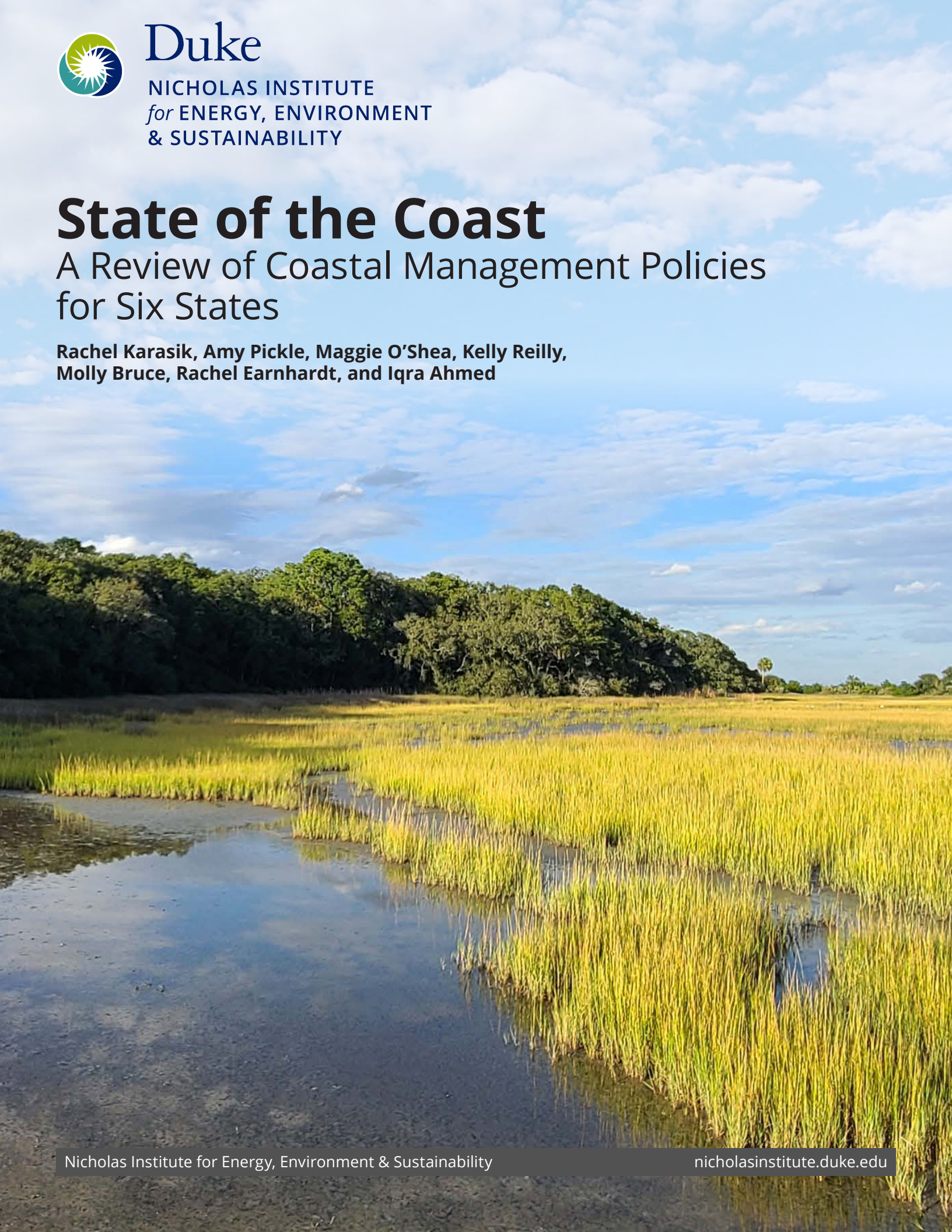
Duke
NICHOLAS INSTITUTE
for ENERGY, ENVIRONMENT
& SUSTAINABILITY

State of the Coast

A Review of Coastal Management Policies for Six States

Rachel Karasik, Amy Pickle, Maggie O'Shea, Kelly Reilly, Molly Bruce, Rachel Earnhardt, and Iqra Ahmed



State of the Coast
A Review of Coastal Management Policies for Six States

CONTENTS

EXECUTIVE SUMMARY AND KEY FINDINGS

Coastal habitats in the United States have been in decline for centuries, while federal and state policy programs to address their decline have only been developed and implemented over the past few decades. This study set out to understand—based on existing policy, published academic and grey literature, and expert perspectives—the status and stressors for four focal habitats and state governments' approaches to their restoration and protection. While the report includes illustrative examples of local and state level governmental interventions designed for and, at times, demonstrably effective at protecting and restoring coastal habitats, the key findings suggest that state coastal management remains fragmented and enabling conditions for effective policy hard to identify and therefore are not replicated across states.

The study focused on four focal habitats—native oyster reefs, mangroves, salt marshes, and seagrass—all of which have been in decline nationally. While longitudinal data on habitat quality decline and loss are not standardized, comprehensive, or available for all the study states and habitat types on the state or even national level, some loss data is available. For example, one study found over 50% of original salt marsh habitat is estimated to have been lost in the United States in the twentieth century alone (Kennish 2001), while US mangrove habitat has declined by between 2.7% and 3.0% between 2000 and 2012 (Hamilton and Casey 2016). Overall mangrove loss may have been buffered as a result of mangrove expansion into salt marsh areas and support by federal and state policies that prohibit direct destruction or impact (Osland et al. 2018). For other habitats, loss has been measured on a global scale rather than at the country level. Evidence of seagrass loss on a global scale demonstrates average an annual global loss of 110 km2 since 1980 and an overall loss of 29% of known seagrass areas from 1879 to 2006 (Waycott et al. 2009). Evidence of oyster reef loss on a global scale is similarly stark, with recent estimates at 85% of oyster reef loss globally; almost all reef habitats assessed in the United States are rated as functionally extinct, poor, or fair (Beck et al. 2011).

The states we analyzed— California, Florida, Massachusetts, North Carolina, Texas, and Washington—have regulatory instruments that prohibit or permit activities in the coastal zone that impact this report's focal habitats. With the ubiquitous exception for shellfish aquaculture, however, most states rely on regulation that applies broadly to the coastal area and is not narrowly tailored to any one of the four focal habitats. Two federal statutes—the Coastal Zone Management Act (CZMA) and the Clean Water Act (CWA)—are consistently used by the six states in this study as the primary regulatory or permitting framework that restricts activities that may impact the study habitats. In addition to state differences in implementing the CWA or CZMA, states had different approaches to monitoring or assessing trends and threats in these habitats. Local government activities were also identified as important, and the study found several local examples of policies that have improved habitat extent or quality.

This study sought to identify evidence of policies that have been effective at protecting or restoring the four focal habitats in the six states of interest. Policy effectiveness was assessed using a broad set of criteria, and the study sought to identify policies that demonstrate one or more of the following:

- An innovative approach
- Qualitative or quantitative evidence of successful mitigation of an identified threat
- Preservation of healthy areas containing one or more of the four focal habitats
- Success in identifying and managing tradeoffs, competing uses and conflicts
- Enabling ecosystem-based approaches to restoration
- Overcoming barriers to successful restoration
- Explicit consideration of climate change impacts and future habitat conditions coupled with management actions.

Despite the limited amount of information on policy effectiveness in the literature review, including a lack of studies that demonstrate a causal connection between a statewide policy and any of the stated criteria, the study identifies several illustrative examples that meet one or more of the above. This report includes illustrative examples of state innovations, local or regional successes, and policy mechanisms currently used by states to improve coastal habitat protection and restoration. The report also details any gaps in the policy framework and the impacts to policy effectiveness that are posed by climate change. To support coastal managers across the United States and to identify successful and replicable policy approaches, more in-depth program assessments are recommended, along with investments in long-term coastal habitat monitoring that can help evaluate both habitat status and policy effectiveness. The key findings of this report are summarized as follows.

Key Findings

(1) With some local exceptions, the four focal habitats have declined in acreage from historical benchmarks across all six study states.

(2) Threats and stressors are common across the six study states; they include direct habitat destruction, impacts associated with coastal development, water pollution, and stressors associated with climate change such as sea level rise, subsidence, and ocean acidification. Local areas may experience acute stressors, but prioritization among stressors statewide was not possible.

(3) Some local areas demonstrate that while habitat restoration is possible, climate change and sea level rise threaten to reverse gains or accelerate the decline.

(4) Interactions among the four focal habitats are poorly understood. However, limited research on habitat interactions indicates that more holistic, ecosystem-based management may be more effective, but may depend on other enabling conditions for effective policy implementation.

(5) Monitoring habitat status is a piecemeal effort in all six study states. None of the study states conduct sustained, long-term statewide baseline monitoring. Without baseline monitoring, there is an information gap about the four focal habitats and their response to stressors and threats. Monitoring is also essential for understanding policy impacts.

(6) States rely primarily on the federal coastal protection and management statutes for habitat restoration and protection. The CWA and the CZMA are the legal frameworks within which states tailor the suite of policies to their individual governance contexts. Some of the study states have adopted innovative policy levers within this federal framework.

(7) Policy implementation, including addressing permitting challenges, matters as much as policy design.

(8) Local initiatives can address threats to coastal habitats through innovative governance mechanisms, comprehensive management, and long-term funding.

(9) Policy effectiveness studies are limited and, rarely, if ever, use causal inference methods. Gaps in understanding effective restoration goals also limit identification of translatable, state-level policies that improve the restoration or protection of the four focal habitats.

(10) The policy landscape is complex and disjointed. The study states use a suite of policies that have distinct goals—like water pollution reduction or habitat-specific protections—and different governance structures. The web of governance structures, policy goals, and policy mechanisms create gaps and barriers that challenge coastal management.

1 INTRODUCTION AND PURPOSE OF THIS STUDY

This study focuses on the policy response of six study states—California, Florida, Massachusetts, North Carolina, Texas, and Washington—to restore or protect four critical and threatened habitats: oyster reefs or beds, mangroves, salt marshes, and seagrasses. These coastal ecosystems, which exist in salt, fresh, and brackish waters along coastlines, provide structurally complex nurseries, shelters, and habitats for a myriad of commercially and culturally significant aquatic species, and other important ecosystem services (Barbier 2013). The study examined the selected six states to capture the diversity of geography, restoration and protection policies, and sources of environmental degradation across the country. The study examined the four coastal habitats because of their historic and current extent along the coastal United States, economic and cultural relevance, and importance in maintaining key ecosystem services including food provision, recreation, coastal resilience, and more.

1.1 Summary of Threats and Habitat Status of the Four Coastal Habitats

Oyster reefs are created by the accumulation and deposition of live and dead oysters and oyster shells that are attached to substrate material, such as rock or hard bottom (NOAA Fisheries 2022a). Mangroves are tropical and subtropical forests that proliferate in estuarine conditions on intertidal mud flats. In the US, three species of mangroves can be found as far north as coastal areas across the Gulf of Mexico and, with rising temperatures, their range is expanding farther north (Romañach et al. 2018; Cavanaugh et al. 2014). Salt marshes are a type of coastal wetland found in the intertidal zone and consist of a diverse array of herbaceous plants, including different types of cordgrass, saltgrass, rushes, and weeds, among others. The composition of salt marsh habitats varies significantly, depending on salinity, biogeography, temperature, submersion level, and sedimentation (Sanger and Parker 2016). Seagrasses are nonemergent, meaning that they grow underwater and are found anywhere from shallow estuarine to deeper marine waters. There are over 70 species of seagrass globally, many of which are found in US seagrass habitats. The species commonly found in the six states of interest include eelgrass, surfgrass, turtlegrass, shoal grass, widgeon grass, and more (Reynolds 2018).

Globally and across the United States, most of these habitats have been declining in area for decades (Duarte 2009). Some data on loss are available on the country level; for example, over 50% of original salt marsh habitat is estimated to have been lost in the US in the twentieth century alone (Kennish 2001), while mangrove habitat in the US has declined by 2.7% to 3.0% between 2000 and 2012 (Hamilton and Casey 2016). Overall, more recent mangrove loss may have been buffered as a result of mangrove expansion into salt marsh areas and support by federal and state policies that prohibit direct destruction or impact (Osland et al. 2018). Evidence of seagrass loss on a global scale demonstrates average annual global loss of 110 km2 since 1980 and an overall loss of 29% of known seagrass areas from 1879 to 2006 (Waycott et al. 2009). Evidence of oyster reef loss on a global scale is similarly stark, with recent estimates at 85% of oyster reef loss globally, and almost all reef habitats assessed in the US rated as functionally extinct, poor, or fair (Beck et al. 2011).

Threats to the four focal habitats are common across geographies. For ease of description, the threats can be grouped into four categories: (1) current and historical physical alteration of the habitat (e.g., impacts from dredge and fill, propeller scaring, and overharvesting) (2) coastal development (e.g., hardened shorelines) (3) water quality (e.g., salinity changes, water pollution [especially nutrient pollution], and turbidity or sediment); and (4) stressors related to climate change (e.g., sea level rise, salinity changes, increased intensity and frequency of storms, and ocean acidification). Threats are not singular but may fit within multiple categories. For example, increased coastal development also increases impervious surfaces, which can cause a decline in water quality (Sanger et al. 2015). The impact from these threats works often, if not always, synergistically to alter and degrade coastal habitats and threaten species. In some geographies, the threats are very severe or already a concern, or coastal habitats have been degraded as a result of historical and legacy impacts. In other places, threats are mild or anticipated to be severe in the future. At the same time, the severity of threats to coastal habitats also varies significantly, with some coasts being more vulnerable or susceptible to hazards than others; there is no clear prioritization of the biggest threats to these coastal habitats for different states within the literature (Wyatt et al. 2017). Coastal habitats are already vulnerable because of centuries of modification, alteration, and conversion through diking, draining, dredging, filling, and channelizing. These activities restrict or modify hydrological flow and sedimentation, widen or deepen rivers, and remove or reshape habitat bottoms. The severity of some of these threats, particularly those that impair water quality, can impede well-intentioned protection and restoration efforts (Bowen et al. 2019). Restoration success both hinges on and can result in water quality improvements, presenting a "chicken or the egg" challenge for decision makers approaching impaired habitats and watersheds. The interconnected and acute or chronic nature of the threats can drive a variety of policy responses and addressing the interconnected nature of these threats may be an essential enabling condition (DeAngelis et al. 2020).

1.2 Coastal Habitat Protection and Restoration Policies are Multijurisdictional

Coastal habitat restoration and protection policy mechanisms can cover multiple habitat types and address a multitude of interrelated threats. The coastal policy framework guiding protection and restoration of coastal habitats in the six study states involves local, state, and federal oversight, including the complex interplay of private and public property ownership and management, land and natural resource use, and environmental and species protection. Many federal and state coastal regulatory programs are tied to jurisdictional lines established by the Submerged Lands Act, which recognizes distinct geographic areas for management by the states or federal government. Both state and federal governments also have numerous departments and agencies that have some authority over coastal areas (Craig 2008). To further complicate coastal management, federal environmental statutes deploy a cooperative federalism model that divides responsibility between federal and state governments, while states may choose to use a centralized or de-centralized framework that empowers local decision making within the cooperative federalism model. State and local governments also have similar overlapping authority, roles, and responsibilities that are established by state legal frameworks. Adding to the complexity, crossjurisdictional or regional efforts involving multiple states and, in some cases, countries, can

also be nested within the coastal habitat governance framework. Thus, local, state, and federal interests and jurisdiction overlap, creating a nested set of laws that may apply simultaneously and may have different objectives, geographic boundaries, and management priorities. This complex interwoven legal authority for coastal resources—where multiple federal, state, local or regional agencies may have regulatory or consultative roles with respect to a particular habitat or activity that may impact habitat—presents challenges for coastal management, such as insufficient information flow between government agencies, administrative inefficiencies, and implementation gaps. This may result in a fragmented policy landscape that addresses threats to ecosystems with species-by-species, habitat-by-habitat, or pollutant-by-pollutant actions rather than in a comprehensive or complementary manner. Thus, the coastal management policy framework creates gaps, barriers, and unexpected synergies that are state-specific and challenging to ascertain from a high-level review of a state's statutory and regulatory language.

Some of the critical federal regulatory statutes for coastal habitat management include the CWA, the CZMA, the National Environmental Policy Act, the Endangered Species Act, the Oil Pollution Act, and the Magnuson-Stevens Fishery Conservation and Management Act. Some federal statutes focus on a category of resources rather than on an ecosystem, such as the Marine Mammal Protection Act, which regulates actions affecting marine mammals, or the Magnuson-Stevens Fishery Conservation and Management Act, which regulates marine and coastal fishing in federal waters. Others are focused on increasing consideration of environmental information in decisions like the National Environmental Policy Act. A list of key federal statutes is included in Appendix C of this report.

While federal statutes are part of the coastal habitat policy landscape, this study focuses on identifying patterns in state-level coastal management policies for six selected states. It is not an exhaustive nor comprehensive legal review of all the federal, state, local, and regional efforts that are part of the coastal habitat governance framework. Research efforts were focused on identifying policies and programs specific to the habitat types of interest. The prominence of federal law and policy and its interplay with state coastal management, however, elevates the importance of understanding a few key statutes that all the states in this study rely on for coastal management for the four focal habitats. Two statutes discussed in more detail later—the CZMA and the CWA—are both critical federal statutes for coastal habitat protection and both apportion authority between federal and state government. Neither are targeted exclusively at one or more of the four focal habitats, but rather are broadly focused on protection of coastal areas or on improving water quality.

This report focuses on the current state of knowledge regarding the status of and threats to these habitats and how states are approaching policy design to restore and protect these habitats in six states: California, Florida, Massachusetts, North Carolina, Texas, and Washington. The report includes sections describing the most up-to-date knowledge and research of threats to and health of these four habitats in each state at the time of publication.

1.3 Objective and Scope of this Study

1.3.1 Study Objective

The objective for this study is to characterize the condition and importance of the key coastal habitats and the state policy strategies that are showing promise in effectively conserving them. To achieve these objectives, this study is based on the following:

(1) A database of state-level policies that have an impact on protection or restoration of the four coastal habitats of concern created for each of the six states

(2) A time-bound literature review for state-level coastal management policies, including information on policy effectiveness

(3) An overview of the four coastal habitat types and threats in each state

(4) Outreach to state experts about gaps in the literature review or assessment

1.3.2 Study Scope

This report presents a select review of policies and approaches that are currently or recently in use in six states, with an emphasis on four focal habitats— mangroves, native oyster reefs, salt marsh, and seagrass. The authors conducted a basic literature review, summarized in following sections and described in more detail in Appendix A, to identify the general condition of the habitats nationally and in representative states and the major threats and drivers of loss. This literature review and resulting assessment should be considered nonexhaustive, based on publicly available habitat assessments, and did not result in the generation of new data.

This study also included a policy assessment with both federal and state policy components. The overview of federal policy was focused on major federal drivers of coastal habitat protection and restoration, with specific relevance for the four focal habitats and the six study states. The objective for this analysis was to synthesize and analyze state-level policy currently being used to protect or restore the four focal habitats and to assess policy gaps, provide insight into policy effectiveness, and highlight best practices. This part of the analysis was conducted primarily by reviewing state-level policy documents using qualitative analysis software, supported by a state-level literature review and informal consultations with state experts, which tended to focus on place-based examples that are showing promise. The policy survey and synthesis combine to form a snapshot that describes the current policy landscape. The policies described herein are in effect as of the date of this report or were state policies that were enacted after 2015 and identified as effective in the literature review or by expert interviews, but that may or may not still be in effect, such as time-bound management plans (e.g., a strategic plan for 2018–2023). It is not a legal analysis or summary of all potential legal protections and should be considered nonexhaustive. In addition, the analysis is focused on state-level policy efforts and does not include policy developed or implemented at the local or regional level, except as illustrative case studies identified in the literature review and through expert interviews.

Finally, this study also assessed the existing policy literature on federal and state policies for coastal habitat protection and their effectiveness. Policy effectiveness literature, including with qualitative, quantitative, or anecdotal descriptors of effectiveness, is limited for both federal

and state coastal habitat management. Effective policy is dependent on many factors, including monitoring, enforcement, and resources. Identification of the enabling conditions for policy conditions may not be ascertainable because of temporal or data limitations. Thus, any statement on policy effectiveness should be viewed as illustrative.

1.4 Report Organization

Based on the scope of this study, this report is organized into the following sections:

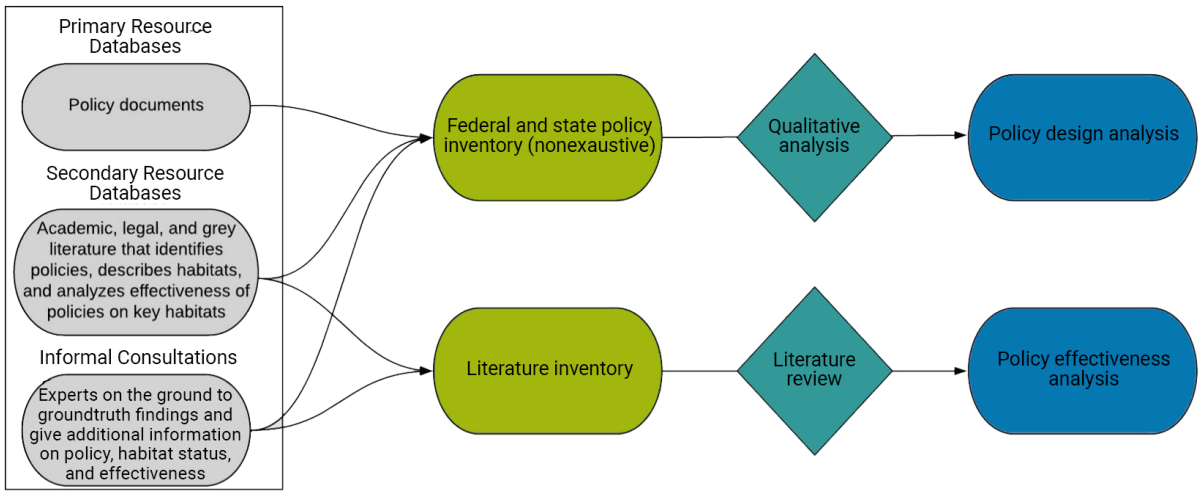
- Summary of the methods used and study limitations
- Aggregated results of policy landscape review
- State-specific summaries for each of the six states, including the following:
  - Current status and threats of the four habitats
  - Summary of the state's habitat-specific and broadly applicable policies
  - Description of the effective state-level policies identified by state coastal management experts
- Discussion of the barriers to effective policy and state innovations

2 METHODS AND STUDY LIMITATIONS

2.1 Methods Overview

This section provides an overview of the methods used for this study. The full methods are provided in Appendix B. Figure 1 outlines the methods used in this research project. Each gray

Figure 1. Methods conceptual model, demonstrating sources of data for primary policy document inventory and secondary literature source inventory, both used to characterize the coastal habitat policy landscape



oval serves as the principal source from which the researchers were able to gather information to conduct a literature review, a policy analysis, and an informal consultation process, described in following paragraphs.

2.1.1 Inventory Development: Policy Documents and Secondary Literature

The project team adapted systematic review methods by Haddaway et al. (2015) to collect, assess, and evaluate the coastal habitat status and policy landscape for the six states of this study using primary and secondary sources. Primary sources refer to the formal policy documents (e.g., statutes, ordinances, laws, management plans, etc.) that hold legal legitimacy in their jurisdiction. In this report, policy documents and primary sources will be used interchangeably. Secondary sources include academic literature, grey literature, legal literature (e.g., law reviews), congressional reports, and, at times, the background section of management plans or strategies that identify and characterize the status and trends of relevant habitats and assesses the impacts of policies. Secondary sources in this study do not include public comments, testimony, permit documents (applications), congressional debates, or meeting minutes.

