incentives for regional shoreline management to accelerate planning and project implementation.

The outputs of these steps will feed into development of a Hawai‘i Coastal Digital Atlas, a web-based geospatial platform that will serve as a clearinghouse for information and data, tools, and guidance. The atlas will be built over time, incorporating lessons learned throughout the process.

All of the outputs are expected to culminate in development of a Hawai‘i State Regional Shoreline Management Plan to serve as a guiding document for the subsequent 5 to 10 years.

The roadmap steps will draw upon the inputs of stakeholders and experiences of the Scoping Study project team, as captured in the report and appendices. While the sequencing of actions is important, especially for steps that collect data and pilot approaches, the roadmap is envisioned as iterative and flexible so that the results of any one step can be learned from and used in subsequent actions.

5.1. Establish a Regional Shoreline Management Action Team

The proposed Regional Shoreline Management Action Team (RSM Action Team) is envisioned as a multi-sector, multi-agency body established to guide, oversee, and advance the roadmap. The RSM Action Team would be established under the existing purview of the coordinating role of the OPSD-CZM to make determinations about revisions to the shoreline delineation methodology and appropriate governance mechanisms that will be needed to improve shoreline management from a regional perspective. The RSM Action Team will need the support of a program integrator responsible for compiling outputs and lessons learned and developing agendas, decision documents, policy briefs, and reports related to implementation of the roadmap.

The RSM Action Team may be established under the existing provisions of the ORMP. The current ORMP Policy Group and Working Group—authorized by Hawai‘i Revised Statutes §205A-62(1) under the Hawai‘i Coastal Zone Management Program—seek to resolve coastal problems and issues that are not adequately addressed through existing laws and rules. HRS §205A-3 (11) empowers OPSD to coordinate the implementation of the ORMP. The 2020 ORMP encourages an ahupua‘a approach that compartmentalizes each island’s resource management from mauka to makai (from the mountains to the sea). This traditional Hawaiian approach may offer a framework within which regional shoreline management plans for individual regions or subregions of shoreline could be developed.

There are numerous agencies involved in permitting, management, and oversight of the shoreline in Hawai‘i. The Action Team would be a representative sampling of this group, which includes but is not necessarily limited to:

- Federal
  - USACE (Clean Water Act; Rivers and Harbors Act)
  - NOAA (National Coastal Zone Management Program, National Estuarine Research Reserve System, etc.)
  - FEMA (emergency preparedness and response, hazard mitigation, floodplain management)

  - U.S. Fish and Wildlife Service (Endangered Species Act)

- State of Hawai‘i
  - Department of Health (Clean Water Act, Sections 11-54, 11-55, 11-56, HAR)
  - Department of Transportation (Highways, Harbors, and Airports Divisions)
  - OPSD-CZM Program (HRS §205A)
  - MACZAC (HRS §205A-3.5)
  - DLNR
    - OCCL (Section 13-5, HAR, HRS §115-5)
    - Land Division (Sections 221 and 171, HAR)
    - Division of State Parks
    - Division of Boating and Ocean Recreation
    - State Historic Preservation Division
    - Hawai‘i State Aha Moku Advisory Committee (Act 288 SLH 2012)
    - Division of Aquatic Resources (reefs, coastal wetlands)
    - Engineering Division (flood zones)
    - Department of Accounting and General Services (Section 13-222, HAR; Shoreline Survey)
  - Hawai‘i Emergency Management Agency (HIEMA) (coordinate with emergency management agencies on each island as well as with FEMA)
  - Department of Hawaiian Home Lands
  - Hawai‘i Department of Education
  - University of Hawai‘i School of Ocean, Earth Sciences, and Technology (Sea Grant)

- County
  - County planning departments (SMA and shoreline rules)
  - County parks departments (county beach parks)
  - County public works departments (highway, engineering, building and grading divisions)

- Other
  - Landowners (e.g., fee owners, lessees)
  - Private consultants (e.g., planners, engineers, architects, cultural consultants)
  - Watershed partnerships
  - Island-based resource specialists (e.g., Ala Kahakai National Historic Trail on Hawai‘i Island, Hawaiian civic clubs)
  - Tourism associations (e.g. Hawaii Lodging and Tourism Association, Native Hawaiian Hospitality Association)
  - Citizen groups (e.g., Surfrider Foundation, The Sierra Club)

5.2. Delineate Shoreline Regions and Subregions for Each Island

The recommended methodology, described in Chapter 3, will be used to delineate shoreline regions and subregions statewide. Implementing a standardized framework for delineation, discussion, and analysis of shoreline regions and subregions will improve the existing regulatory framework, while also facilitating the development of regional shoreline management plans and projects. Incorporating

backshore, foreshore, and nearshore areas will provide the data resources required for analysis of potential sea level rise impacts, as well as other coastal hazards, and evaluation of shoreline adaptation and management options. Shoreline regions will provide a single frame of reference for discussion, decision-making, and management of shoreline resources. This provides continuity along the coastline, which typically has overlapping jurisdictions, ownership, existing plan boundaries, management areas, and zoning in any given project area. Funding for a shoreline delineation project is needed to support this step of the roadmap, together with building a data management system.