2.1.2 Literature Review

The title and abstract of each secondary literature document saved in the literature inventory were screened by six researchers and saved in Zotero (n.d.) and as an internal PDF file if deemed relevant. Secondary literature was deemed relevant because it discussed either status of and threats to the focal habitats or characterized, assessed, and recommended policy approaches to coastal habitats in the states of interest. Each document in Zotero was tagged with at least one of the following indicators: federal policy, policy effectiveness, policy evaluation, policy recommendation, water quality, Massachusetts, North Carolina, Florida, Texas, California, Washington, national, oyster reef, salt marsh, seagrass, and/or mangroves. The search strings were applied to each of the databases for every state and relevant habitat. Searches were considered exhausted when no relevant documents were returned in ten consecutive pages (or within 100 results) or after 20% of the search string had been exhausted, per Diana et al. (2022). In total, 1,165 secondary literature files were saved for review.

To address inaccuracies in the initial literature analysis and to ensure the literature review was current, secondary source documents published after January 1, 2016, and before November 1, 2021, were put into a separate folder. To identify the status of the four focal habitats in the six study states and to gap-fill for current policies that were missed in the policy database, a stratified random sample based on methods applied by Smith and Basurto (2019) was used to select those for deeper reading and analysis. The sample was stratified by year and by state, ultimately selecting five publications per state for each year between 2016 and 2021 (including 2016 and 2021). For those states with less than five publications in a given year, all the documents were reviewed. This approach allowed literature from each state to be considered in the analysis without oversampling from those with a larger number of publications. In total, 172 of the 331 articles were read. In addition, all secondary source documents identified in the fourth phase (n = 331) were screened for policy effectiveness information. The document abstracts were screened and a subset (n = 55) identified for further review and analysis.

2.1.3 Policy Analysis

In total, 1,437 primary policy documents (including state- and local-level policy documents) were saved for review and qualitatively coded using NVivo software (QSR International 2022). Each state-level policy instrument identified within the policy document was coded for the following categories used to describe the design of the policy:

- Goals and objectives, including mentions of science-based targets, ecological goals, or socioeconomic goals (ecosystem services).
- Expected cost.
- Habitats covered.
- Regulated entity, including government entities, the public, or specific stakeholder groups
- Mention of federal policy (indication of cooperative federalism).
- Instrument type, including regulatory affirmative, regulatory prohibitive, economic incentives or disincentives, and information-based instruments. These are briefly described as follows and expanded upon in Appendix B.
    - *Regulatory affirmative*: Defined as regulations or rules that require, or affirm, actions to be taken by specific entities. Permitting regulations are an example of a regulatory affirmative policy instrument.
    - *Regulatory prohibitive*: Defined as regulations or rules that prohibit, partially or completely, actions from being taken by specific entities. An oyster shell ban in landfills is an example of a regulatory prohibitive instrument.
    - *Economic incentives or disincentives*: Defined as fiscal programs that are either required or are voluntary but may compel or discourage actions taken by specific entities. A parcel tax on properties to find restoration is an example of an economic incentive or disincentive.
    - *Information-based instruments*: Defined as efforts to influence the public of specific entities through the transfer of knowledge, communication, and persuasion (Karasik et al. 2020; Bemelmans-Videc et al. 1998). An education and outreach campaign about propeller scarring on seagrass beds is an example of an economic instrument.

Because of the number of primary policy documents, only coded content extracted from habitat-specific policy query categories was assessed, rather than content about coastal habitats more broadly (e.g., wetlands). Relevant information from those policy documents (e.g., policies that demonstrated an intent on behalf of decision makers to support specific habitat protection and restoration or onramps for increased policy engagement by researchers and advocacy groups) was included in the report.

2.1.4 Informal Consultations

Consultations with coastal habitat management experts were conducted in three rounds with state- or region-specific experts ranging in fields from habitat management to government to

academia. To generate a comprehensive list of experts to contact, the project team relied on internal and external contacts from The Pew Charitable Trusts and Duke University, identified experts who first authored secondary source literature documents in the literature inventory at least two times, and reviewed state agency websites for coastal program managers. The interviewee list included those whose expertise and perspectives on coastal habitat and policy would be relevant and significant for our study from the following sectors: academia, government agencies, nongovernmental organizations (NGOs), and private industry (e.g., consulting firms and those with knowledge of permitting). In total, 152 names were identified. A subset of individuals with the most relevant experience and expertise were selected to be contacted for an interview with the project team per state. The criteria in Table 1 explain how individuals were selected from the initial list to be asked for an interview.

The first phase of expert interviews was conducted during the early stages of content analysis, after all documents from the searches had been collected but the coding of the collected content in NVivo was only partially complete. Therefore, the first round of consultations was focused on broad threats and trends within the topic state and relevant habitats. The interview format followed a specified list of broad questions, grouped as either habitat- or policy-related, that were augmented or supplemented to fit each state and expert topic area.

Following the completion of qualitative coding of all documents in NVivo and the initial stage of report synthesis, a second phase of informal interviews was conducted. The intent of this second round of consultations was to ask much more targeted questions about the effectiveness, implementation, replicability, or reception of specific policies or programs on specific habitats and to fill in any identified gaps in the research.

In the third round of interviews, the first three phases of literature review had been conducted. The purpose of the final round of interviews was to crosscheck the findings from the literature review and identify any effective policies, bright spots, or emerging information that may not have come up in the literature.

In total, 62 people were interviewed, most of whom represented Florida, while the fewest interviewees represented Massachusetts and North Carolina. Appendix B provides the questions used in each phase of interviews.

Table 1. Interviewee selection criteria

Sector	Criteria
Academia	At least one journal article in the last five years directly relevant to coastal habitats and policies of interest
NGO	At least one white paper in the last five years directly relevant to coastal habitats and policies of interest, or current active work in coastal habitats of interest
Government	At least one government report in in the last five years directly relevant to coastal habitats and policies of interest, or current active work in coastal habitats of interest
Private sector	Expertise in permitting

2.2 Study Limitations

This study has four limitations that restrict the applicability of the findings. Coastal habitat policies are often broad and not specific or tailored to the four focal habitats. Many examples included in this study are not state-level policies or are not narrowly targeted to one or more of the four focal habitats. These generally applicable policies, however, were identified in the literature and interviews as important coastal management regulations. The study did not fully assess all policies or authority derived from these generally applicable policies and should be considered illustrative. In addition, the terminology for the four focal habitats was not consistent across the states and is not standardized, which created challenges in retrieving policies that were specific to these habitats. Tracing the federal, state, and local government roles and responsibilities and connecting the status and declining trends for the four focal habitats would require research that goes beyond the current study. Furthermore, policy effectiveness studies are somewhat ambiguous and rarely, if ever, use causal inference methods, making it difficult to use consistent search terms and criteria.

For example, some studies focused on the effectiveness of restoration activities rather than the effectiveness of the underlying policy mechanism, and others evaluated process metrics (e.g., the inclusion of diverse stakeholders in the development of a management plan rather than the effect of the management plan). Derived primarily from the interviews and the literature review, this study was able to identify multiple policy examples that demonstrate promising approaches to protect or restore one or more of the four focal habitats, and that could be replicated in other states. Ultimately, this study is an initial review of policy documents and existing literature and is designed to identify trends across states using illustrative examples from each state. It is not a comprehensive nor exhaustive review and analysis. The four limitations are described in more detail in following sections.

2.2.1 Coastal Habitat Assessments are Focused on Broad Categories of Habitat or Group Many Habitat Types within Policies

This study focused on four focal habitats: mangroves, oyster reefs, seagrass, and salt marshes. Coastal habitat research, identified through the literature review, focused on habitat status and trends (including threats) but tends to cover broader geographic coastal areas—namely wetlands, estuaries, shorelines, and bays—that contain a multitude of more specific habitat types, without necessarily defining these specific habitat types or discerning status and trends between them in a given area. Furthermore, salt marsh and mangroves are often assessed as wetlands. As a result, much of the literature included in this analysis described the status of and threats to coastal habitats broadly, most often wetlands, but was neither consistent nor explicit about whether the more generalizable habitat categories included the focal habitats identified in this report.

Many other kinds of coastal habitat types were included in relevant literature but were not focal to this report. These include swamps, bogs, clam beds, salt ponds, tidal flats, coral reefs, kelp forests, and mudflats. Often, relevant coastal habitat research would describe the status of and threats to the coastal habitat types that are not included in this report but are often in the same places or face the same threats as the focal habitat types. These were excluded unless the study also explicitly mentioned status of and threats to the focal coastal habitat types.

2.2.2 The Study Could not Evaluate the Effectiveness of Generally Applicable Policies

This study did not track the authority for each policy document; thus, we cannot determine whether an individual policy document is authorized pursuant to state or federal law. It is beyond the scope of this study to assess the efficacy of the major federal coastal habitat statutes and state implementation; the review of the coastal habitat policies, however, indicate that non–habitat-specific governance is the primary regulatory mechanism for the protection and restoration of the habitats. To the extent that this observed policy choice is indicative of the study states' preferred regulatory framework, it suggests that developing new policies that link habitat-specific information about trends and status is most likely to be accomplished within the CWA or CZMA frameworks.

2.2.3 Geographic Scope of the Literature and the Management of the Habitats is Often not Statewide

Coastal habitat status and management is assessed with either a hyperlocal or regional lens. For example, some of the literature cited focused on a specific bay, estuary, lagoon, or other specific coastal system within a state. At the same time, other studies assessed and described habitat status and threats on a broader level encompassing multiple states. Those included assessments of coastal New England, the Mid-Atlantic, the Gulf of Mexico, and the Pacific/Pacific Northwest. This trend was especially notable in California, where both assessments and management of coastal habitat was decentralized and differentiated across hyperlocal coastal systems, and interviewees confirmed that assessment and management of coastal habitat across the state was compartmentalized by region.

2.2.4 Limited Information on Policy Effectiveness and Current Statewide Habitat Assessments Dominated the Review

The study did not independently develop policy effectiveness criteria or enabling conditions to assess coastal management policies. Without more mapping and monitoring, assessment of program efficacy, tracking cumulative impacts or exemptions from legal prohibitions, and other assessments of policy effectiveness, the relationship between policy design, policy effectiveness, and positive ecosystem outcomes remains opaque. This study also did not use the literature as a basis for refining the nonexhaustive effectiveness criteria that were identified at the beginning of the project. In addition, not all the study states were represented in the limited effectiveness literature. Thus, any policies that this study identifies as demonstrating effectiveness in one or more dimensions should be considered illustrative and not indicative of whether the policy might be effective across geographies or habitats.

Although some states have attempted to increase the frequency and spatial coverage of monitoring, the health and status of coastal habitats on a state level is not regularly assessed nor made publicly available for the six states of interest. As discussed in following sections, monitoring has been identified as one of the key enabling conditions for effective policy implementation and has been cited as missing in many state programs according to our analysis. (Beck et al. 2019; Brockmeyer et al. 2021 The analysis and conclusions of this study, however, describe consistent themes that underscore the threats to coastal habitats that have been observed and reported on for decades in academic and government-produced literature.

3 RESULTS: POLICY LANDSCAPE SUMMARY

3.1 Introduction

State coastal management policy is a complex framework that includes regulatory restrictions and planning or information exercises that cross federal, state, and local jurisdictions and multiple agencies. No one governmental unit has sole authority for the four focal habitats or responsibility for addressing the impacts from the multiple stressors for these ecosystems. Overall, this study indicates that states rely on broad coastal management law and policy, rather than a habitat- or threat-specific approach. In addition, the habitat-specific policies are narrowly tailored and do not address all threats to the four focal habitats. Finally, the governance framework includes local action that could not be adequately assessed in this study, but is an essential component in understanding each state's policy landscape.

3.2 Federal Environmental Statutes Provide the Backbone for Most State-Level Coastal Habitat Management

The multijurisdictional nature of coastal regulation is not unique and is similar to many environmental regulation and protection frameworks. Federal, state, and local laws and policies work together to create a complex web of authority, roles, responsibilities, information flow, incentives, and disincentives. As discussed in the methodology, this study collected policy documents from each of the six states and coded each document for habitat type and instrument design. All states have regulatory instruments that prohibit or permit activities in the coastal zone. With the ubiquitous exception for shellfish aquaculture, however, most states rely on regulation that applies broadly to the coastal area and is not narrowly tailored to one of the four focal habitats. The broadest regulatory and policy structures, and most often reviewed in the literature, are authorized by the CWA or the CZMA. Each of the six study states has its own approach to implementing these acts, and some use definitions of coastal habitat that are broad enough to provide protections for one or more of the four focal habitats.

This section describes the CZMA and the CWA, which are consistently used by the six states in this study as the primary regulatory or permitting framework that restricts activities that may impact the four focal habitats. Given that the interpretation or implementation of federal regulations is subject to change based on Supreme Court decisions and shifting administrative priorities, a more detailed analysis of coastal resource governance, including an assessment of the additional relevant federal statutes listed in Appendix C, should be considered.

3.2.1 The Coastal Zone Management Act

CZMA was enacted in 1972 "to preserve, protect, develop, and where possible, to restore or enhance, the resources of the nation's coastal zone for this and succeeding generations."[1] The National Oceanic and Atmospheric Administration (NOAA) administers the CZMA, which is designed as a voluntary partnership between federal and state governments. Rather than creating mandates for states, the CZMA provides incentives for coastal states to develop and implement coastal management programs designed for each state's unique coastal environment and governance needs.

[1] 16 U.S.C. § 1450; 1452

The CZMA is structured around three programs: (1) the National Coastal Zone Management Program, (2) The Coastal and Estuarine Land Conservation Program, and (3) the National Estuarine Research Reserve System. The National Coastal Zone Management Program requires federal actions that may influence resources in the coastal area to be consistent with the enforceable policies of a state's approved coastal management program.[2] While not a focus of this study, the CZMA federal consistency requirement is a key incentive for state participation in the program.[3]

State-level coastal management programs are all distinct and developed to include regulation, financial instruments, and education tools that protect or enhance the coastal area but guided by NOAA's strategic vision—the current strategic plan is for 2018–2023—that is created in partnership with coastal states. States are encouraged to develop their own priorities within several areas, including protecting natural resources and improving coastal water quality.[4] NOAA provides continuing review of all approved state coastal management programs to ensure state compliance with the CZMA. The CZMA allows states to adopt management approaches that are in alignment with the state's existing coastal governance. For example, states, such as California, which delegates authority to local governments to implement many aspects of the CZMA, can rely on local decision making; states like Texas focus on a more centralized approach.[5] All six states in this study have an established state coastal management program.

The Coastal and Estuarine Land Conservation Program is a funding mechanism for state and local governments to purchase land directly or purchase conservation easements. The last funding cycle was in 2017. Since its inception in 2002, the program has protected more than 110,000 acres of coastal and estuarine land. Future funding efforts are not identified, and the status of the program is not indicated on NOAA's website (Office of Coastal Management 2022).

The CZMA also establishes the National Estuarine Research Reserve System (NERRS), which protects estuaries for long-term stewardship, research, training, and education. The purpose of NERRS is to address declining coastal habitat quality through improving scientific understanding of the estuarine system.[6] NERRS are nominated by governors and designated by NOAA upon finding that the nominated estuary meets the statutory criteria for long-term research and that state laws will provide sufficient protection of the area. All six states in this study have at least one designated NERRS site (Table 2). Upon designation, federal financial assistance is available to help protect the estuary through property acquisition, resource management, research, and education activities. NOAA provides funding and national guidance, while the state and local partners, including universities, manage the estuary.

It is beyond the scope of this study to analyze the effectiveness of the CZMA and the associated state coastal management programs. The interviews suggested, however, that the states view creative use of the CZMA as an effective mechanism for protecting and restoring coastal habitat. One state, Texas, characterized its coastal zone management programs as generally effective:

[2] 16 U.S.C § 1456(c)
[3] 16 U.S.C § 1456
[4] 16 U.S.C. § 1452
[5] 16 U.S.C. § 1455(d)(ii); 15 C.F.R. § 923.42–923.44
[6] 16 U.S.C § 1461(b)(ii)

Table 2. State NERRS and National Estuary Program sites

State	NERRS Sites	National Estuary Program Sites
California	3: Tijuana River, Elkhorn Slough, San Francisco Bay	3: Santa Monica Bay, San Francisco Estuary, Morro Bay
Florida	3: Guana Tolomato Matanzas, Rookery Bay, Apalachicola	4: Indian River Lagoon, Tampa Bay, Sarasota Bay, Coastal and Heartland National Estuary
Massachusetts	1: Waquoit Bay	2: Buzzards Bay, Massachusetts Bay
North Carolina	1: North Carolina[a]	1: Albemarle-Pamlico
Texas	1: Mission-Aransas	2: Galveston Bay, Coastal Bend Bays and Estuaries
Washington	1: Padilla Bay	2: Puget Sound Partnership, Lower Columbia

[a] The North Carolina NERRS Sites cover four sites collectively called "North Carolina National Estuarine Research Reserve"

"In the performance measures from 2019, it was calculated that the 1155 acres of wetland were lost [due to a variety of unnamed activities] and a total of 3663 acres of wetlands were gained due to activities subject to CZM regulatory programs" (Texas CMP 2020). The CZMA is an incentive-based policy and does not mandate states to implement specific regulatory mechanisms.

The CZMA encourages states to develop coastal management plans that are integrated into the state's policy context to address common categories of coastal impacts in an adaptable, flexible manner. The adaptable nature of the state coastal management programs is essential to create a dynamic program that adapts to new or emerging challenges, while still protecting the state's coastal resources (Bailey and Fletcher 2013). The policy flexibility extends to questions of local control. States must decide the level of centralization for their coastal management plans. Advocates for strong centralized state management note that state authorities are insulated from local politics, can be responsive to the interests of the general public, and have the resources to manage policy decisions in a consistent manner. Local control advocates, however, note that local information benefits local management, local decision makers can be more responsive, and local control may create more policy innovation by creating incentives for experimentation in policy implementation (Blizzard and Mangun 2008). The six states in this study deploy varying levels of adaptive management plans and reliance on local coastal management, both of which complicate assessments of policy effectiveness and comparative assessments between states.

While the literature review methods used for this study did not capture NOAA's evaluation of the focal states' implementation of the CZMA, the most recent evaluations for each state were reviewed separately because of the importance of the CZMA in protection and restoration of the four focal habitats. NOAA's review assesses the effectiveness of the operation and management of the program and does not assess policy effectiveness, as this study defines it. Each state assessment, however, contains illustrative examples of the themes identified in this report, which are summarized by state as follows:

- **California (2009–2018).** A project focused on Malibu Lagoon restoration is highlighted for its improvement of coastal habitat and the requirement for extensive monitoring. It is identified as a model for future restoration. The evaluation focuses on increasing beneficial use of sediment and program administration, such as improving partnerships, stakeholder engagement, and increasing permitting efficiency (NOAA 2019a).
- **Florida (2015–2020).** Florida's recognized accomplishments focus on effective utilization of CZMA funding and the program's ability to leverage it with state resilience funding to expand the number of and to scale up the size of resilience projects. The assessment also identifies Florida's Aquatic Preserve Program communication program as facilitating awareness about coastal habitat protection across the aquatic preserve sites (NOAA 2020).
- **Massachusetts (2014–2021).** Massachusetts' efforts focused on providing technical assistance and funding for local projects to address impacts associated with climate change. Over a five-year period, the Massachusetts Office of Coastal Zone Management supported the completion of 73 climate change adaptation projects (NOAA 2022).
- **North Carolina (2011–2020).** A key accomplishment for North Carolina is increasing the permitting efficiency for and the use of living shorelines. Over the five-year evaluation period, the North Carolina Coastal Management Program permitted 20 marsh sill projects (NOAA 2021).
- **Texas (2007–2014).** Texas has focused efforts on increasing the accessibility of science for coastal management decision makers, along with addressing administrative challenges (NOAA 2015b).
- **Washington (2009–2017).** A key effort in Washington was to increase the use of marine spatial planning to develop information and resources to improve coastal habitat management (NOAA 2017).

3.2.2 The Clean Water Act

Water quality improvement is key for restoring the four focal habitats, which can themselves contribute to improved water quality. Water quality threats include, among other things, point sources; nonpoint sources of pollutants from nutrients, suspended solids, debris, chemicals, and toxins; as well as atmospheric deposition from more distant sources. These pollutants have varying impacts on water quality and subsequently the focal coastal habitats in this report. Coastal habitat experts emphasized both the importance of improving water quality for protecting coastal ecosystems, and the role that intact coastal habitats have in maintaining clean water. The interviews also indicated the importance of the CWA for driving coastal habitat restoration. For example, an interviewee in Massachusetts stated, "Coastal managers are now relying on the CWA primarily or exclusively." As a result, the study included a review of state-level statutes concerning water quality broadly.

The CWA is the federal statute designed to improve the nation's water quality from point and nonpoint sources.[7] Importantly, the CWA has been most effective at addressing point-source

[7] 33 U.S.C. § 1251 et seq.

pollution, but addressing nonpoint pollution continues to be a challenge (Rotman, Hollis, and Trauth 2021). The CWA is administered primarily by the US Environmental Protection Agency (EPA), although an area that is critical for coastal management is administered by the US Army Corps of Engineers. (USACE). The CWA has several components that rely upon state planning, implementation, and regulation. Section 402 of the CWA prohibits "the discharge of any pollutant" from a point source without a National Pollutant Discharge Elimination System Permit (NPDES).[8] While point-source discharges, such as water from a pipe, are included in the federal permitting program, many nonpoint sources, such as agricultural or urban and suburban stormwater runoff, are not regulated by the permitting program. Implementation of the NPDES program has been noted by scholars as an essential policy for improving the water quality that impacts regional bays across the six study states, including Tampa Bay, Boston Harbor, and Newport Bay (Beck et al. 2019; Bowen et al. 2019; Green et al. 2021).

Key for this study is the protection and regulatory framework created by the CWA for wetlands, which includes salt marsh and some other types of coastal wetlands. Section 404 of the CWA is the primary federal regulatory program that provides protections for wetlands. The USACE issues permits for any dredge and fill of "waters of the U.S.," which includes some wetlands.[9] The jurisdictional extent of the "waters of the U.S." has been the subject of litigation and remains controversial. Because wetlands are waters of the US, any fill of dredged material, impact, or destruction must be reviewed by the USACE and is prohibited without a permit. Permits are granted for activities that cannot be avoided or minimized; any unavoidable impact must be mitigated. Mitigation includes new wetland construction and protection or restoration of existing wetlands. Mitigation policy, however, is controversial and the wetland permitting and mitigation system has been criticized as ineffective (Brown and Veneman 2001; Sudol and Ambrose 2002). As discussed in Section 5 of this report, Florida is the only state studied that is approved to implement Section 404 permits with the USACE no longer serving as the permitting agency. This authority was granted on December 17, 2020, during the study period, and insufficient time has passed to assess its efficacy.

State regulation pursuant to the CWA also affects federal permitting decisions, including the Section 404 permits issued by the USACE. The CWA requires states to adopt water quality standards that are protective of the designated use for all waters of the US within a state.[10] The state water quality standards are then used in both the point source and nonpoint source programs within the CWA. Section 401 of the CWA requires applicants for federal permits to obtain a certification from the state or a tribal nation that the permitted action will not cause or contribute to violations of the state's water quality standards. Water quality standards are set by the states and approved by the EPA. Based on the state water quality standards, states have authority to grant, deny, or require conditions for a 401 certification.[11] As discussed in more detail later, the policy database developed for this study included policy documents that were developed pursuant to the CWA and were the most significant regulatory policy efforts identified in the analysis. Section 208 of the CWA requires water quality management plans for areas

[8] 33 U.S.C. § 1311(a), (b).
[9] 33 U.S.C. § 1344.
[10] 33 U.S.C. § 1313.
[11] 33 U.S.C. § 1341.

that have been designated by states as having substantial water quality control problems. For example, Massachusetts used Section 208 of the CWA as the foundation for efforts to improve water quality for Cape Cod. In 2015, after litigation initiated a series of actions, the Cape Cod Commission revised the 1978 Cape Cod 208 Plan to include nutrient pollution abatement. To implement the updated 208 Plan, Massachusetts Water Pollution Abatement Trust provided $3.35 million (Perry et al. 2020).

The CWA also establishes the National Estuary Program, which is designed to protect and restore estuaries that have been designated as nationally significant by the EPA.[12] See Table 2 for a list of all state National Estuary Program sites. Once an estuary has been designated as a National Estuary Program site, a coalition of state representatives, EPA administrators, and others must develop a Comprehensive Conservation and Management Plan (CCMP) for it. The CCMP is developed by federal, state, and local governments and other stakeholders from international, interstate, and regional agencies; academic institutions; civil society; and the public.[13] Since 2000, the National Estuary Program has protected or restored over 2.5 million acres; the vast majority of which are forest and woodlands. The four focal habitats are minor components of the National Estuary Program (NEP 2022).

3.3 The Four Focal Habitats Have Limited Explicit Protection in State Regulations but are the Focus of State Coastal Habitat Management Plans

3.3.1 Most Policy Documents do not Contain the Four Focal Habitats

Of the hundreds of policy documents reviewed, only a small subset mentions one or more of the four focal habitats as they were initially defined. Table 3 identifies the number of habitat-specific policy documents by state and habitat type. While mangroves and oyster habitats have relatively consistent definitions across states, the definition of seagrasses and salt marshes were tailored to each state. Developing state-specific definitions for these two coastal habitats did not significantly increase the number of policy documents that were coded as habitat-specific. Most of the policy documents that were assessed by this study did not specify a particular type of coastal habitat, but rather focused on whole systems such as estuarine or wetland ecosystems.

3.3.2 Each State has Enacted Some Level of Management for the Four Focal Habitats

All six states have habitat-specific policies to manage the four focal habitats. While the habitat-specific policies are a small percentage of the total state-level coastal management policies analyzed for each, the relative number of policies within a state are indicative of state coastal management priorities. Oysters are a clear priority for Florida, Massachusetts, North Carolina, and Washington. Seagrass also has significant emphasis for Florida, North Carolina, and Texas. The analysis for salt marshes is more complicated than the relatively low numbers might indicate, because salt or coastal marshes are often included in a state's definition of wetland. As discussed in the study limitation section, general state-level wetland policy analysis is beyond the scope of the report. Thus, identifying all the policies that might address impacts to salt marshes directly was not possible. The policy count, however, is only an initial indicator of state focus, not of policy design.

[12] 33 U.S.C. § 1330.
[13] 33 U.S.C. § 1330(b)(iv–v), (c).

Table 3. Number of coded habitat-specific policy documents

Habitat Type	California	Florida	Massachusetts	North Carolina	Texas	Washington
Oysters	7	16	12	19	3	17
Mangroves	0	7	0	0	0	0
Salt Marsh	8	4	9	5	3	1
Seagrass	5	12	2	8	5	3
Total state-level policies coded	87	74	59	60	37	56

Table 4. Percentages of coded habitat-specific policy documents

Habitat Type	California, %	Florida, %	Massachusetts, %	North Carolina, %	Texas, %	Washington, %
Oysters	8	22	20	32	8	30
Mangroves	0	9	0	0	0	0
Salt Marsh	9	5	14	8	8	2
Seagrass	6	16	3	13	14	5
Total state-level policies coded	87	74	59	60	37	56

All policy documents were assessed for distinct policy mechanisms, such as a permit, regulatory mechanism, or educational mechanism. A few states have clear regulatory prohibitions, but many of the prohibitions focus solely on preservation rather than addressing restoration alongside preserving existing habitat. For example, Florida's 1996 Mangrove Trimming and Preservation Act[14] requires a permit for trimming or removing mangroves, with some exceptions, but the act does not address mangrove restoration outside of mitigation requirements or additional mangrove conservation.

3.3.3 Oyster Aquaculture versus Wild Oyster Reefs

All six states have policies related to oysters or shellfish. While the number of policy documents indicates a strong focus on shellfish, the policies overwhelmingly target aquaculture or shellfish harvest but not necessarily native oyster restoration or oyster reef preservation. This study scope, however, is focused only on native oyster restoration and protection. To ensure that all native oyster-related policies were added to the state databases, the authors searched for shellfish as the broadest category that might include native oyster protections. Two issues arise in assessing whether the state emphasis on shellfish accurately reflects native oyster policy. The first challenge is ascertaining whether a policy document demonstrates an explicit intent to protect or restore

[14] § 403.9321-403.9333, Fla. Stat. "Mangrove Trimming and Preservation Act."

native oysters. For example, several states include shellfish in water quality protection regulations. The water quality standard is related to human consumption of shellfish and the direct intent is to prevent contaminated shellfish harvest to protect human health rather than to manage the oyster fishery. To the extent that native oysters are protected from harvest, then this restriction would have a direct impact. North Carolina, for example, does have oyster sanctuaries that serve as direct protection for oysters. Living shorelines are another policy that has a direct effect of increasing oyster restoration. Several states have policies that are intended to increase the implementation of living shorelines. An example is the 2020–2025 Strategic Plan to Protect California's Coast and Ocean, which calls for the state to "fund and promote innovative and transferable nature-based infrastructure adaptation measures and projects of variable size and scale, including living shorelines, eelgrass and oyster beds, wetland and beach restoration, and other adaptation strategies such as managed retreat, where feasible" (OPC 2022).

The second challenge to assessing state policies relative to oyster habitats is that the majority of the shellfish-specific policies are related explicitly to aquaculture, which is outside this study scope. As was noted in the Massachusetts interviews, "The aquaculture industry has grown hugely in the past two decades and it is critical to coastal economy and provides much the same natural benefits as the natural habitat does. There has therefore been relatively little work on the re-establishment of historic extent of oysters" (Massachusetts interview data). This observation was noted across all six study states. For states that have combined native oyster restoration with an increase in aquaculture, the web of shellfish policies could serve to increase protections and restoration of oysters. North Carolina has the most comprehensive suite of oyster policies, including oyster restoration, aquaculture, and conservation (North Carolina Coastal Federation 2022). Deeper analysis would be needed to ascertain the effects on native oyster populations. Taking these challenges together, this study cannot precisely identify and describe the native oyster policy landscape except to emphasize that shellfish aquaculture dominates over native oyster restoration or conservation, pointing to a possible gap in more comprehensive policy approaches to conserve and restore oysters as an essential habitat.

3.3.4 Mangroves

Texas and Florida are the only two study states that have mangroves. Florida is the only state with policies directed at mangrove preservation. Florida's 1996 Mangrove Trimming and Preservation Act limits activities that might affect mangroves and prohibits excessive trimming. Mangrove restoration outside of mitigation requirements is outside the scope of the act. The Florida wetland mitigation policies may include mangroves, but restoration and mitigation efforts specific to mangroves are not described in the Florida policy database. While Texas has substantial mangroves and long-standing efforts to understand the interplay between mangroves and salt marsh, the state has not yet established any policies for their protection or restoration.

3.3.5 Seagrass

This study used three search terms for seagrass: seagrass, baylands, and eelgrass, which are all considered submerged aquatic vegetation (SAV). SAV was not used as a search term because other terms in search strings for seagrass (e.g., wetlands, coastal, estuary, marine) capture articles and reports that use the term SAV, but not seagrass, baylands, and eelgrass. All six states have policies directed at seagrass. California, Texas, and Washington all regulate impacts from shading

associated with structures in the water, such as docks, or have education and outreach programs to reduce impacts from recreational boating. In addition to these regulatory protections and education programs, Florida, Massachusetts, and North Carolina have focused on improving mapping and monitoring of existing seagrass resources.

Seagrass protection efforts include prohibitions on direct impacts, like prop scarring, and utilization of protected areas to conserve large seagrass areas. In addition to protection from direct impact, states have developed a variety of programs for seagrass restoration. The policies emphasize monitoring and mapping as the essential components of restoration. The literature noted some successes in restoration efforts that were monitored over the long term. For example, initial efforts to conduct eelgrass restoration off Anacapa Island off the Southern California coast began in 1991, with another replanting event occurring in 2002. When monitored a decade later, researchers found that the eelgrass habitat expanded to over 1 mile of nearshore habitat (Altstatt et al. 2014). Boston has also been investing in eelgrass restoration in Boston Harbor and nearby bodies of water in partnership with the Massachusetts Division of Marine Fisheries, the EPA, the New England Aquarium, and Mass Audubon. While initial restoration efforts were not successful, efforts in the early 2000s showed promise, owing in part to improved water quality related to improving wastewater treatment. (Bowen et al. 2019) Without historical data, however, the natural recovery of seagrass is difficult to prove. The cases of successful eelgrass restoration in select locations in Massachusetts and California are attributed mainly to careful site selection, ground truthing of findings, thorough intentional planning, and continued monitoring (Leschen et al. 2010; Altstatt et al. 2014).

3.3.6 Salt Marsh

3.3.6.1 State Definitions of Wetlands Are Not Consistent and Definition Breadth Presents Challenges to Distinguishing Protections for Coastal Wetlands or Salt Marsh

Wetlands is a broad term that encompasses both fresh and coastal wetland systems. Each state has a different definition of wetlands and delineation methodology for wetlands that suits the state-specific wetland species composition and habitat. Wetland protection and restoration is important nationally and the regulation of activities that impact wetlands can be controversial. Because the CWA is the primary federal statute to regulate direct impacts to wetlands, the state-level policies are coordinated with the federal wetland protection efforts developed pursuant to the CWA. States use the authority provided in federal and state law to tailor wetland protection and restoration. All six study states use CWA and state-level authority to create unique wetland protections. Further distinguishing the study states from each other would require an in-depth analysis of state-level wetland programs.

3.3.6.2 Study State Policies on Salt Marsh or Coastal Wetland

This study was focused on a subset of wetlands—salt marshes. Determining whether salt marshes are protected by state and federal wetland regulations is not a straightforward analysis. If a state lists salt marshes in the wetland definition in a policy document, the protection of salt marshes is clear. For example, Massachusetts ensures that salt marsh impacts are prohibited by incorporating salt marshes into the definition of wetland in the Wetlands Protection Act (WPA). The WPA prohibits impact in salt marshes, including altering, filling, or dredging of any "coastal wetland, beach, dune, flat, marsh, meadow or swamp bordering on the ocean or on any estuary,

creek, river, stream, pond, or lake, or any land under said waters or any land subject to tidal action, coastal storm flowage, or flooding."[15] Not all states surveyed, however, so clearly identify salt marshes. Texas regulations, for example, defines coastal marshes as a subset of coastal wetlands. The Texas definition of coastal wetlands is "highly productive coastal natural systems composed of waters, substrate, vegetation, and animal life. Coastal wetlands mean marshes and other areas of high biologic productivity where seawater is present during times other than and in addition to storms or hurricanes as defined by the Beaufort Wind Scale. Coastal wetlands do not, however, include any areas seaward of the line of mean annual low spring tide, nor does it include any mainland area where seawater is present only during storms or hurricanes as defined by the Beaufort Wind Scale."[16] Texas also defines coastal marsh as "land areas within coastal wetlands that contain seawater and are characterized by plants that are emergent, rooted, herbaceous hydrophytes." Texas policies rarely address salt marshes or coastal marshes explicitly; The Texas Conservation Action Plan for the Gulf Coast Prairies and Marshes describes salt marsh as within "sensitive marsh and estuary areas" and the Ten-Year Review and Update of the Seagrass Conservation Plan for Texas includes an action to "evaluate importance of linkages among seagrass habitats, and between seagrasses and other habitats (marsh grasses, oyster reefs, wind tidal flats, etc.)." Thus, any Texas protections for salt marshes are created by the wetlands protection program pursuant to the CWA, but do not appear in the policy database analysis to have heightened protection or habitat-specific regulation. However, information from the literature indicates that Texas coastal marshes have received concentrated restoration attention (TPWD 2012b).

3.4 Local or Regional Protection or Restoration Efforts may be Significant

This study's policy database focused on state-level policies that identified one or more of the four focal habitats and did not directly capture local or regional protections. The policy literature and the expert interviews, in contrast, focus on case studies at the local or regional level and raise the relevance of local and regional efforts to understanding the state-level policies. This literature and interview data, while not comprehensive, emphasizes the strong role that local protection efforts play in some states. This study did not conduct a comprehensive review of local policy directed at the four focal habitats. However, the role of local governments was highlighted in the literature review and interviews for California, Massachusetts, and North Carolina. For example, the Massachusetts Shellfish Initiative Strategic Plan (Massachusetts Shellfish Initiative 2021) highlights that each local coastal government has the authority "to develop effective innovative management strategies that are best suited to the nature of the community and local trends in resource abundance and use." The Massachusetts WPA, discussed previously, is also administered through local government conservation commissions, which can adopt more stringent regulations than the state WPA (Hilke et al. 2020). These two Massachusetts programs highlight the ways in which the regulatory landscape and policy effectiveness can be significantly affected by local governance. The importance of local coastal management applies in the CZMA framework, too. A review of the North Carolina Coastal Area Management Act (CAMA) highlights local enforcement as key to coastal policy effectiveness. North Carolina's

[15] Mass. Gen. Laws ch. 131, § 40
[16] 31 Tex. Admin. Code §15.51

local governments issue CAMA development permits if the development activity meets the requirements of the local land use plan among other permitting requirements. The local land use plan often contains policy statements about key coastal resources. Local development permits can increase policy effectiveness by increasing local oversight and enforcement (Blizzard and Mangun 2008).

Because of the significance of local action, further study and review of local coastal management, particularly in California and Massachusetts, is warranted.

3.5 Limited Policy Effectiveness Results

This study was designed to capture illustrative examples of effective implementation of state policies that have a direct impact on the four focal habitats. As described more fully in the methods section, information on policy effectiveness was based on a nonexhaustive literature review and from interviews with state experts in coastal management. The literature and interviews were analyzed based on a set of qualitative criteria that the team identified, in consultation with the Pew Charitable Trusts, as providing some evidence of effectiveness. For this study, effective policies are those that demonstrate one or more of the following:

- An innovative approach
- Qualitative or quantitative evidence of successful mitigation of an identified threat
- Preservation of healthy areas containing one or more of the four focal habitats
- Success in identifying and managing tradeoffs, competing uses and conflicts
- Enabling ecosystem-based approaches to restoration
- Overcoming barriers to successful restoration
- Explicit consideration of climate change impacts and future habitat conditions coupled with management actions

The purpose of using broad and primarily qualitative criteria was to identify policies that show promise rather than limit the analysis to policies that have demonstrated, causal connection to preservation or restoration of one or more of the four focal habitats.

The literature review was the primary source of effectiveness information. Over multiple stages, the literature review identified 85 articles that included search terms for one or more of the four focal habitats, one of the six study states, and some measure of effectiveness. Thirty articles were excluded because the publication date was prior to 2016. Coastal management policy is dynamic and the criticisms of policy that are more than five years old may not apply to current policy landscape. Time lags also affect scholars' ability to assess policy effectiveness. One paper noted that for nutrient pollution the time lag between policy implementation and observed pollution reduction and improved habitat quality can be several years (Tomasko et al. 2018). The remaining 55 articles were reviewed for policy effectiveness information. The 12 articles that included policy effectiveness information do not represent a systematic review of the literature for coastal policy effectiveness broadly. None of the articles demonstrated a causal connection

between a statewide policy and any of the policy effectiveness criteria described previously. Isolating a causal relationship between a policy and clearly identified outcomes is a more robust measure of effectiveness than only measuring success criteria before and after the policy is implemented (Vincent 2016). This study's literature review and the expert interviews surfaced descriptive analyses or observations of success without connection to specific criteria. The 12 articles provided information on the effectiveness of innovative implementation of the CZMA or the CWA, mostly based on local-level illustrative examples, which are described in following sections. Some identified key enabling factors, such as the availability of long-term monitoring data, for policy effectiveness. Effectiveness information is incorporated where applicable into the discussion that follows.

4 RESULTS: INDIVIDUAL STATE SUMMARIES

These state summaries are based on the literature review and expert outreach (per methods description in section 2 and in Appendix A). They are nonexhaustive and time-bound, so may not reflect recent updates to key policies. While the researchers aimed to extract information about the status and policy landscape for each of these habitats across the state, literature and expert interviewees often focused on a specific region or estuary, confirming that coastal habitat threats and, subsequently, management priorities are not uniform across the state. This section includes summaries of the information that was received about the state level, with many examples of research and policy implementation occurring at the local level.

4.1 California

4.1.1 California Coastal Habitat Status and Threats Overview

California's coastline is expansive, spanning over 1,000 miles. If San Francisco Bay shoreline and estuaries along the coast are added, it is at least 3,500 miles long (Heady et al. 2018). This coastal area encompasses bays, lagoons, and estuaries, supporting many waterfront communities and providing a multitude of ecosystem services. Of the four focal habitats in this report, oyster beds, seagrass, and salt marshes are found in the state. All have declined significantly from historical acreage. The threats, including physical alteration or destruction, coastal development, water quality, and climate change, are similar for all three habitats.

Historic habitat modification, largely for agriculture, industry, and coastal development, has been a driver of coastal habitat and wetland loss in the early twentieth century (EPA 2017). This includes over 80% of tidal wetlands in San Francisco Bay (Stralberg et al. 2011) and 75% of estuarine habitat in southern California (Stein et al. 2014). Of the wetland loss in San Francisco, 39% was caused by watershed development and 61% by conversion to barren land (EPA 2017), largely also for development. In the central coast region, the legacy of diking for agricultural purposes and river diversions has been a driver of coastal habitat loss. In fact, 50% of the historic estuary around Elkhorn Slough is still diked (Elkhorn Slough 2015). Groundwater overdraft and river diversions similarly led to higher salinities and nutrient pollution which still plague the region (ESA PWA 2014). Sea level rise remains—unanimously in the literature and during interviews—an emerging threat, with projections as high as 1 ft by 2030, 2 ft by 2050, and 7 ft by 2100 (LAO 2019; Rosencranz 2017). Specific threats to the focal habitats (salt marshes, oyster

beds, seagrass) and related coastal management priorities are not necessarily uniform across the state. Threat information specific to each habitat is described in individual sections that follow.

4.1.2 Focal Habitat Status and Threats

4.1.2.1 Oyster Beds

Olympia (*Ostrea lurida*); Pacific, also known as Miyagi (*Crassostrea* or *Magallana gigas*); Kumamoto (*Crassostrea sikamea*); and to a smaller extent Eastern (*Crassostrea virginica*) oyster species occur within California's coastal habitats. Of these, only the Olympia oyster, whose historic range included California and for which there is evidence of cultivation by the Chumash peoples over 5,000 years ago (Rick et al. 2005), are native, though classified as "functionally extinct" along the West Coast (Wood 2018), despite some beds remaining open for commercial harvest (Beck et al. 2011).

Most of California's oysters are cultivated for commercial harvest, including wild and aquaculture harvest. The commercial oyster fishery has a rich history dating back to the 1850s, though California Native American tribes and tribal communities harvested oysters well before then (Bailey et al. 2003; Larinto 2010). Commercial fishery operations are concentrated in estuaries in central and northern California, notably in Humboldt Bay, Drakes Estero, Tomales Bay, and Morro Bay, though there are also oyster beds in southern California. The Pacific oyster has "escaped" from oyster farms and been able to establish itself in the wild (CCC 2021). Pacific oysters have substantially increased in abundance and distribution over time—from California and north into British Columbia, Canada—and now show remarkably similar distributions to native Olympia oysters (Kornbluth et al. 2022). Pacific oysters' range may continue to expand north as climate change leads to shifts in oceanic conditions. Potential risks associated with the settlement and expansion of Pacific oyster in the wild include the potential to displace wild oysters and reduce biodiversity in the region, though the literature did not identify the extent of such effects in California specifically (Herbert et al. 2016)

As a result, many of the threats to oysters are also threats to the viability of commercial shellfish fisheries, which are primarily focused on nonnative oyster aquaculture. Noted threats include water quality impairments, habitat degradation from harvesting practices, the use of pesticides in agriculture and the introduction of nonnative species such as invasive crabs and whelks (Bailey et al. 2003; Kimbro et al. 2009), and the introduction of nonnative oysters. Interviews with experts in southern California focusing on threats to Olympia oyster habitat suggest that historical overharvest and habitat modification as well as pollution, shoreline hardening, and disease are threats, though they did not prioritize which were the most concerning threats of the list.

4.1.2.2 Salt Marsh

Salt marsh habitats, often grouped within the "coastal wetland" category in literature and state policy, occur in estuaries, bays, and lagoons in areas along the entire California coast. Approximately 37,000 acres of salt marsh exist in California (Rosencranz 2017). Studies in Southern California demonstrate that the area also once had robust salt marsh habitat, including such diversity as "large fringing freshwater wetlands, salt flats, and alkali meadows" (Leeper et al. 2017).

The main threats to salt marshes were identified as sea level rise, reduction in sediment flow from dams, and coastal development. Salt marshes are sensitive to deviations from their "established marsh elevations" as small as 10 cm, which can affect species distribution, productivity, erosion, and accretion rates (McClure et al. 2016; Rosencranz 2017). Expert interviewees emphasized that dams reduce sediment flow to salt marshes. With insufficient sedimentation in salt marshes, sea level rise threatens their ability to remain above water. At the same time, coastal development and sloped coastal areas prevent salt marshes' ability to migrate inland, a consistent phenomenon across all six states. Modeling of sea level rise scenarios and various management adaptations suggest that without major adaptations, "salt marsh–dependent wildlife in the majority of California coastal zones will be extirpated by 2100 under high [sea level rise] scenarios." The development of military, municipal, and industrial infrastructure in some of these historically wetland-rich areas has since reduced their extent. In Southern California, sedimentation rates have increased in some marshes, in part caused by storm events, but decreased in other areas from droughts, urbanization, and flood control projects. Currently, the long-term effects of sedimentation on salt marshes and their ability to buffer against accelerated sea level rise in southern California are not fully clarified (Rosencranz 2017).

Coastal development can impact salt marshes both by direct physical alteration of the habitat and through hardening of the shoreline. Interviewees suggest that coastal development and its effect on salt marshes is not uniform throughout the state. In Southern California, coastal development has encroached directly into marsh habitat, whereas in Northern California, coastal development is not as much of a threat as the diking of wetlands for agricultural purposes (California interview data). Additionally, research about threats to salt marshes suggest marsh vegetation dieback is in part associated with shoreline hardening and other anthropogenic activities (Alber et al. 2008). The second half of the twentieth century saw armoring of 12% to 30% of all shorelines across the US, with 50% to 70% being urban shorelines (Dugan et al. 2018).

4.1.2.3 Seagrass

In California, seagrass habitat is dominated by eelgrass, and is considered increasingly rare but important habitat that supports juvenile and adult fish (Sherman and DeBruyckere 2018). Over 80% of seagrass meadows are concentrated within five bays: Humboldt Bay, San Francisco Bay, San Diego Bay, Mission Bay, and Tomales Bay. Current estimates for eelgrass habitat in California range between 11,000 to 15,000 acres (around 4,450 to 6,070 hectares) across the state (NOAA Fisheries 2014). In a survey of estuaries across California, Oregon, and Washington, researchers found that eelgrass occurs in 36% of estuaries on the West Coast, though 41% of estuaries do not have data, so that figure may be different. Surfgrass is also found in nearshore habitats in California (CDFW 2022).

Eelgrass is threatened by coastal development, nutrient loading, effluent discharge, and upland sediment discharge (Honig et al. 2017). Boat anchoring can also have significant impacts to eelgrass beds, with a single boat anchoring causing as much as 0.3 hectares of damage in the bed (Kelly et al. 2019). In addition, the limited distribution and depth range under which eelgrass is viable make it vulnerable to sea level rise and temperature changes (NOAA Fisheries 2014; Sherman and DeBruyckere 2018). Research in Morro Bay has found that 95% of eelgrass coverage was lost in the last century, largely from major dieoff events. While the die-off events

in Morro Bay are not yet fully understood, evidence suggests that increased sedimentation from an irregular wildfire season from 1994 to 1997 was the main driver; causes of more recent declines are not well-known (Harenčár et al. 2018). Expert interviews indicated that the effect of increasingly severe wildfire seasons on coastal habitats is not well-elucidated.