The methodology can be implemented in phases. A preliminary statewide delineation can focus on "Tier 1 shorelines", as described in the methodology, where substantial information and data are available to confidently delineate regions and subregions. A second phase of the delineation process could identify "Tier 2 and 3 shorelines" where data are limited and additional data and technical studies are needed to complete the delineation process. Proceeding through this process will inevitably reveal the need for revisions to the methodology and modifications needed for certain conditions/circumstances, such as coastal bluffs.

The delineation process will also reveal areas where proactive regional shoreline management could be implemented to mitigate the impacts of sea level rise. Shoreline adaptation or management options may be identified for these areas as part of the delineation process and prioritized for regional shoreline management accelerator projects.

5.3. Develop Accelerator Projects

An accelerator project is any action to resolve an issue, fill a critical information gap, demonstrate successful implementation, or identify lessons learned, with the intent of advancing regional shoreline management in Hawai'i. Accelerator projects can be used to assess the effectiveness of the methodology, inform other stakeholders of results, improve collaboration, develop funding pathways, and encourage use of successful techniques and methods in similar settings. These projects will help to identify shortcomings and avoid repeating mistakes. It will be essential to evaluate both positive and negative lessons learned in applying regional shoreline management. The Action Team can help to identify and prioritize accelerator projects such as:

- Regional shoreline management projects where shoreline delineation, existing plans, technical studies, cultural assessments, co-management arrangements, and community support are largely in place.
- A programmatic environmental review for regional shoreline management. As described in HAR 11-200.1-18 (c) & 24 (c), program level environmental review is distinguishable from project level review, which is more site and component specific. Programmatic environmental review should be detailed enough to make an informed choice among program-level alternatives and broad adaptation strategies and interventions. This level of review allows for analysis of the interactions of a number of projects or phases under one program in a region and could satisfy compliance with HRS Chapter 343 (Environmental Impact Statements).
- Implementation of regional shoreline management projects for a region or subregion that (1) have met variance requirements or fall under a programmatic environmental assessment or programmatic permit (such as those for small-scale beach nourishment or fishpond restoration), (2) have sufficient datasets readily available, (3) have broad community support, and/or (4) are a

continuation of existing efforts with the intent of documenting success and lessons learned through careful monitoring and evaluation.

- Technical studies and cultural assessments that are needed to address critical state or local information gaps for a shoreline region.
- Comprehensive review of the current shoreline certification process, in terms of the existing guidance and requirements for regional shoreline development and projects.
- Evaluation of HRS Chapter 205A (Coastal Zone Management) and other regulatory policies to support regional plans, programmatic approaches, and/or individual projects consistent with a regional shoreline management approach.
- Plan integration activities at state and county levels, including capital improvement projects, county general plans, community development plans, and watershed management partnerships within a regional shoreline management context.

The State, together with federal and county governments, must provide funding for accelerator projects. Private sector and non-governmental organizations should be engaged through co-management efforts to provide funding or other resources to support these projects. Additional ideas for accelerator projects can be found in Appendix 2.

5.4. Identify Governance Options for Regional Shoreline Management

A regional shoreline management approach may require revisions to existing State and county regulatory frameworks or a new governance framework (Table 7). As discussed in this Scoping Study, many regional shoreline management projects are being undertaken within the existing governance framework. These projects are planned and implemented to address specific shoreline management issues. Some modification of the existing governance framework might be needed to establish a mandate for regional shoreline management and a new entity to regulate development. An entirely new governance framework could be developed to mandate a regional shoreline management approach with an independent quasi-government entity regulating development consistent with a regional context.

Table 7. Initial governance options and operational considerations for implementing a regional shoreline management approach

Governance Options	Operational Considerations			
	Entity	**Voluntary Participation**	**Mandatory Participation**	**Co-Management**
Utilize existing governance framework	Multi-Jurisdictional Entity Advisory	•		•
Modify existing governance framework	Multi-Jurisdictional Entity Regulatory	•	•	•
Establish new governance framework	Independent Quasi Government Entity Administrative/Regulatory		•	•

In a poll conducted during the third workshop for this Scoping Study, over 70 percent of participants considered the existing or revised governance framework to be appropriate for regional shoreline management. A similar percentage suggested that a regional shoreline management approach should be operationalized as a mandatory program and include an emphasis on co-management arrangements.