Wasting disease, caused by the slime mold *Labyrinthula zosterae*, has also led to several major dieoffs on the East and West Coast (Wood 2018), with the most recent one occurring on the West Coast in the early 2010s. However, wasting disease was not cited by interviewees as a major threat to seagrass.

4.1.3 Policy Landscape

In the assessment of state-level policies, several explicitly mentioned the habitats of interest to this study, though few included enforceable or comprehensive provisions for the protection and restoration of the habitats. While there are policies that explicitly mention oysters and oyster habitat, they are focused on cultivation and the commercial fishery and are therefore not included in this report. Interviews did not indicate that a state-level policy is intentionally or unintentionally protecting oysters; as a result, these are not included in the report.

For California, 87 state-level policy documents, including substatutes, codes, and management plans were assessed. Of these, seven mentioned oysters (or shellfish broadly), eight mention salt marsh, and five mention seagrass or eelgrass. The policy landscape description that follows is a summary of the relevant habitat-specific text extracted from policy documents, a noncomprehensive literature review, and expert interviews.

4.1.3.1 Habitat-Specific Policies

Eelgrass Mitigation Policy (National Marine Fisheries Service). In 2014, NOAA Fisheries released its California Eelgrass Mitigation Policy, which is intended to achieve no net loss of functional eelgrass habitat for California. The policy is consistent with the avoid, minimize, and mitigate policy developed for wetlands pursuant to the CWA and fills a gap in California, which did not have a statewide strategy for the mitigation of eelgrass impact.

State of California Ocean Acidification Action Plan (California Ocean Protection Council). This multi-pronged approach for ocean acidification includes commitments to research, conserve, manage, restore, and enhance all three habitats of interest (Berry et al. 2021; Phillips et al. 2018). While ocean acidification is a direct threat for shellfish, salt marshes and seagrasses can sequester carbon and ameliorate ocean acidification. Implementation of these initiatives is still under development, primarily led by the California's Ocean Acidification and Hypoxia Science Task Force. The California Ocean Protection Council is a cabinet-level oversight body created pursuant to the California Ocean Protection Act and serves to coordinate state agencies and develop and recommend state-level policies to work towards ocean protection efforts (OPC 2022).

Strategic Plan to Protect California's Coast and Ocean 2020–2025 (California Ocean Protection Council). This strategic plan has set measurable and time-bound targets for specific seagrass preservation (15,000 acres) and creation (1,000 acres) and identified the California Eelgrass Mitigation Policy as a key resource and guidance for protection and restoration of seagrass. It also intends to fund nature-based infrastructure, including eelgrass, oyster bed, and

wetland restoration, as well as managed retreat as adaptation measures. It set a goal of increasing the total statewide acreage of coastal wetlands by 20% by 2030 and 50% by 2040 through preservation, creation, or restoration.

California State Wildlife Action Plan (California Department of Fish and Wildlife). This set of plans, released in 2015, has measurable and time-bound targets for salt marsh habitat extent, genetic connectivity, and diversity, as well as water quality that affects salt marsh habitat. It also supports the acquisition of land through fee title or conservation easements across the state, and intends to fund research, monitoring, and education and outreach about conservation and restoration programs.

4.1.3.2 Broadly Applicable Policies

Management and oversight of coastal habitats in California is desegregated and concentrated along independent systems along the coast. This finding reflects both the literature for California, which tends to focus on specific ecosystems, and expert interviews, which acknowledge the decentralized nature of coastal governance. What follow are descriptions of some agencies and state policies that contribute to the governance of coastal systems on a state level with the potential to have significant effects on the focal habitats. In addition, some local programs that are working within the confines of or in partnership with the state agencies are highlighted in the next section, along with measures of effectiveness.

The California Coastal Act and the McAteer-Petris Act. The California Coastal Act, established in 1976, and the McAteer-Petris Act of 1965 form the state's coastal zone management program. The authority to implement the CZMA rests with the California Coastal Commission, Coastal Conservancy of California, and San Francisco Bay's Conservation and Development Commission (BCDC). The California Coastal Commission and the BCDC implement the federal CZMA, oversee restrictions for potential environmentally sensitive habitat, regulate coastal development permits (Reiblich et al. 2018), and support local government planning and enforcement of local coastal programs (LCPs), which also guide development in coastal areas. The Coastal Conservancy, established in 1976, is a nonregulatory agency that supports habitat protection, enhancement, and restoration, as well as increased access for restoration. It also implements the relevant components of the State's Wildlife Action Plan, highlighted above.

California Department of Fish and Wildlife. Among many other programs, the California Department of Fish and Wildlife oversees marine protected areas (MPAs) designated through the state's Marine Life Protection Act. California's marine protected areas can include marine reserves (no-take), marine conservation areas (limited take for some commercial species), and marine parks (recreational fishing allowed). They are not explicitly designed for the protection and restoration of the three habitats of interest, though many units within the state MPA network include nearshore areas, including in Elkhorn Slough and Morro Bay. The Department of Fish and Wildlife also oversees the Wetlands Restoration for Greenhouse Gas Reduction Program under the state-level Greenhouse Gas Reduction Fund. Wetland restoration projects are a part of an effort to support carbon sequestration (Leo et al. 2019).

The California Water Boards. Established via the Porter-Cologne Water Quality Control Act to oversee the implementation of the CWA, The California State Water Resources Control Board and nine regional Water Control Boards (the California Water Boards) review and approve applications for dredge and fill activities that lead to discharges of pollutants or sediments into coastal areas including wetlands, bays, and estuaries. One of the many responsibilities under the water boards is the protection of "existing and future beneficial uses of bay and estuarine waters," which includes identifying water where "shellfish, fish, and wildlife are threatened by toxic pollutants," or sediment quality issues, as consistent with federal law.[17] The water boards are subsequently responsible for toxic hotspot remediation, water quality control, and pollution prevention, which can at times include the development of more stringent waste discharge requirements. As a part of this, the deposition of dredge spoils is prohibited in areas where it may harm fish, shellfish, or wildlife. As discussed in the Section 5 of this report, one of their recent relevant accomplishments was the adoption of the State Wetland Definition and Procedures for Discharges of Dredged or Fill Material to Waters of the State, which clarified "1) a wetland definition; 2) a framework for determining if a wetland feature is a water of the state; 3) wetland delineation procedures; and 4) procedures for the submittal, review and approval of applications for Water Quality Certifications and Waste Discharge Requirements for dredge or fill activities" (California Water Boards 2021).

The California Environmental Protection Agency and Natural Resources Agency. Together, these agencies jointly oversee the California Water Quality Monitoring Council to more effectively integrate monitoring and reporting of water quality and its impact on ecosystems. This includes a California Wetland Monitoring Workgroup, an Estuary Monitoring Workgroup, and an Ocean and Coastal Ecosystem Health group.

The California Natural Resources Agency. This agency developed a Climate Adaptation Strategy (CAS) in 2009, which is periodically updated, including most recently in April 2022. The CAS has created seven sector working groups composed of and led by stakeholders from various government bodies and communities: public health, ocean and coastal resources, flood protection and water control, forestry, agriculture, biodiversity and habitat, and transportation and energy infrastructure. Local governments are encouraged to update all local coastal plains under the CAS by using Cal-Adapt, a web-based mapping tool designed to help local governments access climate research, to account for the impacts of climate change in the state following guidelines from the California Conservation Corps, and integrating the Delta Risk Management Strategy, which models risk reduction and cost-benefit analyses (Blakely and Carbonell 2012).

These agencies rarely work in isolation from each other. For example, the California Coastal Commission oversees the process for living shorelines, which require Coastal Development Permits. If any dredge, fill, or sediment are implicated in projects, California Water Agency and USACE consultation is required. Likewise, work on public trust lands requires coordination with the State Lands Commission. Consultation from water quality boards and NOAA may also be required. Living shorelines came about in California from a policy push by NOAA, USACE, and the California Coastal Commission. In the San Francisco Bay, living shorelines are implemented

[17] Cal. Wat. Code § 13390–13396.9.

using oyster shell bag mounts and eelgrass beds under the guidance of the California Coastal Conservancy and 17 other partners (Reiblich et al. 2018; Coastal Conservancy, State of California, 2018).

4.1.3.3 Highlighting Integrated Local Initiatives

While this report intends to focus on the state-level implementation of coastal habitat protection and restoration measures, the consensus from interviews that oversight of coastal habitats in California is highly decentralized begets the need to highlight a number of examples of local programs that protect coastal habitat and operate within the state policy framework. Throughout the literature and interviews, close to a dozen such initiatives were mentioned spanning the entire coastline, described in the sections and table that follow.

Parcel Taxes for Restoration (Measure AA). The San Francisco Bay Clean Water, Pollution Prevention and Habitat Restoration Measure, otherwise known as Measure AA, which was voted on by nine counties surrounding San Francisco Bay and passed in 2016, imposed a $12 annual parcel tax on properties in the nine counties adjacent to the Bay. Revenues from this parcel tax are used to fund wetland restoration and provide recreation opportunities (Adaptation Clearinghouse 2016). The funding is expected to raise 25 million dollars annually, and 500 million dollars over 20 years.

Newport Bay Eelgrass Protection and Mitigation Plan for Shallow Waters in Lower Newport Bay: An Ecosystem Based Management Program. This plan was developed to protect eelgrass in Newport Harbor during maintenance dredging activities in residential and commercial docks. Under this plan, an eelgrass management threshold (EMT) is determined areas with eelgrass habitat from which mitigation actions are established and what the allowable impact to eelgrass is depending on the EMT. If a maintenance dredging activity is at or above the EMT in stable or transitional zones, several actions are triggered to mitigate and monitor the impact of the activity on eelgrass, including deploying eelgrass seeds, surveying eelgrass coverage, and conducting outreach programs (City of Newport Beach 2015).

Layered Governance of Elkhorn Slough. Portions of the Elkhorn Slough are jointly or individually managed by different state and federal partners including the Elkhorn Slough National Estuarine Research Reserve (NOAA and the state), the Elkhorn Slough Foundation, and the California Department of Fish & Wildlife (Elkhorn Slough n.d.). Numerous state and national protection initiatives take place in and around Elkhorn Slough; the region is home to the Elkhorn Slough State Marine Conservation Area, the Elkhorn Slough State Marine Reserve and Moro Cojo Slough State Marine Reserve, and three other MPAs (California Department of Parks and Recreation 2022). Likewise, local government authorities such as the Moss Landing Harbor District and the County of Monterey oversee components of Elkhorn Slough management through the Title 20 Zoning Coastal Implementation Plan, Monterey County General Plan, Monterey County Local Coastal Plan, and the North County Land Use Plan.

Elkhorn Slough management focuses on habitat restoration and managed retreat to respond and adapt to habitat loss and sea level rise. Projects include restoring a 61-acre tidal wetland and marsh (Elkhorn Slough 2019), a project to remove invasive eucalyptus and restore native

grasslands, and native oyster and eelgrass restoration projects. One of the challenges to efforts intended to address SLR in Elkhorn Slough is the lack of sediment. Despite fairly extensive current and historical dredging happening in channels in and around Elkhorn Slough, the process for taking advantage of dredged material for beneficial uses to facilitate restoration and managed retreat remains inefficient, with dredged material being expensive and inaccessible for restoration projects.

South Bay Salt Pond Restoration Project (SBSPR) and San Francisco Bay Area Wetlands Ecosystem Goals Project. The SBSPR is the largest tidal wetland restoration project in the Western United States and, when completed, will restore a total of 15,100 acres as a part of a broader goal to restore 100,000 acres in San Francisco Bay. As of 2016, 1,500 acres have been restored (DeAngelis et al. 2020, Pontoriero 2016). This was only made possible by the initiative taken by the San Francisco Bay Area Wetlands Ecosystem Goals Project and a partnership with Cargill, the state and private philanthropy, as this project set the goals and mechanisms in place to catalyze meaningful restoration projects of the San Francisco Bay. This project was developed by a group of scientists, managers, and nine state and federal agencies including the California Department of Fish and Wildlife, the National Marine Fisheries Service, the US Fish and Wildlife Service, the San Francisco Bay Regional Water Quality Control Board, the San Francisco Estuary Institute, as well as an interagency Resource Managers Group (Goals Project 1999). More recently, funding from Measure AA has supported this major restoration project. The effort aimed to bring together these groups working individually on the San Francisco Bay to create a shared vision for the estuary (DeAngelis et al. 2020). By setting quantitative recommendations, such as a number of acres of tidal wetlands restored, this initiative has facilitated greater funding for restoration from which the SBSPR project has benefitted. The Goals Project has also been incorporated into state and regional planning in the San Francisco Bay and has resulted in significant improvements to the local ecosystems of the San Francisco Bay, a result of the collaboration and coordination between agencies, scientists, and resource managers. Adaptive monitoring is essential for evaluating progress toward set goals. For example, monitoring of the site during California's historic drought from 2011 to 2015, and before then from 2009 to 2011, found that "vegetation increased at a mean rate of 1,979 m2/year during California's historic drought, 10.4 times slower than … when the state was not in drought" (Chapple and Dronova 2017).

Carbon Markets for Wetlands in the Sacramento–San Joaquin Delta. In partnership with California's Department of Water Resources, Department of Fish and Wildlife, academia, industry, and NGOs, the Sacramento–San Joaquin Delta Conservancy developed a California Wetland Protocol to guide carbon offset certification for wetlands. It has since been certified by California's carbon offset certifier, the American Carbon Registry. This signals a potential for integration of wetland projects into California's carbon compliance and offset program (Sapkota and White 2020). Since the development of the California Wetland Protocol in 2017, the coalition has worked with "public and private landowners and project developers to build pilot projects that can verify greenhouse gas emission reduction credits and realize revenue by trading credits on the voluntary carbon market," providing incentives to landowners (Delta Conservancy 2022). Carbon offsets from wetlands, however, may be complicated by the uncertainty associated with their sequestration potential (Sapkota and White 2020).

Table 5. Additional local interventions not described, but identified in literature review and interviews process

Initiative	Location
Native Olympia Oyster Collaborative (OysterNet n.d.)	University of California, Davis
Sea Level Rise Research Hubs (Stephens 2021)	University of California, Santa Cruz; University of California Irvine
San Diego Bay Living Shorelines/ Oyster Restoration Project (SCWRP n.d.)	Southern California Wetlands Recovery Project: San Diego Bay

4.1.4 State Innovations and Current Initiatives Leading to Effective Policy

Across the literature and interviews, a number of policy agenda items are currently being pursued by coastal habitat practitioners. Across the state, coalitions are forming to develop and institutionalize these initiatives that facilitate habitat restoration and catalyze protection for existing habitats. These initiatives are highlighted as follows.

Cutting the Green Tape Initiative. This cross-agency initiative aims to streamline and coordinate across agencies to improve the regulatory landscape under which environmental interventions are approved. In their 2020 report, the authors lay out 14 recommendations developed from extensive stakeholder input, to amend the permitting process for restoration and other projects (California Landscape Stewardship Network 2020). These include recommendations for both small- and large-scale projects, as well as coastal zone and freshwater projects specifically, and include provisions for simplifying permit applications across agencies. These recommendations are also expected to reduce costs and save time. Interviewees have referred to it as a "good faith effort" to reconcile opposing views on the impact of various regulatory permitting processes on restoration efforts across the state.

Beneficial Dredging. While beneficial reuse of dredged material is overseen by California Water Boards and a "minor amount of fill" can be permitted for habitat purposes, information gained from the literature and interviews suggests that coordination between different agencies for beneficial fill is minimal and using a larger amount of beneficial fill triggers the BCDC or California Coastal Commission standard fill policy, an additional regulatory hurdle for restoration. Distinguishing between fill for restoration and fill for development may help remove this barrier and reduce the cost of securing sediment for restoration significantly (BCDC 2016). For salt marshes, iterative sediment fill from dredging (which occurs regularly) can be a lifeline. In October 2019, the BCDC amended the San Francisco Bay Plan with the Fill for Habitat Bay Plan Amendment which will enable more fill for habitat projects in the bay, expedited permitting of restoration in the bay and encourage additional understanding and consideration of the effects of sea level rise on coastal habitat (BCDC 2022). The effectiveness or impact of this amendment had not been evaluated or mentioned in the literature or interviews, likely because it has not yet been implemented in the area.

Salt River Ecosystem Restoration Project. One interviewee noted this project as a strong example of the permitting process being an effective tool for restoration project implementation. This project proposed to restore a 400-acre property to tidal marsh and retain 75 acres of short grass estuary habitat, in addition to river and upslope restoration. Upon finding that the Environmental Impact Report submitted for the restoration project would mitigate or avoid negative environmental effects, the Coastal Conservancy authorized a disbursement of close to $700,000 to the Humboldt County Resource Conservation District to support the project. According to this interviewee, "it's not easy to go through that permit process, but it can be useful."

Measure AA. In 2018, the governing body overseeing funds raised from Measure AA began awarding $47 million in funding for restoration projects (San Francisco Bay Restoration Authority 2018). From this funding, close to 6,500 acres of habitat has been restored, including 4,800 acres of tidal marsh, achieving over 30% of their restoration goals. As for shellfish beds and submerged aquatic vegetation (e.g., seagrass), the funding from measure AA has so far reached 1% of their goals (totaling 1 acre and 3 acres currently restored, respectively). No annual report on the progress of measure AA has been published since 2018, though they continue to generate upwards of $20 million annually for restoration (San Francisco Bay Restoration Authority 2021).

4.2 Florida

4.2.1 Florida Coastal Habitats Overview

According to NOAA shoreline assessment, Florida has approximately 8,436 square miles of coastline, including estuaries, bays, sounds, and the tidally influenced portions of rivers and creeks (NOAA 2019b). Florida is one of four coastal states with all four focal habits—mangroves, salt marsh, seagrass, and oyster habitat. According to the 2016 Cooperative Land Cover Map (version 3.2), Florida contains approximately 378,690 acres (153,250 hectares) of salt marshes, 571,750 acres (231,380 hectares) of mangrove swamp, 2.2 million acres of seagrass and an estimated but not comprehensive 19,580 acres (7,920 hectares) of live oyster reefs (Radabaugh et al. 2019). While this report is focused on the four focal habitats, some of the state-specific data aggregate habitat types. For example, salt marshes and mangroves are often grouped under a broader wetland category in state policy and habitat assessments for Florida. The Coastal Habitat Integrated Mapping and Monitoring Program, for example, monitors salt marshes and mangroves. This report highlights these distinctions where possible.

Florida's habitats have been significantly impacted by direct conversion to developed land and the associated impacts from coastal development All of the four focal habitats have experienced declines related to the stressors associated with the development, but salt marsh and mangroves have been especially affected (Radabaugh et al. 2019). Changes in freshwater flow as a result of historic impoundments, damming, and flow modification for agriculture and subsequent changes in salinity, water quality, and sedimentation have also had significant impacts on the coastal habitats of interest, as confirmed in the literature and in interviews. Among interviewees, there was not consensus on the significance of septic systems to overall degraded water quality in coastal systems, with some interviewees suggesting it is a large contributor, and others considering it minor compared to other sources of nutrient pollution.

Because of the large amount of coastal area and the difference in development density, freshwater sources, and flow throughout the state, habitats in Florida are rarely evaluated on the state level and are often disaggregated by water management district or other regions.

4.2.2 Habitat Status and Threats

4.2.2.1 Mangroves

Mangroves are found throughout Florida, but the mangrove species composition varies by latitude. Of the four dominant mangrove species—red, black, white, and button—only black mangrove can tolerate winter weather. (A. Watson et al. 2017). Black mangrove is migrating northward as climate change reduces the number and severity of freeze events. (Florida DEP 2022b) As noted elsewhere in this report, black mangrove habitat is expanding into salt marsh in the western Gulf of Mexico but is a less significant threat to salt marsh than sea level rise (A. Watson et al. 2017; Florida and Texas interview data). Within the literature reviewed for this report, estimates of mangrove distribution vary from 571,750 acres to 614,098 acres or 1.71% of land cover. (Radabaugh et al. 2019; Volk et al. 2017). The Florida Department of Environmental Protection estimates mangrove habitat at 600,000 acres (Florida DEP 2022c). The spatial extent of mangroves changes over time in response to freezes, rainfall, and storms, including hurricanes (A. Watson et al. 2017). Overall, the extent of mangrove distribution has been in decline. For example, in the 1980s, 23% of historical mangrove coverage was estimated to have been lost to development (150,000 acres or 60,702 hectares) (Radabaugh et al. 2017). Currently, much of Florida's existing mangroves are on conservation lands (Radabaugh et al. 2019).

Threats and stressors to Florida mangrove systems include coastal development and the associated land use change and increased rates of water pollution, sea level rise and impacts associated with climate change, and invasive vegetation (Radabaugh et al. 2017; A. Watson et al. 2017). The Florida interviews identified the interaction between the dredge and fill and hardening of the shoreline associated with coastal development and sea level rise as the biggest current threats to mangroves. Mangroves can adapt to sea level rise through upland migration (A. Watson et al. 2017). If coastal development prevents the migration, suitable mangrove habitat is eliminated. Invasive species, which include the Brazilian pepper, Australian pines, and melaleuca, can also adversely affect mangroves (Radabaugh et al. 2017).

4.2.2.2 Oyster Reefs

Florida oyster populations are the most stable on the eastern seaboard. However, oyster reefs are still classified as in poor and declining condition (Radabaugh et al. 2019, 8). In Florida, oyster reefs have suffered a decline in spatial extent of 90% to 99% from historical levels (A. Watson et al. 2017). The Apalachicola Bay oyster reef system was historically one of the most significant systems for oyster harvest in Florida, accounting for more than 90% of oyster sales (Hintenlang 2020). The fishery collapsed in 2012 likely from reduced freshwater flow and the resulting increase in salinity, as well as overharvest (Brown 2016). The collapse resulted in an "official fisheries disaster declaration by NOAA in 2013" (Hintenlang 2020; Camp et al. 2015; Florida SeaGrant 2012). The Florida Fish and Wildlife Conservation Commission voted to shut down Apalachicola Bay to wild oyster harvest in July 2020 through 2025 to help enable restoration efforts (Hintenlang 2020). Apalachicola Bay has been classified as an Area of Critical State Concern (Florida FWC 2019). In 2022, The Florida Fish and Wildlife Conservation Commission launched

restoration efforts in Apalachicola Bay, with tens of millions of dollars from the National Fish and Wildlife Foundation dedicated to deploying reef material for recruitment (McNeal 2021). Interviewees noted that there are competing interests and conflicts between oyster reef and seagrass restoration as well as horseshoe crab nesting site protection in the state.

Threats and stressors to Florida oyster reefs include salinity changes, temperature changes, habitat alterations associated with coastal development, sedimentation, nutrients, sea level rise, and ocean acidification (Florida FWC 2019). As altered hydrology affects salinity—usually by decreasing freshwater inflows to oyster reefs—oyster growth rates can decline, along with increasing predation, disease, and mortalities. As sea surface temperatures increase, oyster growth declines and mortalities increase (A. Watson et al. 2017). Coastal development changes the habitat structure, including the surface area available for oyster reefs. In addition, sea walls increase wave energy, which adversely impacts adjacent oyster reefs. Sea level rise is anticipated to be a significant stressor for oyster reefs because it may increase salinity in oyster reef areas and increase water depth and submergence times at a faster pace than oyster reefs can elevate or migrate landward. Climate change may also alter rainfall patterns and result in increasing ambient temperatures, which will exacerbate the stressors already discussed (Radabaugh et al. 2019). Some interviewees noted that diseases are more prevalent under saltier conditions and that the prevalence may be getting more severe, especially in Southeast Florida, where the prevalence of oyster drills makes oysters more vulnerable to other threats. Other interviewees noted that invasive species, such as the burrowing sponge (*Cliona celata*) degrades the quality of the shell and reduces the resilience of oyster reef areas, though this threat was not cited in the literature.

4.2.2.3 Salt Marsh

Salt marsh is the dominant coastal habitat from Apalachicola Bay to Tampa Bay (Florida DEP 2021). As of 2015, Florida had 378,678 acres of salt marsh. (Volk et al. 2017, 74) Salt marsh, which is made up of salt-tolerant grasses, rushes, succulents, and shrubs, generally occurs in bays and estuaries that are protected from wave action and are in shallow, low-sloping coastal areas (Radabaugh et al. 2017).

Salt marsh has historically been impacted by impoundments built to manage mosquitos and other insects. (Radabaugh et al. 2017). For example, between 1950 and 1960, nearly 40,000 acres of saltmarsh were impounded for mosquito control, with management strategies that included ditching, enclosure, dewatering, filling, and spraying with dichlorodiphenyltrichloroethane (DDT) (Adam 2002; Carlson et al. 2019; Radabaugh et al. 2017). There are also records of salt marsh dieback in the Florida panhandle between 1990 and 1995, though there is no clear consensus on their cause or recovery (Alber et al. 2008). Other threats to salt marshes in Florida include oil spills, waste disposal, coastal development, sea level rise, and displacement by mangroves (Radabaugh et al. 2017). Sea level rise is anticipated to have a significant impact on salt marsh. Modeling projects that a 3-meter sea level rise will adversely impact approximately 88% of Florida's salt marsh. (Florida FWC 2019). Salt marshes and seagrass are often grouped under a broader wetland category in state policy and habitat assessment.

4.2.2.4 Seagrass

Florida's seagrass areas cover approximately 2.5 million acres of shallow sediments and nearly 2 million acres of offshore seagrass habitat off the Big Bend region. As of 2016, there is 618,000 acres of nearshore seagrass concentrated in the Big Bend and Springs Coast regions, while south Florida has about 1.6 million acres. Overall, seagrasses have been in decline across Florida since the 1950s (Yarbro and Carlson 2016). Some local restoration efforts discussed in this report have shown some effectiveness in stemming the decline, including Tampa Bay and Sarasota Bay.

The significant threats for seagrasses are primarily those that limit light from reaching the grass blades on seagrass beds, such as increased sediment, nutrients, or water color changes; impacts from coastal dredge and fill activities; and physical impact from boat propeller scarring (Yarbro and Carlson 2016).

4.2.3 Policy Landscape

4.2.3.1 Habitat-Specific Policies

As reviewed in Section 3, the state-level policy assessment identified a limited number of policies that explicitly mention one or more of the four focal habitats, though few include enforceable or comprehensive provisions for habitat protection and restoration. While there are policies that explicitly mention oysters and oyster habitat, they are focused on cultivation and the commercial fishery, and therefore are not included in this report. Interviews did not indicate that a state-level policy is intentionally or unintentionally protecting oysters; as a result, these are not included in this report. The Florida habitat-specific policies identified in the policy database, literature review, and expert interviews are as follows:

The Mangrove Trimming and Preservation Act of 1996. This act is designed to protect and preserve mangroves "from unregulated removal, defoliation, and destruction" and to encourage voluntary private property actions to encourage mangrove planting.[18] Florida interview data suggests that this policy is effective in reducing the selective clearing or removal of mangroves, but that it has limited flexibility and cannot accommodate new shoreline management activity like living shorelines.

Seagrass Integrated Monitoring and Mapping Program (SIMM), Coastal Habitat Integrated Mapping and Monitoring Program (CHIMMP), and Oyster Integrated Mapping and Monitoring Program (OIMMP). Florida had several habitat-specific policies related to increasing mapping and monitoring of one or more of the four focal habitats. While these policies are not currently funded, Florida's effort to develop and maintain statewide monitoring and data sharing for seagrass, mangroves, and salt marsh is notable.

- SIMM was established in 2009 to create a data platform for seagrass mapping and monitoring programs. Mapping was not implemented consistently across the state and funding limitations ended the formal program (Yarbro and Carlson 2016).
- CHIMMP was designed to collect information through workshops and outreach that was incorporated into a technical report for use in coastal management decisions for salt marshes and mangroves (Brockmeyer et al. 2021).

[18] § 403.9323, Fla. Stat.

- OIMMP had the same purpose as CHIMMP and SIMM. The final technical report was published in 2019 and some regions have updated information as recently as March 2022 (Radabaugh et al. 2019).

Statewide Ecosystem Assessment of Coastal and Aquatic Resources. This project is an ongoing collaboration intended to create an inventory of information related to five priority submerged habitats, including the four focal habitats. As of the date of this report, the inventory has been released and can be accessed at https://data.florida-seacar.org/ (SEACAR 2022).

The Florida Aquatic Preserve Act of 1975.[19] In addition to providing protection for habitats, the act has a specific policy lever targeting propeller impacts on seagrass. Within an aquatic preserve, any person damaging seagrasses is subject to a civil penalty.

Florida interview data also suggested that the state had invested heavily in education efforts to reduce prop scarring impacts on seagrass.

4.2.3.2 Broadly Applicable Policies

Broadly applicable policies are those that may not mention or refer directly to one or more of the four focal habitats but were identified by the literature review or expert interviews as important for their conservation or restoration. The following are Florida's policies identified in the secondary sources and interviews:

The Florida Aquatic Preserve Act of 1975.[20] This act establishes marine conservation areas that are to "be set aside forever as aquatic preserves or sanctuaries for future generations."[21] To date, 42 aquatic preserves have been established, including the Nature Coast Aquatic Preserve, approved in 2020 to preserve seagrass.

Ad Valorem Taxes. Local governments can use ad valorem tax revenues for the purchase of "land for the protection of natural floodplains, marshes, or estuaries" or for the "restoration of altered ecosystems."[22] This provision has been used effectively by Miami–Dade and Brevard Counties, and is discussed further in the next section.

Adaptation Action Areas. Florida encourages local governments to designate Adaptation Action Areas, which are defined in statute as "areas that experience coastal flooding due to extreme tides, storm surge, and sea level rise."[23] The AAAs are incorporated into the county comprehensive plan and are part of Florida's efforts to incorporate adaptation to climate change into coastal decisions that impact natural systems, among other aspects.

Florida Forever. This is Florida's flagship restoration and preservation funding program and is the country's largest public lands acquisition program. Based on interview data, salt marsh migration corridors are included in the Florida Forever prioritization criteria for land acquisition.

[19] § 258.35-258.394 and 258.40-258.4 Fla. Stat.
[20] § 258.35–258.394 Fla. Stat.
[21] § 258.36 Fla. Stat.
[22] § 125.01(aa) Fla. Stat.
[23] § 163.3177(6)(g)(10) Fla. Stat.

4.2.3.3 Highlighting Integrated Local Initiatives

Several local efforts were identified in the secondary source review and expert interviews. As discussed in sections 4 and 5 of this report, local initiatives are often used as case studies and identified as successful efforts for restoration or protection of one or more of the four focal habitats.

Tampa Bay is the most referenced local initiative for this study. The literature consistently referred to it as a success—see section 5 of this report—and some interviewees praised the effort (one interviewee noted Tampa Bay as a good example of agencies coming together to address water quality impacts on the bay, with seagrasses coming back "in a roaring fashion.") Other interview data suggests, however, that progress may have halted and that seagrasses have declined in recent years. Regardless, the cooperative management structure and the quantified nutrient pollution reduction illustrate the potential for local initiatives to use the CWA to create effective policy mechanisms. Similar analyses have identified Roberts Bay nutrient strategy in Sarasota County as successful (Green et al. 2021; Tomasko et al. 2018).

4.2.4 State Innovations and Current Initiatives

Florida interview data highlights the large-scale restoration activities that have arisen from the funding available to the states from the Deepwater Horizon Oil spill settlement. Over a 5-year period, Florida received $356 million for restoration efforts (FFWCC and FDEP 2018). While not directly related to oyster bed or salt marsh restoration, living shorelines are an increasingly important tool for coastal area resilience and restoration of coastal habitat. As discussed in this report, Florida has permitted more living shorelines than any of the other study states. While it does not have a regulatory preference for living shorelines to address areas of erosion, Florida has engaged in education efforts and living shorelines are exempt from Environmental Resource Permits, so long as the project is less than 500 ft and uses native plant species (Hilke et al. 2020).[24]

4.3 Massachusetts

4.3.1 Massachusetts Coastal Habitats Overview

Of the four habitat types closely examined in this report, Massachusetts has native oyster reefs, salt marshes, and seagrasses. Massachusetts has approximately 1,519 miles of coastline (Rhodes et al. 2019).

In an assessment of risks to habitats in the Northeast and Mid-Atlantic regions, researchers found that coastlines and coastal habitats in Massachusetts have areas at high risk. Causes of risk were focused on climate stressors, social vulnerability of fishing communities, and cumulative habitat impacts, and include sea surface temperature, shipping, recreational activity, nutrient loading, oil spills, and dredging, among others. Their research found that wider swaths of coastline in Massachusetts, in addition to Delaware, New Hampshire, and Maine, are considered high-risk areas, as compared to Virginia and Maryland, which have narrower coastal areas at risk. These states, apart from Delaware, are also considered to have the highest concentrated risk along their coastlines, with ecosystem risk being highest in Boston and Plymouth Bays. The areas of high

[24] § 62-330.051 (12)(e) Fla. Admin. Code.

risks are correlated with high intensities of demersal fishing activities, and areas of low risk are correlated with lower shipping density and restricted fishing access (Wyatt et al. 2017).

4.3.2 Habitat Status and Threats

4.3.2.1 Oyster Reefs

In the northeastern United States, oyster populations have declined 99% from their historical abundance. In Massachusetts, documented threats to oyster reef include stormwater and nutrient pollution and associated sedimentation (Baillie and Grabowski 2019), ocean acidification, and harmful algal blooms (HABs) (EEA 2015b). Some interviewees noted that it is not the nutrient pollution itself, but rather the eutrophication (which causes increases in primary productivity and decreases in light penetration and oxygen, threatening many species) caused by nutrient pollution that is the biggest threat to oyster reefs, as well as the other habitats of interest to this report. In particular, ocean acidification in the southern extent of the Gulf of Maine in Massachusetts appears to threaten the nearshore oyster aquaculture sector (Massachusetts CZM 2020; Gottlieb et al. 2020). Likewise, oyster reefs in Narragansett Bay, which spans Massachusetts and Rhode Island, were contaminated in the early twentieth century by pathogens, metals, and organic contaminants from minimally treated wastewater (Schmidt et al. 2020), leading to closures in those shellfish beds for public health reasons.

4.3.2.2 Salt Marsh

Massachusetts salt marsh habitat consists mostly of cordgrass (*Spartina alterniflora*) and salt marsh hay (*Spartina patens*). In statewide assessments of shorelines along Massachusetts communities, researchers found that salt marshes comprise 23% of the shoreline (EEA 2015a). There are significant losses documented (Massachusetts CZM 2020; MCZM 2020), caused both by coastal eutrophication and its impacts (e.g., low dissolved oxygen and algal blooms) as well as legacy impacts from historic habitat modification (e.g., ditching and diking for agriculture and mosquito control), restriction of tidal flow, subsidence, and storm overwash (Rhodes et al. 2019; Schmidt et al. 2020), many of which affect sediment supply to marshes (Massachusetts CZM 2020). Some of these threats are expected to increase with sea level rise and other climate change–induced effects (e.g., more intense storms and flooding). Salt marsh habitats have experienced decades of die-off events in Massachusetts and elsewhere in New England; studies of at least one of these events in Cape Cod links the die-off to high densities of the grazing and burrowing crab Sesarma reticulatum, whose predators are often targeted by recreational fishing, leading to the crabs' expansion (Pettengill et al. 2018).

Like salt marshes across all states, the salt marshes of Massachusetts are susceptible to rising sea levels (E. Watson et al. 2017). Longitudinal evidence in Cape Cod's Great Sippewissett Marsh demonstrates that sea level rise rates are accelerating (Valiela et al. 2018). At the same time, in the northern part of the Cape, the salt marsh may be more resilient to these changes as a result of a naturally high tidal amplitude compared to south of the Cape, according to interviewed experts. Research in Cape Cod National Seashore indicates that the total salt marsh acreage could increase with sea level rise, but the quality and quantity of the ecosystem services will vary as the salt marsh migrates (Smith 2020). Regional sea level rise rates for southern New England have been up to 50% greater than the global average, making marsh in this area particularly vulnerable to

its effects (E. Watson et al. 2017). Marsh migration into inshore and terrestrial zones will depend on adjacent upland habitat and the presence or absence of infrastructure (Smith 2020).

Experts interviewed for this report emphasized coastal eutrophication, at least partially from the use of septic systems in coastal areas, as the biggest current threat to salt marshes. Failed septic systems also lead to harmful bacteria from fecal waste as well as mercury and emerging contaminants (e.g., microplastics and pharmaceutical compounds) that are not removed during wastewater treatment entering coastal systems (Gottlieb et al. 2020). This contrasts with the Massachusetts Coastal Zone Management program's most recent report, which clarified that there remain significant gaps to determine "sources and solution to marsh degradation" (Massachusetts CZM 2020). While marshes are afforded significant protection under Massachusetts' WPA, they experienced a relatively small loss of 89 acres between 1990 and 2005, primarily caused by natural events.

Since approximately 1950, there has been considerable spread in salt marshes of the invasive common reed, Phragmites australis. Attempts to reverse the spread of P. australis using herbicides and controlled burns, as has been done in other states such as North Carolina, have had varying degrees of success (Adam 2002). In recent decades, there has been significant vegetation dieback of salt marshes in Massachusetts and the Northeast generally, confirmed by aerial photography (NPS 2018). For instance, over 50% of selected marsh sites in Massachusetts studied over the course of one summer had detectable bare spots where marsh plants would have been expected to thrive (Alber et. al. 2008).

4.3.2.3 Seagrass

Overall, eelgrass is in decline in Massachusetts. However, one-third of eelgrass beds monitored by the state have demonstrated acreage increases (EEA 2015b). Some increases are attributed to improving water quality by improving wastewater and stormwater treatment (EEA 2015b). Other threats to eelgrass habitat include from coastal storm events (e.g., Superstorm Sandy's effect on the North Shore (EEA 2015b).

There are regional differences in the factors leading to eelgrass population losses in Massachusetts. In the beginning of the twentieth century, eelgrass populations in Massachusetts and throughout the north Atlantic were decimated by wasting disease (Wilbur 2007). Mapping efforts by the Massachusetts Department of Environmental Protection documented a 42% loss of eelgrass acreage in Boston Harbor from 1996–2006 (Bowen et al. 2019). According to one survey, 90% of embayments in Massachusetts have lost eelgrass populations since 1995, largely as a result of eutrophication (Leschen et al. 2010). Eutrophication has also been identified as a cause of the historical and current loss of eelgrass from estuarine systems in Massachusetts, accelerated by nitrogen loading (Hauxwell et al. 2003; Gottlieb et al. 2020). One study cited the impact of eutrophication on eelgrass loss in the state, but only substantially in the southern regional habitats; it concluded that "coastal waters in northern Massachusetts do not appear stressed by nutrient loading" (Wilbur 2007). Nonetheless, eelgrass loss is affected by many factors in addition to eutrophication, including disease and shading from structures and docks. Beyond the immediate impact of eutrophication to eelgrass populations, most locations with high incidences of eutrophication are thought of as not suitable for restoration until the eutrophication can be

remedied (Leschen et al. 2010). This means that until the water quality issues in a given area are addressed, that area will not be able to facilitate seagrass growth. If otherwise suitable areas for coastal restoration continue to have nutrient pollution problems, there are limited places where seagrass restoration is viable.

Notably, sea level rise and increased flooding incidence heighten the risk of the spread of wasting disease, which had accounted for a mass die-off of eelgrass populations in Massachusetts a century ago (Ashton et al. 2008). Interviewees also noted that propeller scarring is a threat to seagrass. Because seagrass in Massachusetts can be found relatively further offshore, ocean economy infrastructure, including liquefied natural gas pipelines (Ehler 2021) and offshore renewable energy projects may threaten seagrass. Eelgrass habitats are classified as "special, sensitive and unique" in the Ocean Management Plan (EEA 2015a, b), (see section 4.3.3.1), which means new developments (e.g., offshore energy) will be directed away from seagrass habitat areas. Interviewees likewise suggested that offshore eelgrass habitats remain protected under state and federal regulations. Seagrasses that are not under the Ocean Plan's jurisdiction are not afforded those same protections from development, according to one interviewee, though the WPA does provide protections for inshore seagrass habitat.

4.3.3 Policy Landscape

4.3.3.1 Habitat-Specific Policies

As reviewed in section 3, the state-level policy assessment identified a limited number of policies that explicitly mention one or more of the four focal habitats, though few include enforceable or comprehensive provisions for habitat protection and restoration. While there are policies that explicitly mention oysters and oyster habitat, they are focused on cultivation and the commercial fishery, and are therefore not included in this report. Interviews did not indicate that a state-level policy is intentionally or unintentionally protecting oysters; as a result, these are also not included in this report. The Massachusetts habitat-specific policies identified in the policy database, literature review, and expert interviews are the following:

Massachusetts Wetlands Protection Act. This act was cited in the policy database, the literature, and the expert interviews as effectively protecting salt marshes. The act prohibits any impact to salt marshes, stating that activities on or near salt marshes "shall not destroy any portion of the salt marsh and shall not have an adverse effect on the productivity of the salt marsh."[25] Massachusetts is the only state that explicitly creates enhanced regulatory protections for salt marshes. As noted in Section 4 of this report, Massachusetts's WPA has stemmed declines in salt marsh loss, but the habitat is at risk from storm events and sea level rise that will increase in frequency and intensity as a result of climate change (Rhodes et al. 2019). While eelgrass is in decline throughout the state, about one-third of the monitored beds have increased in acreage. For these beds, the CWA regulatory programs, as implemented by Massachusetts, are reducing water pollution that adversely affect eelgrass (EAA 2015b).

Massachusetts Oceans Act. This act, enacted in 2008, was the nation's first ocean planning legislation. The act was incorporated into the Massachusetts Coastal Program and requires ocean-based projects to be consistent with the plan (Ehler 2021). The 2021 Massachusetts Ocean

25 310 Code Mass. Regs. § 10.32.

Management Plan designates eelgrass as a "special, sensitive, or unique resource" that should be avoided because it is vulnerable to disturbance (EEA 2015b) While the language and protections in the Ocean Management Plan are strong, it does not cover all known eelgrass areas because its jurisdiction (known as management area) starts further offshore. According to Massachusetts interviews, some people have advocated for a legislative change to extend the Ocean Plan to the nearshore area to address this gap.

4.3.3.2 Broadly Applicable Policies

Broadly applicable policies are those that may not mention or refer directly to one or more of the four focal habitats, but were identified in the literature review or the expert interviews as important for their conservation or restoration. The following are Massachusetts's policies identified in the secondary sources and interviews:

Executive Order 569. This order requires the state to develop an Integrated Climate Change Strategy, which provides funding for local governments to restore wetlands and acquire land that might serve as marsh migration corridors (Massachusetts CZM 2020).

Massachusetts Ocean Sanctuaries Act. This act protects oceans from "exploitation, development, or Activity that would significantly alter or otherwise endanger their ecology or appearance in the issuance of Authorizations for Activities subject to jurisdiction."[26] The Ocean Sanctuaries Act has created five major ocean sanctuaries: the Cape Cod Ocean Sanctuary, the Cape Cod Bay Ocean Sanctuary, the Cape and Islands Ocean Sanctuary, the North Shore Ocean Sanctuary, and the South Essex Ocean Sanctuary (Massachusetts CZM 2022a).

Area of Critical Environmental Concern (ACEC). These are place-based designations that create enhanced legal and regulatory protections for areas that have been identified by local governments as having significant natural resources.[27] Since 1975, Massachusetts has designated 30 ACECs. While interviews noted the importance of ACECs, interviewees also note that only one management plan has been adopted—Sandy Neck—and suggest that new ACECs are unlikely, despite the policy's potential power and scope.

4.3.4 State Innovations and Highlighted Local Initiatives

Many of the state innovations are discussed previously in this report. One additional initiative identified in the literature is Massachusetts' work to elevate consideration and action on ocean acidification. The Ocean Acidification Commission, which completed its work in 2021, identified two ocean acidification pathways that threaten Massachusetts: atmospheric deposition of CO_2 and acidification related to nutrient pollution. The final report recommended that Massachusetts pursue policies that "reduce nutrient pollution, restore coastal wetlands, and improve coastal monitoring." In addition, the report provided detailed information about ocean acidification in Massachusetts and included a call for conducting water quality monitoring that included parameters for acidification (Ocean Acidification Commission 2021; Turner et al. 2021). Efforts to reduce local nutrient pollution would be beneficial for the focal habitats, along with coastal wetland restoration and improved coastal monitoring.

[26] 301 Code Mass. Regs. § 27.00.
[27] 301 Code Mass. Regs. § 12.00.

Massachusetts governance is heavily weighted toward local governments. Two examples highlight the importance of local action. The WPA is one of the few state-level policies that directly protect or restore one or more of the focal habitats. The WPA framework is established by the Massachusetts Department of Environmental Protection. Local governments, however, can set more protective standards than those in state and federal law and are also responsible for issuing permits. The 351 Massachusetts local conservation commissions issue WPA permits. Of those, over 170 have also promulgated regulations that are more stringent than the state. The ACECs, also discussed previously, are largely local government–driven. The designation of an ACEC is initiated by local governments and can include additional restrictions on wetland impacts and projects that impact coastal habitats (Hilke et al. 2020). Local government implementation of the WPA and ACEC may vary widely even within a small geographic area. One initiative seeks to create a regional shoreline management program to address common needs to enhance resilience across local government jurisdictions. The towns of Eastham, Wellfleet, Truro, and Provincetown are developing a regional shoreline management program for areas within their jurisdiction on Cape Cod Bay. A comparison of the four towns' regulatory programs revealed distinct approaches across multiple standards. An essential step in creating the regional program is to reconcile the different approaches and develop a more consistent approach (Mague, McFarland, and Borrelli 2020).

In addition to strong local action within state programs, several local and regional efforts illustrate the layered governance and importance of the federal statutes for effective restoration and protection. The Massachusetts interviews emphasized the role of local government and noted that local governance may be more important in Massachusetts than the other study states. Massachusetts authorizes local government agencies to implement environmental protections that arise from state and federal laws, like the CWA and the CZMA. For example, the Massachusetts Shellfish Initiative Strategic Plan highlights that each local coastal government has the authority to "regulate, promote and manage the shellfisheries . . . [and] insure the enforcement of applicable regulations" (Massachusetts Shellfish Initiative 2021). Cape Cod and Boston Harbor are two of the most cited examples of local or regional success stories in the literature review and Massachusetts interviews.

Cape Cod Bay, encompassing over 600 square miles of coastal and marine habitat, is the southernmost area of the Gulf of Maine and contains significant eelgrass, salt marsh, and oyster reef habitats. Like many coastal regions, Cape Cod Bay faces synergistic threats from rising sea levels, subsidence, invasive species, dredging, water pollution and coastal eutrophication, excessive sedimentation, coastal development, and recreational and commercial overuse (Center for Coastal Studies 2022). There are eight ACECs within Cape Cod Bay, the last of which were designated in 1991, totaling more than 40,000 acres of ACEC area. In addition, Barnstable County has 12 designated Districts of Critical Planning Concern (DCPC). DCPCs are different from ACECs because they give towns or groups of towns the authority to impose moratoriums on development and other activities in a specific area, which ACECs cannot do. The most recent DCPC was designated in 2017. DCPC are tools only available in Cape Cod and not the rest of Massachusetts.