The OPSD-CZM has initiated a Hawai‘i Silver Jackets team to inform and develop shoreline protection priorities, guidelines, and a decision-making framework for proactive shoreline management. This effort will facilitate study and discussion among regulatory and planning agencies with intersecting jurisdictional responsibilities along Hawaii's shorelines. These agencies include OPSD-CZM, DLNR-OCCL, DOH-CWB, HIEMA, UH Sea Grant, USACE, and partner county planning agencies.

Utilize the Existing Governance Framework. The existing governance framework could be used to further a regional shoreline management approach. The ORMP Coordinated Working Group has served as a successful forum for state and county entities to share information, issues, and solutions. A multi-jurisdictional and multisectoral RSM Action Team as described in Section 5.3, could represent a broad a range of entities with coastal-related authority and expertise. The advantage of this governance option is that there is existing collaboration and networking for ORMP implementation of its Focus Area to address coastal hazards, led by OPSD-CZM to accommodate a regional shoreline management approach. Regional shoreline management would remain a voluntary approach but incentives could be used to catalyze implementation. In Florida, the state government provides financial incentives and technical support to municipalities that voluntarily develop plans for adaptation action areas.

Modify the Existing Governance Framework. Modifications to the existing governance framework could establish a mandate for regional shoreline management and a multi-jurisdictional entity to grant approvals for regional shoreline management projects. An adopted regional shoreline management plans could be mandatory before projects can be approved.

The Coastal Resources Agency Board in the Commonwealth of the Northern Mariana Islands consists of the leaders of the government's resource agencies. This allows projects and plans to be reviewed in the context of existing capacity and limitations by decision-makers who have knowledge of other planned or permitted public and private projects. Board review can help facilitate project changes to conform with agency rules and regulations, improve data collection to inform permitting, and focus project proponent expectations. In Hawai‘i, this is often achieved through agency pre-consultations with project proponents. Individual permitting authorities often send project plans to other agencies for comment during formal permit review, which can significantly lengthen the permitting process and increase the associated documentation.

The DLNR-OCCL created a Technical Advisory Group of subject matter experts to review and comment on beach restoration projects and proposals. Although not a decision-making body, this group offers project proponents a valuable resource to help craft appropriate methods, data collection, monitoring, mitigation measures, best management practices, and deliverables to improve a project's performance. The group's support can signify to agencies that the project has been thoroughly evaluated by knowledgeable, third-party individuals.

Establish a New Governance Framework. The Hawai‘i State Legislature could enact legislation to create a new office of marine and coastal affairs to consolidate coastal zone management responsibilities and functions that reside within multiple agencies. This would support consolidated, integrated and uniform planning and management of Hawai‘i's shoreline and coastal resources. An autonomous oversight

agency tasked with broad-based review, research and information collection, and education responsibilities is required to help manage the complex natural and social forces interacting in the coastal zone. It should serve as an information and review resource available to all State and county agencies. The creation of such an office was discussed in a white paper by MACZAC.

Washington State's Department of Ecology administers all aspects of the state's coastal zone management program overseeing many state and federal laws designed to protect Washington's land, air, and water. Coastal communities are mandated to have a shoreline master plans. The plans incorporate a critical area ordinance that identifies sensitive and hazardous coastal areas. The State provides a handbook with guidance on how to develop a suitable plan, offering a rich shoreline inventory with some 50 parameters of data to build upon. As an incentive to communities and municipalities, the State provides funding to implement plans and projects if a plan is finished early. This moves coastal zone management from planning and permitting to management actions and activities. Washington State has invested substantially to collect data in a uniform manner and committed resources over a long period of time to be able to inform individual municipal shoreline master plans.

The California Coastal Commission, an independent, quasi-judicial state agency, regulates development along the California coast. Appointing a single entity to lead coastal decision-making helps to ensure unified decisions and consistent implementation of actions and programs. Local governments are required to prepare and update Local Coastal Plans that are approved by the California Coastal Commission. This approach offers predictability, which is attractive to developers, but creates its own inertia as a bureaucracy with consolidated power.