In addition, there is federal regulatory oversight of some parts of Cape Cod. The Cape Cod National Seashore, managed by the National Park Service, encompasses over 40,000 acres of coastal habitat and 40 miles of seashore, including salt marsh and eel grass areas. The Monomoy National Wildlife Refuge, on the Nantucket Sound side of the area, includes over 7,500 acres of coastal and freshwater habitats, providing critical habitat for migratory birds. The Mashpee National Wildlife Refuge has cooperative management between federal, state, and private groups and encompasses nearly 6,000 acres, 341 acres of which are directly under the US Fish and Wildlife Service ownership. Likewise, the Waquoit Bay NERRS on the south shore of Cape Cod is cooperatively managed by the Massachusetts Department of Conservation and Recreation and NOAA. This NERR includes 2,700 acres of coastal and upland habitat. The Waquoit Bay NERRS is pursuing research and education efforts to develop the data needed to use coastal wetland restoration as a source for blue carbon projects (Howard et al. 2017).

The expert interviews emphasized the importance of the CWA section 208 updated water quality management plan for Cape Cod (Cape Cod Commission 2015) in reducing nutrient pollution. The 2017 Cape Cod Wide Area Water Quality Management Plan Update identifies successes, but also notes the need for continued reductions from all nutrient sources in the area. Long-term sustained funding was noted as the biggest barrier to continued nutrient reductions.

Boston Harbor is generally considered to be a successful implementation of the CWA. (Green et al. 2021) The poor water quality in Boston Harbor was the initial driver to treat sewage effluent; restoration of salt marshes and seagrasses, however, became part of the cleanup plans early on. Seagrasses require good water quality, so restoration efforts were delayed until the clean-up was considered complete. Over decades, Boston Harbor has had both successful and unsuccessful seagrass restoration projects, which highlight the need for more information about the enabling conditions for successful restoration and how the local context affects seagrass restoration (Bowen et al. 2019; see also Sherman and DeBruyckere 2018 for local context considerations for eelgrass restoration).

4.4 North Carolina

4.4.1 North Carolina Coastal Habitats Overview

The North Carolina coastal zone is made up over 12,000 miles of coastal shoreline consisting of marshes, coastal forests, bluffs, and beachfront. Historically, North Carolina has encouraged maintenance of a natural shoreline and, as a result of its policies, only 6.3% of the shoreline has hardened (Hilke et al. 2020). North Carolina has three focal habitats—oysters, salt marshes, and seagrass—and is home to the Albemarle-Pamlico estuary, which is second in size only to the Chesapeake Bay. The three habitats have all declined from their historical acreage and have been the focus of state-level restoration and protection efforts.

Threats to North Carolina's coastal habitats include direct physical alteration through dredge and fill, overharvesting, propellor scarring, coastal development, sea level rise, and water pollution, which was identified by one interviewee as the most critical threat in North Carolina. In a study reviewing and soliciting expert feedback on the greatest threats to coastal habitats in the Southeast, development was ranked as the most important local threat to wetlands, with modification to freshwater flow and shoreline hardening following (Kyzar et al. 2021). North

Carolina's ocean and estuarine coasts are ranked as having moderate to very high vulnerability to sea level rise (NC DEQ 2016b). Projected ranges for sea level rise in North Carolina suggest an increase from 11–21 cm by 2030 and 26–81 cm by 2080 (Powell et al. 2019; Bin et al. 2007). Storm events, including hurricanes, are also significant threats. Hurricanes have had devastating effects on the state's environment and economy, including recent hurricanes Matthew (2016) and Florence (2018), which totaled more than 17 billion dollars in damages to the state, and led to massive agricultural losses and prolonged flooding, which then increased nutrient and chemical runoff into coastal habitats and drinking water supplies (Hovis et al. 2021).

4.4.2 Habitat Status and Threats

4.4.2.1 Oyster Reefs

Oysters are found throughout the Albemarle-Pamlico Estuary to the South Carolina border and have played a unique and important role in the North Carolina coastal ecosystem and economy (D'Anna 2016). High sediment delivery from local rivers has made the Pamlico Sound a particularly conducive habitat for oyster reefs, allowing for a historically high concentration of oysters (Allen et al. 2014). Intertidal oyster beds are plentiful in the southern estuaries (DEQ 2016), As filter feeders, oysters provide essential water filtration, which can also leave them vulnerable to certain types and thresholds of water pollution. In addition to water filtration services, oyster reef restoration studies have demonstrated that they provide structurally complex habitats that support other species like fish and crabs.(Baillie and Grabowski 2019). However, the once-abundant oyster populations in North Carolina have collapsed to 90% of their historical levels, threatened by a variety of forces including overfishing, disease, pollution, changes to precipitation, acidification and habitat loss (Allen et al. 2014; DEQ 2016; Kyzar et al. 2021). In Pamlico Sound, oyster reefs are considered functionally extinct (Beck et al. 2011; D'Anna 2016) Of the many threats facing the health of oyster habitat, oyster disease and eutrophication are particularly pernicious. Many experts also consider protozoan oyster diseases, such as Perkinsus, Haplosporidium, Marteilia, and Bonamia, to be significant barriers to the full restoration of native oyster habitats (Fernández Robledo, Vasta, and Record 2014; Powers et al. 2009). At the same time, there is a growing body of evidence of oyster reef resilience to changes and fluctuations in sea level (Ridge et al. 2017).

Disease prevalence in oyster sanctuaries is lower than expected because "the protection from fishing disturbance and the resulting cultivation of high-relief structural habitat may enhance the resistance of oysters to infection given that the effects of disease on marine populations are typically greatest when combined with other physiological and environmental stressors" (Powers et al. 2009). In addition to long-term threats facing oysters, hurricanes, like Florence (2018) and Matthew (2016), the former of which left the southern coast of North Carolina with a month's worth of rainfall in under a week (Spencer-Davis 2020), have caused tremendous damage and disruption to oyster stocks (North Carolina Coastal Federation 2019). While restoration efforts since the hurricanes have been promising, climate change is predicted to increase the frequency and severity of hurricane activity, which puts existing oyster reefs at risk and further jeopardizes successful restoration efforts.

The economy built around both wild oysters and oyster aquaculture in North Carolina is significant. During the period from 2003 to 2012, commercial fishers in the region harvested nearly 520,000 pounds of oysters annually, netting on average $2.5 million in profits (Allen et al. 2014). However, this represents a 90% decline in oyster harvest since the early 1900s (Rutledge et

al. 2018); oyster harvest now makes up just 2.5% of all catch that is landed in the state (D'Anna 2016) In addition to the ecosystem services and economic benefits already outlined, certain kinds of oyster aquaculture can provide habitat for fish species important in both recreational and commercial industries (Allen et al. 2014).

4.4.2.2 Salt Marsh

For roughly the past 50 years, there has been considerable spread of both native and invasive species of the common reed, *Phragmites australis,* in salt marshes in the North Carolina coastal plains. Attempts to reverse the spread of large swaths of *P. australis*, including herbicides and controlled burns, have had varying degrees of success (Adam 2002). In addition, there have been salt marsh dieback events. Historically, the dieback has been attributed to dredging, but the role of reduced or impaired soil conditions is now also recognized as a contributing factor (Alber et al. 2008). Saltwater intrusion into freshwater marshes and bogs resulting from sea level rise will cause the saltwater marshes to migrate inland and freshwater marshes to retreat, which will convert more coastal forested land into marsh. Marsh migration, however, is limited by a number of factors, largely coastal squeeze, whereby fewer and fewer suitable areas for marsh habitat are available for migration. As noted in the North Carolina interviews, however, slope and geology are of critical importance for salt marsh migration. Sea level rise is seen as the biggest threat to salt marshes in North Carolina (Kyzar et al. 2021).

Between 1970 and 1984 alone, over 1,700 hectares of salt marsh, representing nearly 2% of salt marsh habitat in North Carolina, were authorized for development or alteration by either CAMA, the Dredge and Fill law,[28] or Section 404 of the CWA. Development projects including bulkheads, canals, drilling, private development, and utilities installations altered salt marsh habitats and wetlands generally. Agriculture and forestry practices are not classified as development under CAMA, and therefore are exempt from the permitting and review process. Thus, impacts from these activities are not reflected in the statistic above, although they likely also contributed to habitat loss (Stockton and Richardson 1987).

4.4.2.3 Seagrass

North Carolina has an estimated 130,000 to 200,000 acres of SAV (Powell et al. 2017), the second highest of any Atlantic Coast state beyond Florida (NC DEQ 2016b). At least 14 common species make up SAV. SAV habitats in North Carolina support commercially and recreationally significant species such as clams, scallops, shrimp, blue crab, juvenile fish, groupers, sea trout, and flounder. Seagrass health is often an indicator of broader water quality trends. When seagrass beds become impaired, it can mean water quality is degraded. North Carolina SAV habitats face multiple threats, including from excessive nutrient and sediment loading, dredging, construction, increasing water temperatures, and the expansion of mariculture (Field et al. 2021), shoreline hardening operations, and injury from boat propellers (Erftemeijer and Lewis 2006). Beyond physical damage to the grass, nutrient runoff and eutrophication can also impact water quality and degrade its health.

Seagrass monitoring in North Carolina's Albemarle-Pamlico estuarine system in 2006 and 2013 discovered a significant loss of continuous seagrass that was partially gained by patchy seagrass (Table 6).

[28] N.C. Gen. Stat. § 113-22

Table 6. Comparison of seagrass extent from multiple surveys in North Carolina

Spatial Cover Class	Survey 1 (2006–2007), acres	Survey 2 (2013), acres	Change, acres	Change, %
Continuous	46,120	30,347	−15,773	−34.2
Patchy	54,723	64,810	10,087	18.4
Total	100,843	95,157	−5,686	−5.6

Adapted from Field et al. (2021).

Current anecdotal evidence suggests that SAV loss may be as high as 50% (NC DEQ 2016b).

4.4.3 Policy Landscape

4.4.3.1 Habitat-Specific Policies

As reviewed in section 3, the state-level policy assessment identified a limited number of policies that explicitly mention one or more of the four focal habitats, though few include enforceable or comprehensive provisions for habitat protection and restoration. Because North Carolina has integrated oyster reef restoration and preservation, living shoreline advancement, and shellfish harvest and aquaculture into an integrated coastal habitat restoration program, the North Carolina habitat-specific policies include those that intentionally protect oysters, which is distinct among the study states. The North Carolina habitat-specific policies identified in the policy database, literature review, and expert interviews are as follows:

North Carolina Coastal Habitat Protection Plan (NC CHPP). NC CHPP was developed between 1998 and 2004 with a purpose to promote the "long-term enhancement of coastal fisheries associated with coastal habitats" (NC DEQ 2017). The NC CHPP is designed to improve information flow between state-level regulatory agencies in order to effectively manage habitats that are of importance to the state, including seagrass, salt marshes (or coastal wetlands), and oysters. Produced every five years, the NC CHPP is adopted by all three state-level commissions that have regulatory authority impacting the coast—the Environmental Management Commission, the Coastal Resources Commission, and the Marine Fisheries Commission—which is intended to promote a linked management approach. The NC CHPP goals include to "improve effectiveness of existing rules and programs protecting coastal habitats; identify and delineate strategic coastal habitats; enhance coastal habitat and protect it from physical impacts; and enhance and protect water quality" (NC DEQ 2021). Despite these goals, the current status and trend for the coastal habitats is one generally of decline and ongoing mapping and monitoring is piecemeal. Thus, the NC CHPP remains primarily a tool for aggregating data and ensuring that cross-agency activities are coordinated.

The Oyster Blueprint. The North Carolina Coastal Federation has created an integrated report that tracks North Carolina's efforts to protect, restore, and harvest oysters. While not a state policy, the Oyster Blueprint has become an important vehicle for synthesizing information on oysters, including restoration efforts, and for promoting integrated habitat management that includes shellfish harvest, oyster restoration and preservation, and related restoration of coastal wetlands. The Oyster Blueprint also connects to the NC CHPP discussed previously and aggregates information from all state regulatory agencies, including progress pursuant to the

Oyster Sanctuary Program and Artificial Reef Program discussed below. In 2014, there were 12 oyster sanctuaries in North Carolina totaling almost 230 acres; as of 2020, there were 15 in the Pamlico Sound alone, totaling nearly 260 acres (North Carolina Coastal Federation 2019).

North Carolina Division of Marine Fisheries (NCDMF) Programs. The NCDMF engages in oyster restoration and enhancement through multiple programs, including ones for shellfish rehabilitation, oyster sanctuaries, and artificial reefs, and invested over $20 million dollars to support over 500 acres of habitat between 2010 and 2015. The benefits of such programs were measured by an Albemarle-Pamlico National Estuary Program–funded study, which found that for every dollar invested in enhancement activities, there are about four dollars in market and nonmarket benefits. These benefits relate to commercial harvest, recreational harvest, and water quality improvements, which contribute to job creation, revenue, and household income (Callihan et al. 2016). Artificial oyster reefs can also serve similar ecosystem functions as natural reefs, in terms of supporting communities of fish and shrimp, which can have important implications for the recovery of fisheries (Rutledge et al. 2018).

Living Shoreline Permit. North Carolina has focused on increasing the use of living shorelines to protect and restore salt marshes. In response to the USACE development of a new nationwide permit (NWP) for living shorelines (NWP 54), the North Carolina Division of Coastal Management created a new general permit under the coastal regulatory program to reduce the administrative barriers to incentivize greater use of living shorelines. Hardened shoreline permitting in North Carolina only requires a single state agency approval and is often completed by field staff onsite. Changes made to the state coastal rules in 2019 created parity for receiving approval for a marsh sill, a type of green infrastructure composed of engineered material and vegetation intended to protect shorelines from erosion and other threats. North Carolina's efforts continue to include education and outreach—the state sponsored 13 education events between 2016 and 2021 (Wagner 2021). The marsh sill permit allows the North Carolina Division of Coastal Management to issue state general permits for the construction of marsh sills without a case-by-case federal review.[29] The new general permit may also help with oyster restoration in the state.

Prohibited Gear, Secondary Nursery Areas.[30] In this code, the use of trawl nets in primary or secondary nursery areas is prohibited. Seagrass are classified as primary and secondary nursery areas in the state, providing some protection from trawling impacts, though somewhat indirectly.

4.4.4 State Innovations and Highlighted Local Initiatives

North Carolina has made significant investments in oyster restoration, coastal wetland restoration and protection, and improving information flow to enhance coastal management and permitting. Its efforts are exemplified by the NC CHPP, which was highlighted in the North Carolina interviews, along with the Oyster Blueprint. Despite these efforts, however, policies related to seagrass and salt marshes are diffuse, monitoring and mapping are noted as perennial needs, and the state does not have a state-level authority responsible for protection and restoration efforts (NC CHPP; North Carolina interview data).

[29] 15A NCAC 7H .2700.
[30] 15A NCAC 3N .0105.

As discussed in the report, North Carolina has also worked to increase the use of living shorelines for erosion control by reducing the regulatory burden for permits. The use of living shorelines is integrated into the oyster and salt marsh restoration goals identified by the CHPP and Oyster Blueprint. According to North Carolina interviewees, much of North Carolina's successful use of living shorelines and oyster restoration is attributed to the North Carolina Coastal Federation, a state NGO. One paper noted that different coastal areas have had varying success in oyster reef restoration. While noting the progress that has been made in North Carolina's Pamlico Sound, the paper also notes that the disparity in success may suggest that larger areas will need to be restored (Bersoza Hernández et al. 2018). North Carolina's work on promoting living shorelines as a viable alternative to hardened structures is supported by research on the effectiveness of living shorelines at reducing erosion rates (Polk and Eulie 2018). Green infrastructure, such as living shorelines with salt marshes and oyster reefs, have proven to withstand these threats; for example, hurricane Irene's impact in 2011 damaged 75% of bulkheads in the Outer Banks, but salt marsh habitat and living shorelines with reef wave breaks were not impacted (Hilke et al. 2020). Living shorelines have documented success in reducing erosion, protecting salt marshes, and increasing resilience to storm events (Polk et al. 2022).

4.5 Texas

4.5.1 Texas Coastal Habitats Overview

Texas's coastline includes over 3,000 miles of shoreline, around 20% of which is hardened. The Texas coast has experienced high rates of erosion and shoreline retreat, which has been more than 15 feet per year in some areas. Coastal wetlands have decreased by an average of 1,600 acres per year since the middle of the twentieth century. Galveston Bay alone has lost over 20% of its tidal marshes since the 1940s from subsidence and shoreline erosion. As a result, shoreline stabilization is an important management priority in the state (Hilke et al. 2020). Subsidence has been cited as another driver of coastal habitat loss in Texas in both interviews and in literature. Rates of subsidence differ along Texas's coastline, but the average natural subsidence rate is 1.4 mm/y. Historical subsidence from groundwater withdrawal plagued the Texas coast, particularly in the Houston-Galveston area, in the mid-twentieth century; after groundwater regulations came into force in the 1980s, this source of subsidence no longer threatens coastal habitat. (Zhou et al. 2021).

4.5.2 Habitat Status and Threats

4.5.2.1 Oyster Reefs

Oyster reefs occur in subtidal and intertidal zones across Texas. According to A. Watson et al. (2017), "despite greater than 50 percent loss, this region is one of the few oyster ecosystems still in fair condition, making it possible to repair and restore oyster reefs to historical levels." In some areas of Texas, including Laguna Madre, the West Gulf Coastal Plain, the Mississippi Alluvial Plain, and the Southern Coastal Plain, oysters have become functionally extinct (A. Watson et al. 2017). Many assessments of oyster habitat are performed in the Gulf of Mexico region and are often not Texas-specific, so we were unable to find up-to-date and publicly available estimates for oyster reef habitat the state of Texas alone.

Large storms and other weather events can result in increased sedimentation and salinity changes in oyster habitat. Sedimentation can cover oysters and increase mortality by up to 100% (Texas

GLO 2019). Likewise, if salinity decreases below 5 ppt as a result of freshwater pulses, oyster spawning, recruitment, and growth rates decline (A. Watson et al. 2017). Likewise, droughts that lead to increased salinity in oyster habitat pose an additional threat to oyster reefs. Droughts in South Texas are relatively common (Texas CMP 2020).

Until the passage of House Bill 51 in 2017 (described in following sections), there was not replenishment of shells to provide habitat for additional growth in areas where oysters are harvested, (TPWD 2012b). Though changes to hydrology are largely considered the biggest threat to oyster reefs, subtidal and intertidal oyster reefs are adversely impacted by increasing incidences of Vibrio bacteria, dermo disease, and oyster drill snails, and other diseases and predators (Robinson n.d.). Disease prevalence is expected to increase with changes to salinity and sea surface temperature (Beseres Pollack et al. 2012; Marshall et al. 2021). These effects, exacerbated by large rainfall and freshwater pulses, lead to oyster die-offs and subsequently threaten the commercial oyster industry. HABs have also led to closures of the commercial oyster industry in Texas, though estimates of the economic losses from HABs is not publicly available (Texas CMP 2020).

4.5.2.2 Salt Marsh

Though salt marshes historically had a much larger extent, today Texas supports as much as 601,000 acres of marsh, including salt and freshwater marshes (TPWD 2012b). Salt marshes are primarily concentrated to the south of Galveston Bay, especially along the bay side of barrier islands and along narrow bays (TPWD 2012b). Between 1998 and 2004, over 44,000 acres of estuarine marsh were lost along the Gulf Coast (Stedman and Dahl 2008), primarily to open water and development.

Marsh resilience, particularly as sea level rise and flooding worsens, is largely influenced by marsh elevation, given the important role it plays in determining the type of marsh ecosystem or whether the marsh will survive at all (A. Watson et al. 2017). Coastal storms play an important role in influencing marsh elevation both through inundating marshes as well as depositing sediment, both of which can alter the ecosystem as well as increase vulnerability to invasive species (Chabreck 1970; A. Watson et al. 2017). Disturbance from human activities similarly impacts these ecosystems, particularly the threat of coastal development limiting the space for marsh migration as sea levels rise (A. Watson et al. 2017). Beyond climate change and urbanization, Texas salt marsh ecosystems face a distinct threat from encroaching mangroves. The increasingly mild winters have led to mangroves overtaking marsh habitat (Texas CMP 2020; A. Watson et al. 2017), though interviewees in Galveston Bay were far less concerned with this threat than those along the southern Texas coast.

4.5.2.3 Seagrass

Seagrasses are a dominant habitat in Texas estuaries and bays (TPWD 2012b, 2012a). These habitats are made up of five species, including shoalgrass, turtlegrass, and manateegrass, as well as others. Shoalgrass is the most abundant of the seagrass species and occurs in high-salinity regions along Texas's coast. Much of the seagrass coverage (79.1%) in Texas is concentrated in the Laguna Madre, with the remaining 19.2% primarily in the San Antonio, Aransas, and Corpus Christi Bays and just 1.7% in Matagorda Bay. Prior to 2000, seagrass covered 235,000 acres in

Texas, though this number has fallen because of increased threats from development and coastal storms (TPWD 2012a). One study estimates that Texas has lost 70% of seagrass over 150 years (Thorhaug et al. 2020).

Overall measurements of seagrass habitat in Texas show recent gains of 4,896 hectares, or 5.6% between the publication of the status and trends update in 2007 and that in 2020 (Handley and Lockwood 2020). These changes in gain and loss were not uniform across the Texas coastline, with significant gains observed in Galveston and Christmas Bays and more modest gains in the midcoast region.

Seagrass distribution is largely determined by water clarity, temperature, and salinity, and they are highly sensitive to physical disturbances. Given this, the greatest threats to seagrass habitat first include anthropogenic habitat disturbance, especially marine transportation, commercial fishing, tourism, and recreational boating. These can cause habitat disturbance and boat scarring, which can lead to deepening of the scarred area and erosion (TPWD 2012a). Dredging plays a similarly central role in reducing seagrass habitat, especially from burial of the habitat as well as the disturbance of sediment that reduces water clarity and light penetration (Dunton and Tomasko 1994). Finally, agriculture and urban development are considered the largest, though not yet quantified, sources of nutrient loading, which can lead to irreversible damage to these ecosystems. Combined, propeller scarring, dredging, and nutrient loading are considered the most destructive influences on seagrass habitat in Texas (TPWD 2012a).

4.5.2.4 Mangroves

Texas has a small portion of mangroves along the Gulf of Mexico—only about 34 km2 (Osland et al. 2018). Mangroves most commonly occur in the southern portions of the Texas coast, though their range is expanding as temperatures rise and winters become milder, often into salt marsh habitat. As winter temperature extremes rise, black mangroves are expected to inhabit the entire Gulf of Mexico coast (Weldon 2021), though they are currently most commonly found in Florida. Mangroves are most impacted by extreme freeze events and storm events that erode sedimentation and cause changes to freshwater flow (A. Watson et al. 2017). Mangroves may be vulnerable to rising sea levels, though their ability to accrete soil means they will be resilient to any sea level rise that is under 12 cm per 100 years. Other stressors to mangroves include shoreline modification, coastal development, and reduced water quality, though mangroves can adapt to some of these modifications.

4.5.3 Policy Landscape

The Texas policy landscape is sparse and the information outdated relative to the other study states. Both the Texas interviews and Texas government reports indicate that the CWA and the Coastal Zone Management Program provide the regulatory framework, which has sufficient authority to promote restoration and protection efforts of the focal habitats in the state. (Texas interview data; TPWD 2012b) Distinct from the other study states, the historical lack of coastal development pressures has focused the state's restoration and protection efforts on a single region: Galveston Bay. As population increases, along with development pressures, however, Texas is facing increasing pressure to address the impacts associated with anthropogenic pressures on the coast (Texas CMP 2020).

The Texas General Land Office (Texas GLO) is the primary coastal management agency. As described in following sections, the Texas GLO is focused on strategic use of CZMA funding to support state and local restoration priorities, including awarding more than $2.2 million in federal funds (Texas GLO n.d.).

4.5.3.1 Habitat-Specific Policies

As reviewed in Section 3, the state-level policy assessment identified a limited number of policies that explicitly mention one or more of the four focal habitats. The Texas habitat-specific policies identified in the policy database, literature review, and expert interviews are as follows:

Texas Parks and Wildlife Code. Texas prohibits the physical alteration or damage to seagrass from propellors.[31]

The Seagrass Conservation Plan for Texas. Developed in 1996 and updated in 2012, the Seagrass Conservation Plan for Texas provides guidance on use of educational materials to reduce damage to seagrasses from boats. Texas expert interviews indicate that Texas has invested substantial resources in an education campaign on propeller scarring of seagrass. The Seagrass Conservation Plan, coupled with the statutory prohibition on damaging seagrass, is the state's most comprehensive regulatory effort to protect or restore seagrass. One study from the literature review noted that information about Texas efforts to restore seagrass, including areas of Laguna Madre and Galveston Bay, are often not published. The study did note that, for the Texas restoration efforts from Laguna Madre to southern Galveston Bay, the current water quality was sufficient to support sustained seagrass restoration (Thorhaug et al. 2020).

House Bill 51. This bill passed in 2017 and includes a requirement for oyster harvesters to distribute no less than 30% of their volume of oysters purchased as cultch material in approved areas, which can facilitate restoration.

4.5.3.2 Broadly Applicable Policies

Broadly applicable policies are those that may not mention or refer directly to one or more of the four focal habitats, but were identified in the literature review or the expert interviews as important for their conservation or restoration. The following are Texas's policies identified in the secondary sources and interviews:

The CWA and the Texas Coastal Zone Management Program. These programs were identified as the primary regulatory agents for seagrass protection (TPWD 2012b). Texas, however, identified a lack of specificity within Section 404 of the CWA as a barrier to protecting coastal freshwater wetlands and isolated wetlands (TPWD 2012b).

Texas Coastal Management Program. Texas interview data suggest that the Texas Coastal Management Program has sufficient authority to increase protection and restoration for the four focal habitats.

Funding Mechanisms. Texas interview data identified several funding mechanisms—the Dune Protection Act, Coastal Preserve Program, Coastal Restoration and Improvement Fund, and

[31] Tex. Parks & Wild. Code § 66.024.

Coastal Erosion Planning and Response Act (CEPRA)—that, if focused together, could impact coastal habitat.

The Texas Open Beaches Act. This act created a rolling easement program that shifts the state jurisdiction as the vegetation line moves, which could be a useful tool in adaptation to sea level rise. The literature search did not indicate whether Texas intended to use the Open Beaches Act for habitat protection or adaptation to climate change (Dedekorkut-Howes, Torabi, and Howes 2020; Naismith 2020; Spencer-Davis 2020).

The Texas Coastal Resiliency Plan. This plan, which seeks to address coastal hazards through the recommendation of restoration projects, was updated in 2019. According to Naismith 2020, this "piecemeal approach to coastal restoration" is insufficient for achieving coastal resiliency goals.

4.5.4 State Innovations and Highlighted Local Initiatives

The literature review and interviews focus primarily on strategic use of federal and state funding to restore coastal habitats. As noted, the Dune Protection Act, the Coastal Preserve Program, the Coastal Restoration and Improvement Fund, and CEPRA, could be effective for restoration, if used strategically. CEPRA alone has funded 97 shoreline erosion projects from 2012–2019 (Texas CMP 2020) Because Texas's coastal restoration efforts are project- rather than region- or habitat-specific, this study was not able to identify illustrative examples of Texas coastal management activities that met the broad effectiveness criteria. In Texas's Parks and Wildlife Code, the department is given authority to develop a system of scientific areas that are protected and managed for research and educational values. One such area is the Redfish Bay State Scientific area, with over 32,000 acres of seagrass habitat and a prohibition of seagrass uprooting in the area (TPWD n.d.).

4.6 Washington

4.6.1 Washington Coastal Habitats Overview

Washington has 157 miles of coastline and over 3,000 miles of shoreline surrounding islands, estuaries, rivers, and more (NPS 2022). and includes three of the four coastal habitats central to this report: oyster beds, salt marshes, and seagrasses (Bailey et al. 2003). Coast Salish peoples, who settled in Washington long before Europeans, are considered the original human stewards of coastal habitat in Washington State; alteration, development, and loss of coastal habitats has occurred since colonization (Barsh 2003). The central agency managing these habitats is the Washington State Department of Ecology, which works alongside agencies including the Department of Natural Resources, the Department of Fish and Wildlife, and others (Bailey et al. 2003). Much of the management and research of coastal habitats in the state has historically been concentrated in the Puget Sound as well as Grays Harbor, Willapa Bay, Padilla Bay, and the lower Columbia River because of the concentration of habitat, industry, cultural services and livelihood access in those areas.

4.6.2 Habitat Status and Threats

4.6.2.1 Oyster Reefs

Most of the oyster population in Washington is managed for commercial purposes, rather than for conservation. Currently, five species of oyster are managed for commercial and recreational harvest in Washington, where the commercial shellfish harvest industry leads the nation (Vermillion 2016), earning over 100 million dollars in annual revenue. Close to 2,100 acres of state aquatic lands are leased for oyster aquaculture. Nonnative Pacific oysters now make up 95% of the total oyster population in Washington (Washington Sea Grant 2015). Native Olympia oysters, on the other hand, are scarce: "Less than 4% of historic core populations of native Olympia oysters remain in Puget Sound" (Horowitz and Hoberecht n.d.), and the commercial harvest of this species ended in the 1930s after over a century of overharvest (Elliott et al. 2020).

Notable threats to oysters identified in the literature and interviews include water quality issues and habitat loss. The habitat loss, particularly in densely developed areas such as the Puget Sound, not only threatens current oyster populations but serves as a limiting factor for ongoing and future restoration potential. Climate change–related impacts such as extreme heat waves and ocean acidification have likewise led to die-offs of shellfish beds, and eroded oyster shells respectively, according to one interviewee in the state. Additional threats to the Olympia oyster include the introduction of invasive species (e.g., the European green crab), the discharge of sulfite from paper mills, and the removal of shell accumulations (Elliott et al. 2020; Grason et al. 2018).

4.6.2.2 Salt Marsh

Land use changes on the coast, including residential and industrial development as well as agriculture and aquaculture, have resulted in significant losses to tidal marshes in Pacific Rim estuaries, including those in Washington (David et al. 2016). This not only leads to loss of habitat extent but also to fragmentation and disconnection between salt marshes, threatening the fish and invertebrates that depend on them for protection and food. In addition, the installation of tidal flow controls such as culverts, tide gates, and levees have left salt marshes disconnected from naturally occurring tidal inundation, which has resulted in habitat loss of brackish salt marshes in particular. With the onset of sea level rise, and steep elevations along coasts, avenues for migration are substantially limited by these development pressures and marshes in Washington are subject to the phenomenon known as coastal squeeze. In Washington's Snohomish River estuary, however, salt marsh habitat is expected to increase from the impacts of sea level rise, though this will result in losses of other coastal habitats (Christie et al. 2018). Even this, however, is likely to be impacted by the scale of development and space for migration in the region. According to experts, the coastal squeeze effects are exacerbated in Puget Sound as compared to the remainder of Washington's open coast.

The nature of threats leading to coastal habitat alteration and loss is not recent (Bailey et al. 2003; Ballanti et al. 2017). By the twentieth century, the salt marsh and wetland habitats in areas like Padilla Bay and the Nisqually River Delta had been extensively diked and drained for farmland. Hydrological modifications like this were also used in the lower 46 miles of the Columbia River,

causing the alteration or destruction of nearly 70% of tidal wetland habitat with 40% of this loss attributed to agriculture alone (Bailey et al. 2003; Marcoe and Pilson 2017).

Cordgrass is a particularly aggressive invasive species that has outcompeted and displaced native mudflats and salt marshes, altering their structure and function, and is proven to be both unwieldy and expensive to manage once established (Bailey et al. 2003). Some of the more direct impacts of cordgrass include reduction of feeding habitat for shorebirds and increased competition with endemic salt marsh vegetation (Washington Invasive Species Council 2022). In Willapa Bay, the oyster industry has been given a permit to use herbicides on Spartina (Patten et al. 2017).

4.6.2.3 Seagrass

The six seagrass species in Washington are *Zostera marina*, *Zostera japonica* (nonnative), *Phyllospadix serrulatus*, *Phyllospadix scouleri*, *Phyllospadix torreyi*, and *Ruppia maritima* (Christiaen et al. 2019). Of these, native eelgrass (*Zostera marina*) is the most common form of seagrass along the West Coast (NOAA Fisheries 2022b), including in Washington where it occurs along the outer coast in Willapa Bay and Grays Harbor, Baker Bay near the mouth of the Columbia River, and in the greater Puget Sound area (Sherman and DeBruyckere 2018). Poor water quality and increased nutrient runoff, (Christiaen et al. 2019) human alterations to the landscape, and the resulting change in sediment flows have driven the loss of seagrass meadows across Washington through burying substrates and reducing growth and survival (Rubin et al. 2017). Like with salt marshes, seagrass meadows have become patchy and fragmented, which increases their vulnerability to threats.

Puget Sound is estimated to have 23,000 hectares of native seagrass, the majority of which is eelgrass, and half of which is on tidal flats and the other half fringing in small areas along the shoreline (Christiaen et al. 2019). In Puget Sound, seagrass can grow at greater depths because the water is relatively clear (Eisemann et al. 2021). According to one expert, this makes seagrass somewhat less vulnerable to the impacts of development because beds are located further away from the coastline. The health of eelgrass is seen as an indicator for the health of the entire system. Though the Puget Sound Partnership created a goal to increase their eelgrass habitat by 20% by 2020 (Christiaen et al. 2019), this goal was not met (though some areas in the region did have slight increases [interview data]).

4.6.3 Policy Landscape

4.6.3.1 Habitat-Specific Policies

Bush Act and Callow Act of 1895. Washington policy and regulatory programs have overseen oyster habitat since the late nineteenth century, when the Bush Act and Callow Act of 1895 allowed tidelands to be privately owned, laying the foundation for the state's shellfish industry (Washington Sea Grant 2015; Washington State Department of Natural Resources n.d.).

Shoreline Management Act. Washington's government has also pursued oyster protection in addition to facilitating and supporting commercial harvesting. Shellfish restoration occurs on a case-by-case basis to mitigate impacts from development, as consistent with the Shoreline Management Act (described in section 4.6.3.2). Other programs seek to support the restoration of

native oyster populations specifically, including the Washington Shellfish Initiative, Washington Department of Fish and Wildlife Plan for rebuilding Olympia Oyster Populations in Puget Sound, Intertidal Shellfish Enhancement Program, and the Volunteer Cooperative Fish and Wildlife Enhancement Program (Mississippi-Alabama Sea Grant Legal Program 2014). Some of these are described in following sections.

The Washington Shellfish Initiative. This program has identified the need for an improved permit review process for shellfish aquaculture and reduced redundancies and inconsistencies between agencies involved in the permitting process. The Washington Shellfish Initiative, which includes participants from the Washington Department of Ecology, the Department of Fish and Wildlife, the National Marine Fisheries Service, and others, created the Shellfish Interagency Permitting team; there has been documented improved permitting processes through increased communication (Lund and Hoberecht 2016).

Olympia Oyster Stock Rebuilding Plan. In an effort to recover native oyster species, Washington's Department of Fish and Wildlife developed the Olympia Oyster Stock Rebuilding Plan in 1998, establishing close to 20 restoration sites in the Puget Sound. These efforts are overseen by the nonprofit Puget Sound Restoration Fund (Blake and Bradbury 2012).

Washington's Administrative Codes (WACs). There are also a number of laws and statutes in WACs pertaining to shellfish harvest and monitoring water quality for public health, briefly described as follows:

- **WAC Chapter 222-24-041.**[32] This law requires water crossing structures to mitigate in order to achieve no-net-loss of fish and shellfish habitat.
- **WAC Chapter 220-330, Personal-Use Shellfish.**[33] This law specifies the daily limit for personal oyster harvest, required shell to be replaced in tidelands and prohibits Oyster harvest in over 127 identified locations, including oyster reserves.

Eelgrass restoration is primarily focused on Puget Sound, but Washington has adopted prohibitions on physical alterations of seagrass beds that apply statewide.

WAC Chapter 220-660.[34] This is an example of a law that oversees dredging, marine building, and restoration activity. This law requires mitigation to achieve no net loss, prohibits dredging in certain areas, requires a seagrass habitat survey for new projects, and requires that activity avoids adverse impacts to seagrass, kelp beds, and other coastal habitats.

4.6.3.2 Broadly Applicable Policies

Washington has a coastal zone management program consisting of several policies and programs. Relevant programs that showed up in policy documents, secondary literature, or interviews are described, though there is limited information about the implementation and enforcement of these policies from the literature review and they were not mentioned or named specifically in the interview process.

[32] WAC 222-24-041
[33] WAC 220-330, Personal-Use Shellfish
[34] WAC 220-660

The Shoreline Management Act. This act, passed in 1971, outlines and assigns regulatory programs for shoreline protection and coastal development to local governments. These local governments are then responsible for developing, adopting, and updating shoreline master programs (SMPs). SMPs are reviewed and approved by the Department of Ecology.

Ocean Resources Management Act. This 1989 act delegates management of coasts, seabeds, coastal waters, and ocean uses to the Washington State Department of Ecology where the shoreline management act does not apply, such as offshore oil projects.

Marine Waters Planning and Management Act. This act, passed in 2010, directed the Governor's office to convene an interagency working group to develop a framework and recommendations for marine spatial planning with a focus on renewable offshore energy (Washington Department of Ecology 2018; Smythe and McCann 2018). The Marine Spatial Plan it created (described later) does not supersede state or local governments. As of 2019, Washington was one of four states to have created and approved spatial plans (Ehler 2021).

Marine Spatial Plan for Washington's Pacific Coast. The Marine Spatial Plan includes policy recommendations to facilitate and execute marine spatial planning in accordance with the principles and goals outlined in the Marine Waters Planning and Management Act.

Floodplains by Design Program. This funding program, a collaboration between the Washington State Department of Ecology, The Nature Conservancy, and the Puget Sound Partnership, has supported over 200 million dollars in flood hazard reduction, including through habitat protection and restoration (Humberg 2021; Shi 2020).

Green Shores Program. This voluntary incentive program overseen by the Washington Sea Grant provides education and incentives for waterfront homeowners to restore shorelines and implement living shorelines across their properties (Conger and Chang 2019).

Aquatic Reserves Program. The Washington Department of Natural Resources manages roughly 2.6 million acres of state-owned aquatic land among their 5 million acres of owned land. Since 2004, via WAC 332-30-151, Washington Department of National Resources has implemented a program that incentivizes the development of additional aquatic reserves with the goals of protecting and restoring ecosystems, as well as creating access for scientific and educational use (Bailey et al. 2003; Mississippi-Alabama Sea Grant Legal Program 2014). Washington interviewees note that this program is "small-scale, but effective" at protecting aquatic habitats while providing opportunities for research and education. Currently, there are seven marine reserve programs in Washington State.

HB1382, Streamlining the Environmental Permitting Process for Salmon Recovery Projects. In 2021, the state legislature passed Washington HB1382,[35] a policy intended to prevent habitat restoration projects from needing to comply with certain permitting processes that can delay or prevent progress. In addition, it created the Habitat Recovery Pilot Program to pilot restoration projects that benefit "freshwater, estuarine, or marine fish, or the habitat they rely on" that are exempt from those permitting processes.

[35] Wash. HB 1382 - 2021-22

4.6.4 State Innovations and Highlighted Local Initiatives

Washington lacks a unified, implementable, and proactive policy that sets goals for habitat restoration, manages upland threats, prevents shoreline armoring, and mitigates erosion. Washington's management of coastal habitat, though not comprehensive, is heavily collaborative and facilitates interagency and multisector cooperation. Much of the restoration work is driven by members of the public, including community groups and NGOs rather than the state (interview data). According to one interviewee, Washington's approach is bottom up: communities approach governments about restoration and policy tools are designed to fund those restoration projects, rather than designing and implementing them without community buy-in. Additional gaps noted by interviewees were lack of funding for monitoring and enforcement of marine debris removal policies.

Olympia Oyster Restoration in Puget Sound. Partners of this project include state agencies, tribes, county agencies, nonprofits, shellfish harvesters, and more; its implementation and monitoring is overseen by the Puget Sound Restoration Fund. Since 1999, the efforts have been concentrated in key areas in the Puget Sound. As of 2021, the project has accomplished its goal of restoring 100 acres and plans to restore an additional 50 by 2025 (Puget Sound Restoration Fund 2021).

Snohomish River Estuary Restoration. In Snohomish County, collaborative restoration work has been facilitated through their Sustainable Lands Strategy and Floodplains by Design program (described prior). As of 2016, their restoration efforts have approached their 10-year target (over 500 hectares for salmon recovery), and planners are contemplating expanding their goals. Within these restoration communities, some farm owners are negotiating for land swaps with the restoration community in an acknowledgement to continuing soil issues caused by "flooding, saltwater intrusion, drainage problems, and dike failures" (Christie et al. 2018).

Smith Cove Blue Carbon Pilot Project in the Port of Seattle. This project, a pilot with the Port of Seattle and funded by the Puget Sound Restoration Fund and the Washington State Department of Natural Resources in 2018, has planted over 25 acres of shellfish, seagrass, salt marsh, and kelp in Smith Cove. The Port of Seattle intends to generate offset credits through this project, which it will apply for its own mitigation as well as to fund additional restoration projects (Hutto et al. 2021).

The Grays Harbor Conservation District. Though this local agency has no regulatory authority, it serves and partners with farmers, the public, and private landowners to implement conservation and restoration practices on privately owned lands. These include forest fish passage projects, voluntary agriculture stewardship projects, salmon recovery projects, and conservation projects on riparian lands (Grays Harbor CD 2019). These efforts, and others from groups such as the Grays Harbor Stream Team and the Twin Harbors Waterkeeper, rely on voluntary buy-in for coastal habitat advocacy and protection.

In addition, county governments across the state (i.e., Skagit County, Snohomish County, King County, etc.) have initiated restoration projects and marine debris removal programs to restore and protect coastal habitats (Conger and Chang 2019).

5 DISCUSSION OF POLICY CHALLENGES AND INNOVATIONS

As discussed prior, policy effectiveness is challenging to assess. The study results reflect the complexities in the web of policies with overlapping federal, state, and local authority; the multitude of threats affecting the focal habitats; and evolving restoration science. The literature review suggests that cooperative management within federal, state, local governments, along with streamlining the permitting process, creating regional agencies, and developing open, transparent data-sharing can facilitate effective policy implementation (Rasmussen et al. 2021). While the state innovations described in this section cannot be correlated to the policy effectiveness criteria, the policies illustrate both innovations and remaining gaps in management. The policies in this section were identified primarily by interviews with state coastal management experts across sectors and the literature review. The innovations and gaps described include: (1) policies that build on the CWA or CZMA in a way that is distinct from other study states; (2) policies that seek to address implementation barriers, such as permitting challenges and information gaps; (3) local restoration and protection efforts; and (4) tackling climate change and sea level rise in policy mechanisms.

5.1 Creative Use of CWA and CZMA

The CWA and the CZMA establish joint roles and authority for state and federal agencies and, as discussed previously, are the comprehensive coastal management statutes most used by the study states. The literature review noted that implementation of the CWA has led to restoration success in some of the study states. For example, one study noted that California and Florida successfully used the CWA regulation and management practices incentives to reduce nutrient pollution in two local bays. Roberts Bay in Sarasota, FL, and Newport Bay in Orange County, CA, both continued to have improved water quality and marine habitats despite population increases over several decades (Green et al. 2021). The article also noted similar improvements to Tampa Bay, FL. Historically, Boston Harbor also faced dramatic losses of salt marshes and seagrasses through the nineteenth and twentieth centuries, losing over 1,000 acres of salt marsh between 1951 and 1971, although that loss slowed once the CWA passed. Seagrass habitats also declined in Boston Harbor by 42% between 1996 and 2006 (Bowen et al. 2019). Water quality improvements in Boston Harbor, driven by the CWA, improved the spatial extent of eelgrass (EEA 2015a). However, other local case studies implementing nutrient reductions pursuant to the CWA did not show the same level of success, and Green et al. (2021) attribute Roberts Bay and Newport Bay's successes to nonpoint source best management practices implementation rather than a specific policy.

Two of the study states have adopted rules that target one of the focal habitats—salt marshes—within the CWA regulatory frame. Both Massachusetts and North Carolina have policies designed to address threats to salt marshes, but each state has a different policy lever. Massachusetts is focused on protection of existing salt marshes; North Carolina is using living shoreline permitting to increase its restoration.

Massachusetts has the most comprehensive set of policies of the study states targeting salt marshes. The Massachusetts WPA explicitly includes salt marshes within the program. Massachusetts rules that implement the WPA state that any activity in or near a salt marsh "shall

not destroy any portion of the salt marsh and shall not have an adverse effect on the productivity of the salt marsh."[36] This "no-touch" policy does have some exceptions, but according to Massachusetts coastal management experts, this is a very high bar and salt marsh acreage has had only small declines over decades (Rhodes et al. 2019). Salt marsh protections are also incorporated into the two National Estuary Program sites—Massachusetts Bay and Buzzards Bay—which are authorized under the CWA and include extensive monitoring of salt marshes within the National Estuary Program.

North Carolina has focused on increasing the use of living shorelines to protect and restore salt marshes. In response to the USACE development of a new NWP for living shorelines (NWP 54), the North Carolina Division of Coastal Management created a new general permit under the coastal regulatory program to reduce the administrative barriers to incentivize greater use of living shorelines. The marsh sill permit allows the North Carolina Division of Coastal Management to issue state general permits for the construction of marsh sills without a case-by-case federal review.[37] (NC DEQ 2019). The new general permit may also help with oyster restoration in the state. Hardened shoreline permitting in North Carolina only requires a single state agency approval and is often completed by field staff onsite. Changes made to the state coastal rules in 2019 created a process for approving marsh sills with the same administrative ease as hardened structures such as bulkheads.

California and Florida have each taken significant steps to change how the CWA is implemented in each state. While neither of these efforts are targeted to any of the four focal habitats, both represent a change in how wetland protections pursuant to the CWA are implemented.

In 2019, California amended its definition of wetland to address any differences in protection for waters of the US and state waters to maintain the state's strict level of protections for wetlands. The State and Regional Water Resources Control Boards' Wetland and Riparian Area Protection Policy requires the use of the new definition in water control plans (CCC 2021). By amending the definition of wetland, California expanded the permit requirements for activities that need a CWA section 401 certification. For coastal areas, the new definition includes tidal flats and tidal ponds that might not otherwise be covered by the CWA's prohibition on dredge and fill.

To date, Florida is one of only three states (joining Michigan and New Jersey) to have secured approval from the EPA to implement the CWA section 404 permit program and the first state in more than 25 years to request it. On December 17, 2020, EPA approved the transfer of permitting authority from USACE to the State of Florida. Florida's request generated over 3,000 comments during the public comment period.[38] The Florida experts interviewed for this study did not indicate whether this would be a policy mechanism that would be effective in protecting or restoring the four focal habitats. The change, however, was noted as a significant one that alters Florida's policy landscape and positions Florida differently with respect to CWA authority than the other study states.

[36] 310 Code Mass. Regs. § 10.32.
[37] 15A NCAC 7H .2700.
[38] 85 Fed Reg. 246, 83553 (Dec. 20, 2020)

The effectiveness of wetland restoration, undertaken pursuant to the national wetland policy established by the CWA, is hard to measure. Wetland mitigation banking, however, plays an important role in coastal wetland restoration efforts, including salt marsh restoration. The CWA mandates that impacts to wetlands are to be avoided, minimized, or mitigated. Wetland mitigation consists of creating or restoring wetlands so that there is "no net loss" of wetlands. The no net loss policy has been controversial. One paper observes that post-2008 studies of this policy are rare and that additional research is needed to determine rate of mitigation compliance. Regardless, the combined effect from anthropogenic and natural impacts outstrips the mitigation policy's ability to force additional wetland restoration (Gittman et al. 2019).