Establish Co-management Arrangements. Regardless of the governance framework, establishing co-management arrangements among government, non-government, and private sector entities promotes a shared responsibility for management. Co-management can support place-based management, regulatory compliance, collaboration, and lead to greater stakeholder engagement. Co-management arrangements need to be discussed early, with clear roles and responsibilities established. Transparent planning and decision-making processes need to be laid out, along with an emphasis on capacity and consensus building around shoreline adaptation strategies and management interventions. The co-management arrangements briefly described below represent incremental steps away from a parcel-by-parcel approach, focusing on solving a shared problem, often for a particular stretch of coastline.

- **Special Improvement Districts**, **Community Facilities Districts.** Special improvement districts or community facilities districts collect taxes from a distinct area and redistribute them to pay for targeted improvements such as beach restoration, dune plantings, or erosion mitigation. The geographic scopes of these districts are well-suited to function at the scale of a shoreline region or subregion. Because the tax is a relatively predictable amount, often collected through a government entity, it can be leveraged, and banks are more willing to lend money for projects that will be paid back over time. Those taxed typically have some form of representation but do not dictate the outcome or parameters of a project.
  For instance, a proposed community facilities district for Kahana Bay, Maui envisions an extra tax levied for 20 years upon 10 condominiums with 1,100 units, each paying about $55 per month. This would pay for a proposed beach restoration project fronting the subject properties. The project costs are entirely borne by the private landowners and not by public tax dollars. The private landowners benefit by having a sandy beach that attracts guests and generates rental income, while it buffers coastal hazards and reduces the need for other adaptation measures

(e.g., shoreline armoring, managed retreat). At the same time, the public benefits from having a wide, accessible beach.

- **Interagency Memorandums of Understanding.** Some beach parks and public spaces are the result of executive orders or memorandums of understanding. These agreements allow a local agency with capacity to manage a particular site, usually with minimal oversight from the lead agency. They can be advantageous for local stakeholders to be more actively involved in day-to-day activities and management that benefits the public since stakeholders can more readily liaise with local agencies and their staff. For instance, Baldwin Beach is provided to the Maui County Parks Department by memorandum of understanding with A&B Properties, which owned most of the park until recently. Kanaha Park on Maui's north shore was transferred via executive order from the DLNR to the Maui County Parks Department.
- **Public-Private Partnerships.** DLNR-OCCL has partnered with the Kā'anapali Operators Association to retrieve offshore sand to nourish the eroding beach and enhance the backshore with a vegetated berm. While the State shoulders much of the cost, the Association is contributing substantially, which will be returned overtime through taxes on the resorts and higher occupancy rates given a more attractive beach asset. As the partner government agency, the DLNR-OCCL can ensure that appropriate best management practices are tailored to resource protection needs and monitor their implementation. The agency can also require the resorts to provide additional public benefits such as dedicated public parking, restrooms, and beach access, that may not be part of a typical resort funded project. The public will gain a wider beach and improved shoreline access through this type of public-private partnership.
- **Non-governmental Organizations.** Nāpili Bay on Maui's west side is surrounded by low-rise resort condominiums that periodically experience severe erosion and beach loss. The Nāpili Bay Beach Restoration Foundation was established to identify whether suitable sand is available offshore and to restore offshore reefs that protect the bay from large swells. The Foundation can seek grants and seed money from a variety of sources to explore restoration options.
- **Citizen Groups.** The North Shore Community Land Trust partnered with the Turtle Bay Resort and U.S. Fish and Wildlife Service Pacific Islands Coastal Program to restore a vital strand of coastal dune ecosystem on O'ahu's north shore. The volunteer-based community stewardship and coastline restoration effort provides safe birthing habitat for Hawaiian monk seals, ground nesting seabirds, and sea turtles. This section of shoreline is bordered by a golf course on one side and a wildlife refuge on the other side. Invasive species have been replaced with native plants on 5 acres of sand dunes that have been restored through the partnership. In addition, the collaboration has resulted in Laysan albatross successfully nesting in the region for the first time in decades.

5.5. Identify Incentives for Regional Shoreline Management

Any change in management can face hesitancy about a new process with uncertain results. A variety of incentives should be considered by the State and counties to support planning for and encouraging participation in strategies towards implementation of a regional shoreline management approach. Incentives may take a variety of forms and several are described here and are not intended to be inclusive.

The State could provide grants to counties, nongovernmental organizations, and community groups to support regional shoreline management planning and implementation. These grants could focus on

shoreline regions and subregions that have established some form of co-management arrangements (see Section 5.4) and developed coastal adaptation and shoreline management concepts.

The State could also provide technical support in the form of resources, tools, and technical staff to counties that incorporate a regional shoreline management approach in their permit review process. The State could develop a permit review checklist with guiding questions and criteria for the permit review that could be adopted by each county. The checklist could be developed to reflect key elements of a regional shoreline management approach such as the geographic scale of analysis, consideration of historical trends and future conditions, incorporation of place-based and traditional ecological knowledge, and analysis of cumulative impacts. Technical support from the State could be provided to assist each county review permit applications using the checklist.

Private landowners within a shoreline region that work together to develop a regional shoreline management plan could receive a special permit review process by State and county entities. Further, the State and county could prepare a programmatic environmental assessment based on the regional shoreline management plan. This would reduce the need for each property owner to prepare an environmental review document.

Incentives are an important tool to catalyze regional shoreline management within the existing governance framework. Accelerator projects, discussed in Section 5.4, provide an immediate opportunity to test various incentives and draw lessons for the long-term.

5.6. Build and Maintain a Hawai‘i Digital Coastal Atlas

Currently, information needed for regional shoreline management is available across multiple platforms and maintained by multiple entities. A Hawai‘i Digital Coastal Atlas is recommended as a critical tool to consolidate updated information. It is envisioned as a web-based geospatial data management system that will provide not only coastal data, but also the tools, guidance, and information needed to make the data useful in plan development, pre-consultation, and permit preparation. The Hawai‘i Digital Coastal Atlas (see Section 3.9) could be developed in phases beginning with inputs from the shoreline delineation process and expanded over time to include products such as guidance documents, permitting tools, and regional shoreline profiles and studies. This would require investment in developing the database and identification of an appropriate entity with administrative and technical capacity to host and maintain the data. Several examples of such platforms were reviewed as part of this Scoping Study (see Chapter 2). NOAA’s Digital Coast is another model that can be explored as a model for a Hawai‘i-specific Digital Coastal Atlas.

5.7. Develop and Implement Hawai‘i Regional Shoreline Management Strategic Plan

The ultimate output of the RSM Action Team is the creation of a Hawai‘i State Regional Shoreline Management Strategic Plan (RSM Strategic Plan). At a minimum, the RSM Strategic Plan will:

- Document the results and lessons from steps undertaken as part of the 5-year roadmap
- Revisit and revise, as needed, the Theory of Change toward a regional shoreline management approach in Hawai‘i
- Establish priority regions for proactive shoreline management planning and implementation

- Provide a detailed analysis of governance options for implementing a regional shoreline management approach
- Describe the preferred governance framework for a regional shoreline management approach with detailed steps, resources, and a timeline needed to implement the proposed amendments.
- Present a detailed analysis of funding, tools, and staffing requirements at both State and county levels to support a regional shoreline management approach

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6. A Call to Action

Shoreline erosion and the cumulative impacts of coastal storm hazards will progressively worsen in the future with sea level rise and other impacts of climate change. Increased pressure to develop along Hawaii’s shoreline will increase vulnerability and liability in this realm. Preparing for and increasing resilience to these conditions will require the expertise contained within all shoreline-related agencies and organizations working together. These parties will have to cooperate to maximize safety for people and property, minimize the public and private costs of these impacts, and preserve the natural and cultural environment along the coastline. Steps toward proactive regional shoreline management should be considered a state priority for urgent action.

The Hawai‘i State Legislature took bold steps to address climate change through the establishment of the Hawai‘i Climate Change Mitigation and Adaptation Commission and preparation of the 2017 Hawai‘i Sea Level Rise Vulnerability and Adaptation Report. The high return on that investment is documented in the Commission’s recently released 2022 Hawai‘i Sea Level Rise Adaptation and Vulnerability Report 5-Year Review and Update. Building on this momentum, and with similar investments, a regional shoreline management approach can be adopted within the existing governance framework for more sustainable and resilient shorelines in what promises to be an increasingly complex future in Hawai‘i.

Human and financial resource capacity at both State and county levels must be bolstered to catalyze a proactive regional shoreline management approach as an alternative to the existing reactive parcel-by-parcel approach. The 5-Year Roadmap recommended in this Scoping Study provides multiple entry points for investment. Embarking on a new pathway will require not only new talent, tools, and funds, but commitment and collaboration among government, non-governmental groups, the private sector, and communities to work together, expanding and developing new co-management arrangements. Unfortunately, the window for timely action is already closing, as evidenced by the negative impacts currently being seen along Hawai‘i’s shoreline.

Appendices (see separate file)

Appendix 1: Existing Shoreline Management Framework in Hawai‘i

Appendix 2: Challenges and Opportunities for Implementing a Regional Shoreline Management Approach in Hawai‘i

Appendix 3: Examples of Regions Shoreline Management in Hawai‘i

Appendix 4: Regional Shoreline Management Case Study – Kapukaulua, Maui

Endnotes

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