Wetland mitigation banking is one mechanism for meeting the no net loss policy because the restoration or creation of a wetland can replace the function of an impacted wetland within the right hydrologic unit. Post-2008 onsite mitigation declined significantly as states increased the use of mitigation banks and in-lieu fee programs (Gittman et al. 2019). Generally, it is more effective to restore wetlands than create them at the watershed and landscape scales (Barbier 2011). Even effectively restored wetlands, however, often cannot substitute for undisturbed wetlands (Gittman et al. 2019). Large-scale projects, however, may function more similarly to undisturbed systems. Mitigation banks can encourage large-scale restoration and provide for buffer zones to facilitate habitat adaptation to the impacts from climate change and sea level rise (Radabaugh et al. 2017). In addition, a study on in-lieu fee programs, in which mitigation responsibilities for permit holders are satisfied through depositing funds to natural resources management agencies or nonprofits rather than through restoring or enhancing habitat directly (Hough and Harrington 2019) identified Massachusetts as prioritizing preservation projects rather than restoration, which is opposite the national trend (Kihslinger et al. 2019). Furthermore, the Florida legislature introduced, but failed to pass, a bill to establish a mitigation bank for seagrass (FL interview data) This study could not assess whether mitigation banks for salt marshes, mangroves, or seagrass could be an effective policy mechanism for restoration but does observe that the study states use them.

Overall, states do have wide latitude in crafting state-level programs under the CWA, CZMA, and other federal policies that meet their identified needs, as has been demonstrated in these examples. Likewise, study states continue to use mitigation banks as a mechanism for restoration of one or more of the four focal habitats. However, knowledge of the overall effectiveness of CWA, CZMA, and related US wetland mitigation policy on protection and restoration of the four focal habitats in the six states of interest, and how those protections may change over time, is beyond the scope of this study. Long-term monitoring of coastal habitats and causal studies on policy implementation can help clarify these effects and identify replicable, effective approaches.

5.2 State Initiatives that Address Barriers to Policy Implementation

Several enabling conditions have been identified that result in more effective policy implementation, though study states have not yet incorporated or created these enabling conditions. As a result, their absence serves as a barrier to more effective policy implementation. These conditions include presence and support for long-term and comprehensive monitoring programs of the four focal habitats, permitting programs that facilitate restoration, and statewide

approaches to habitat or critical species conservation. The sections that follow describe the six states of interest responses, or lack thereof, to monitoring, permitting, and conservation as it relates to the four focal habitats.

5.2.1 States do not Have Comprehensive Monitoring Programs for the Four Focal Habitats that Produce Timely Data for Assessing Policy Effectiveness

Statewide monitoring or monitoring conducted outside the scope of an individual project is important for establishing a baseline and for understanding statewide policy effectiveness. Long-term monitoring of coastal habitats establishes baseline status, tracks the impact to the habitat and trends from the known threats, and is recognized as an essential component for coastal habitat management (Radabaugh et al. 2017). While each of the six study states has developed and implemented comprehensive monitoring programs for one or more of the four focal habitats at different times, none of them have long-term comprehensive monitoring programs that consistently and rigorously assess these focal habitats. This lack of comprehensive monitoring impacts policy implementation (Field, Kenworthy, and Carpenter 2020). For example, as discussed previously, the range of black mangrove is moving northward and potentially competing with salt marshes. To determine the effect of climate change on mangrove habitat, migration pattern, and change in spatial extent, sustained, regional monitoring is needed (Giri and Long 2016; Reece et al. 2018). Florida engaged in a comprehensive monitoring program for seagrass, which provided important information until the program was discontinued for lack of funding. (Florida FWC 2019; Yarbro and Carlson 2016). Table 7 provides detail on whether each habitat is monitored by state government agencies and if the data are made publicly available in each state. This information is based on the literature review, state agency searches, and interviews. This table does not include federal monitoring programs, and there may be other sources of habitat monitoring information that were not captured through this process.

At the project level, habitat monitoring, including monitoring of habitat function and spatial extent, that is conducted regularly over long study periods is the ideal for assessing the effectiveness of restoration efforts and the implementing policies (Abelson et al. 2020; Beck et al. 2019; Powell et al. 2019). Long-term restoration project monitoring across multiple habitats and multiple success criteria is needed for assessment of restoration efforts (Raposa et al. 2018). Relative to land-based restoration activities, monitoring coastal habitat is hampered by lack of funding, which affects the length of time a restoration project is monitored or whether the project is monitored at all (Abelson et al. 2020; Fancy and Bennetts 2012; Raposa et al. 2018). In Florida, restoration projects on public lands are most likely to be monitored. Lack of funding, however, precludes most projects from being monitored for more than three to five years (Radabaugh et al. 2017). As another example, mangrove ecosystem structures can take decades to be fully established, but the average monitoring period is only three to five years, leaving major gaps in the knowledge and data about the effectiveness of mitigation projects (Barbier 2011).

Table 7. Current habitat monitoring efforts by state governments, 2016 to present

State	Habitat	Most Recent Publication with Statewide Extent Assessment	Source	State-Led?	Publicly Available, Ongoing Monitoring or Assessment Program?
California	Seagrass	2014	California Eelgrass Mitigation Policy and Implementing Guidelines (NOAA Fisheries 2014)	No	No
	Oyster	Unknown	Unknown	Unknown	Unknown
	Salt marsh	2012	Determining the Health of California's Coastal Salt Marshes Using Rapid Assessment (Solek et al. 2011)	No	No
Florida	Seagrass	2019	Seagrass Integrated Mapping and Monitoring (SIMM) Program and Florida Fish and Wildlife Conservation Commission (Yarbro and Carlson 2016)	Yes	No
	Oyster	2021	Oyster Integrated Mapping and Monitoring Program (OIMMP) and Florida Fish and Wildlife Conservation Commission (Radabaugh et al. 2019)	Yes	No
	Salt marsh	2021	Coastal Habitat Integrated Mapping and Monitoring Program and Florida Fish and Wildlife Conservation Commission (Radabaugh et al. 2017)	Yes	No

State	Habitat	Most Recent Publication with Statewide Extent Assessment	Source	State-Led?	Publicly Available, Ongoing Monitoring or Assessment Program?
Florida	Mangrove	2019	Coastal Habitat Integrated Mapping and Monitoring Program and Florida Fish and Wildlife Conservation Commission (Radabaugh et al. 2017)	Yes	No
Massachusetts	Seagrass	2020	Eelgrass Mapping Project (MassDEP 2022)	Yes	Yes
	Oyster	N/A	MassGIS Data: Designated Shellfish Growing Areas (MassGIS 2017)	Unknown	Unknown
	Salt marsh	Date uncertain	Geospatial Characterization of Salt Marshes for Massachusetts (Ackerman, Zafer, and Kamal 2021)	No	Unknown
North Carolina	Seagrass	2021	North Carolina Submerged Aquatic Vegetation (NC DEQ n.d.b)	Yes	Yes
	Oyster	2010	North Carolina Shell Bottom Habitat (NC DEQ n.d.a)	Yes	Unknown
	Salt marsh	N/A	Unknown	Unknown	Unknown
Texas	Seagrass	2020	Texas Statewide Status and Trends (Handley and Lockwood 2020)	No	Unknown
	Oyster	N/A	Unknown	Unknown	Unknown
	Salt marsh	N/A	Unknown	Unknown	Unknown
	Mangrove	N/A	Unknown	Unknown	Unknown

State	Habitat	Most Recent Publication with Statewide Extent Assessment	Source	State-Led?	Publicly Available, Ongoing Monitoring or Assessment Program?
Washington	Seagrass	Date uncertain	Washington Marine Vegetation Atlas (Washington DNR, n.d.)	Yes	Unknown
	Oyster	N/A	Unknown	Unknown	Unknown
	Salt marsh	Date uncertain	Washington State Coastal Atlas Map (Washington Department of Ecology n.d.)	Yes	Unknown

Monitoring habitats over time is critical to connect protection and restoration efforts to long-term goals and to adapt policy mechanisms in response to changing threats (Brockmeyer et al. 2021). Both Florida and North Carolina have made significant investments in habitat monitoring, data collection, and data accessibility. Florida established the SIMM Program in 2009 and built the CHIMM Program off of SIMM's success. SIMM was created "to protect and manage seagrass resources in Florida by providing a collaborative platform for reporting seagrass mapping, monitoring, and data sharing" (Yarbro and Carlson 2016). The mapping effort was not a statewide, comprehensive program, with some areas in the program being assessed regularly and others intermittently (Florida FWC 2019). While the SIMM Program is no longer funded, the Florida Office of Resilience and Coastal Protection continues to monitor some locations across the state (Florida DEP 2022c). The CHIMM program was designed to "build a network of collaboration among salt marsh and mangrove mapping and monitoring programs … to identify the status and needs of coastal wetlands and to make recommendations for their management." The final report noted that coastal wetland monitoring programs are often not long-term and utilize different methodologies. The final report also recommends "methodologically consistent, long-term statewide monitoring" and notes that "cooperation is necessary among federal, state, and local governmental agencies and nonprofit groups to coordinate" management and migration for coastal wetlands (Radabaugh et al. 2017). Neither of these programs are currently operating in Florida due to the lack of long-term, consistent funding.

NC CHPP began in 1998 and its purpose is to promote the "long-term enhancement of coastal fisheries associated with … coastal habitats."[39] The report is produced every five years. The NC CHPP is adopted by all three state-level commissions that have regulatory authority impacting the coast—the Environmental Management Commission, the Coastal Resources Commission, and the Marine Fisheries Commission—which is intended to promote a linked management approach. The NC CHPP focuses on several habitat types, including three of the four focal habitats of this study – seagrass, salt marsh (or "coastal wetlands") and oysters. The NC CHPP

[39] G.S. 143B-279.8

goals include "improve effectiveness of existing rules and programs protecting coastal habitats; identify and delineate strategic coastal habitats; enhance coastal habitat and protect it from physical impacts; and enhance and protect water quality." Despite these goals, the current status and trends for the coastal habitats is one generally of decline and ongoing mapping and monitoring is piecemeal. (NC DEQ 2021) Thus, the NC CHPP remains primarily a tool for aggregating data and ensuring that cross-agency activities are coordinated.

In addition to monitoring coastal habitats, effective habitat management tools include modeling information to inform restoration or preservation activities, particularly as sea level rise and climate change are anticipated to intensify the threats to the four focal habitats. Some research indicates that habitat migration landward should be a management priority (Leo et al. 2019). As discussed above, Massachusetts has a long-standing emphasis on salt marsh and coastal wetlands. While the trend in salt marsh is relatively stable, with only small declines, sea level rise is anticipated to stress the system. Massachusetts has developed a tool to help "develop statewide predictions of the future extent and distribution of coastal wetlands" in order to identify coastal wetland migration corridors (Massachusetts CZM 2020). As of the date of this report, the information developed through the Sea Level Affecting Marshes Model (SLAMM) has not been made public (Massachusetts CZM 2022b).

5.2.2 Implementation, Including Permitting, Affects Effectiveness as Much as Policy Design and is Challenging to Track for Statewide Policies.

Coastal development is one of the key stressors on all four focal habitats. Development pressures impact habitat in multiple ways—water quality is impacted by runoff, pesticides, fertilizers; habitat is destroyed; shorelines hardened; and seagrass areas are shaded. Both the CZMA and the CWA establish regulatory authority for activities within the coastal zone, including permits that affect how development activities are conducted. Permits, guided by the standards and practices established by the state implementation rules of the federal law, are tailored to the habitat impact, the activity, and, depending on the scale of the impact, the site.

Cumulative impacts arising from multiple permitting decisions, interrelated impacts and exemptions from federal and state regulatory programs can all impact the effectiveness of a given policy. Permits also do not regulate the cumulative impacts associated with an activity. For example, the Washington expert interviews suggested that eelgrass impacts are addressed permit-by-permit. As a result, the permitting program misses opportunities to address cumulative impacts from multiple projects. Without a comprehensive eelgrass management plan that can assess and address cumulative impacts, Washington does not have a policy mechanism for measuring the cumulative impacts or incorporating better development practices that account for the cumulative impacts. In another example, a study looked at the effect of requirements and restrictions for docking on surrounding salt marsh habitats in Massachusetts. The study acknowledged that "while individual docks only impact a small area of salt marsh habitat, cumulative impacts at the town, embayment, or state level can impart broader loss of marsh production and associated ecosystem services" (Logan et al. 2018). The volume of approved permits for impacts to wetlands illustrates this challenge. For example, between 1999 and 2003, the U.S. Army Corps of Engineers approved over 12,000 permits for development projects on wetlands and rejected only one in Florida (Levina et al. 2007). While the total number of

permits may not be indicative of the level of impact associated with each permit, if each approved permit allowed a small impact on coastal habitat, the cumulative impacts could be evading review. Without an exhaustive analysis of the permit instruments themselves, this study cannot determine whether a statewide permitting program is effective. However, given these examples from the literature and expert interviews about the gap in assessing cumulative impacts and potential role this regulatory gap may play in the decline of the focal habitats, a future area of research analyzing permit instruments and statewide permitting programs would be beneficial.

Innovative or new policy approaches may also be restricted by permit program implementation, since for the most part permitting programs were created to manage development impacts as opposed to restoration and other nature-based strategies for coastal management. For example, living shorelines are a type of nature-based infrastructure that can stabilize eroding coastal shorelines. They often use marsh vegetation and sills that are composed of rocks or oyster shells. Construction of a living shoreline, however, must go through the same permitting program as hardened structures like bulkheads. The US Army Corps of Engineers (USACE) recently created a new NWP to help streamline permitting for living shorelines (NWP 54). Out of the six study states the NWP 54 has been used most often in Florida (Hilke et al. 2020). Discussed more fully in Section 5, one of North Carolina's innovations is using this new permitting structure to increase utilization of living shorelines in the state. Other study states in this report are also exploring policy mechanisms to increase the incentives for using living shorelines but are facing barriers that arise from the state's CWA permitting program. For example, an interviewee from Massachusetts reflected on permitting living shorelines that the state agencies "are supportive of living shorelines, and yet they are individual people, and they see a lot of bad projects that come across their desk that they shouldn't permit and see some good ones that strain their mandate." (Massachusetts interview data).

Permitting restoration often faces the same regulatory barriers as permitting development on the coast. As discussed above, a method for reducing barriers to restoration efforts like living shorelines, is to coordinate the federal and state permits. North Carolina now has a streamlined coastal general permit for living shorelines that meets the federal CWA requirements and the state coastal area management act. California has also developed an initiative to streamline and coordinate across agencies to improve the regulatory landscape under which environmental interventions are approved—the Cutting Green Tape Initiative. In their 2020 report, the authors lay out 14 recommendations developed from extensive stakeholder input, to amend the permitting process for restoration and other projects (California Landscape Stewardship Network 2020). These include recommendations for both small-scale and large-scale projects, as well as coastal zone and freshwater projects specifically, and include provisions for simplifying permit applications across agencies. This is an ongoing effort and cross-agency initiative and at the time of this publication has not yet been institutionalized in California law, but the goal of the initiative is to codify and implement streamlined restoration permitting in the state.

5.2.3 State Conservation Policies

One dimension for assessing a state's efforts to address threats to the four focal habitats is how the state approaches conservation or preservation of habitats. Conservation efforts such as acquisition of land can preserve the habitat in perpetuity and accommodate landward migration

of salt marsh and mangroves in response to climate change and sea level rise. Restoration and conservation efforts can also be combined. In addition, preserved areas can enhance the ecosystem function of adjacent nonprotected areas. For example, enhancing no-take oyster sanctuaries helps to seed nearby oyster reefs that are open to harvest (Peters et al. 2017).

Florida has an emphasis on conservation efforts at both the state and local level. Florida Forever is the state's flagship effort to acquire and conserve priority land. Managing approximately 10 million acres, it is the largest public land acquisition program in the United States (Florida DEP 2022a). Salt marsh migration corridors are included in the priority lands (FL interview data). In addition to Florida Forever, Miami-Dade and Brevard County, local governments in Florida, have enacted conservation programs that utilize a property tax to acquire environmentally endangered lands, including salt marsh and mangroves (Miami-Dade County 2021; interview data). Florida also has an extensive aquatic preserve system. The current aquatic preserve program includes 42 aquatic preserves. The most recent, the Nature Coast Aquatic Preserve, was approved in 2020. Four aquatic preserves—Big Bend Seagrasses, St. Martins Marsh, Pinellas County, and the Nature Coast Aquatic Preserve—collectively provide protections for the largest seagrass meadow in the Gulf of Mexico and the largest spring-fed seagrass bed in the world (Florida DEP 2022b). The Aquatic Preserve Program includes stakeholders in a public engagement process in developing a management plan for each of the aquatic preserves (Florida Coastal Management Program 2020). California also uses a marine protected area program that conserves about 16% of all state coastal waters within 124 protected areas (CDFW 2022).

5.3 Local or Regional Efforts Can Lead the Way

Local and regional efforts are highlighted in the literature and in the expert interviews because (1) the state and federal regulatory structure can incentivize and facilitate effective local action; (2) without statewide monitoring of the trends and threats to the four focal habitats, knowledge of local habitat issues may motivate action at the substate level; and (3) the local context is important for effective restoration. All study states have examples of restoration or preservation efforts that bring together federal, state, and local governments, along with stakeholders, some of which are described in following sections. The federal environmental statutes create the framework within which the local effort can succeed. State-level coastal habitat protection and restoration efforts are primarily nested within the cooperative federalism structure of the CWA and CZMA, both of which have statutory mechanisms for supporting local or regional projects. For example, NERRS authorized by the CZMA establish federal, state, and local partnerships. The National Estuary Program, established by the CWA, uses a collaborative process that includes federal, state, and local government, along with key stakeholders, to develop a Comprehensive Conservation and Management Plan. Furthermore, several states in this study have active local government management of the coast. California and Massachusetts are notable for the level of local government involvement in coastal habitat management and permitting.

One of the essential attributes for effective large-scale restoration identified in the literature review is the importance of information about the decline or status of the impacted habitat (DeAngelis 2020). This actionable information is documented in three case studies, including Chesapeake Bay, Tampa Bay, and San Francisco Bay, as a key enabling factor for those areas

(DeAngelis 2020). Without statewide monitoring, local or regional emphasis in state monitoring programs can facilitate local action.

Finally, local threats and local context may be more important for assessing effective policy implementation than statewide information. For example, local threats to eelgrass may be more critical to understanding eelgrass decline along the West Coast than previously appreciated (Sherman and DeBruyckere 2018). In addition, implementation has a significant impact on restoration and protection outcomes. The literature emphasizes the importance of funding, ongoing sustained monitoring, consistent enforcement, and increased communication across jurisdictions as the critical enabling factors for effective governance (DeAngelis 2020). These enabling factors may be more achievable within a local or regional effort than statewide.

While this study was designed to identify effective habitat-specific, statewide policy mechanisms, the following local projects described suggest that local or regional efforts might be a more effective scale for restoration and protection policy than statewide mechanisms.

5.3.1 CWA and CZMA Provide the Framework for Local Restoration and Protection Efforts

Local restoration and protection efforts are also driven by the CWA and CZMA. As outlined, both federal statutes create a framework for multijurisdictional projects. Several illustrative examples of local efforts had repeated mentions in both the literature and in the interviews. Tampa Bay Estuary Program (TBEP) was one of the most referenced and is described here, along with Puget Sound. Other examples, including Boston Harbor, Galveston Bay, Narragansett Bay, and San Francisco Bay, are included in the state summaries. The themes revealed from these examples include (1) strong local authority, (2) management for multiple habitats, (3) the importance of funding, (4) long-term monitoring, and (5) ongoing threats that may undo or impede progress.

The National Estuary Program, established by the CWA, provides the federal statutory framework for both Tampa Bay and Puget Sound. Both National Estuary Program sites, however, have additional layers of state and local programs, which result in fundamentally different policy levers and governance structures for each site.

Tampa Bay, Florida's largest open-water estuary, is 400 mi^2 with a drainage basin of 2,200 mi^2 (Tomasko et al. 2018). The primary threats to Tampa Bay have been nutrient pollution from coastal development, along with phosphate production and port activities. Nitrogen levels in Tampa Bay have been monitored since the mid-1970s (Beck et al. 2019). Caused in part by nutrient pollution, Tampa Bay experienced a loss of 47% of its seagrass coverage between 1950 and 1999. Significant nutrient pollution reductions from point sources allowed seagrass to recover to 1950 levels by 2016 (Tomasko et al. 2018). TBEP included seagrass restoration in its goals, and it is recognized as one of the first large-scale restoration successes (Angelo and Glass 2021). It should also be noted that TBEP's management goals also include mangroves and salt marshes. While Tampa Bay is referenced in the literature as a success, the expert interviews suggest that the threats continue to increase as the population around Tampa Bay grows, which the interviewees indicate may impair TBEP's ability to sustain the restoration gains.

The policy success in reducing nutrient pollution comes from the interactions of multiple state and local activities. One estimate suggests that restoring Tampa Bay's seagrass to the historic 1950 levels involved more than 900 public and private efforts (Beck et al. 2019). The National Estuary Program, however, provides the governance structure within which most of the activities are coordinated and funded. Tampa Bay received the "estuary of national significance" designation in 1991, which established the TBEP. One of the significant components of the program was the binding interlocal agreement—the first of its kind in a National Estuary Program. The agreement required local governments to adopt the CCMP goals and incorporate the targets in their local management plans. TBEP also established the Tampa Bay Nitrogen Management Consortium as a subgroup of the TBEP, which engages stakeholders to advance the goals identified by TBEP (Angelo and Glass 2020). TBEP's funding comes from federal, state, regional (water management district) local, and private sources. DeAngelis (2020) noted that federal funding is the smallest percentage of the overall budget and identifies combining multiple funding streams as essential for large-scale restoration efforts.

Like Tampa Bay, Puget Sound was designated as a National Estuary Program site in 1988. The governance and restoration goals of Puget Sound, however, are distinct from TBEP in that they have a central management agency established by statute and are focused on the full ecosystem rather than specific threats. This difference highlights the flexibility within the National Estuary Program to accommodate different restoration goals and governance, along with its importance in driving restoration efforts. Puget Sound has a central management agency, the Puget Sound Partnership (PSP). The PSP was established in response to the criticism that restoration efforts were fragmented and lacked coordinated goals. The PSP is a state agency, and its purpose is to coordinate multiple partners to achieve legislative goals. (Jones et al. 2021). The statutory goals include "[a] healthy Puget Sound where freshwater, estuary, nearshore, marine, and upland habitats are protected, restored, and sustained."[40] In contrast to TBEP, the PSP's objective is an ecosystem-based approach rather than a threat-specific approach.

PSP and TBEP both include significant local authority and management. TBEP, however, nests more authority with local governments and uses an innovative, binding local agreement. PSP sets the strategic direction for Puget Sound, known as the Puget Sound Action Agenda, through a collaborative process, involving federal, state, and local governments; academics; local residents; tribal leaders; environmental nonprofit organizations, and representatives from affected industries. Once the Puget Sound Action Agenda is set, it is implemented by local organizations. The Local Integrating Organizations' boundaries are based on the subregions of Puget Sound and are designed to further the ecosystem-based and collaborative governance approach (Jones et al. 2021).

Both PSP and TBEP illustrate the importance of local authority and action, as well as how state and federal policies are interwoven into local policy initiatives. The governance framework is distinct for each program, however, highlighting the importance of local context restoration.

[40] RCW 90.71.300

5.3.2 Local Projects can also Demonstrate Effective Policy Mechanisms that may be Useful in Developing Statewide Habitat Policies or in Addressing Climate Change

Local management activities can be important as a test bed for state-level policy development and meeting federal program objectives. For example, effective local programs can be scaled up or serve as demonstration sites that can inform more effective statewide policies. One example is the California Eelgrass Mitigation Policy (CEMP), developed by NOAA and based on the existing "Southern CA Eelgrass Mitigation Policy." NOAA identifies the Newport Bay Eelgrass Comprehensive Management Plan as meeting the objectives of the CEMP and a success story. The Newport Bay Eelgrass Comprehensive Management Plan was developed as part of the City of Newport Beach Harbor Area Management Plan issued in 2010 (City of Newport Beach 2015). The plan creates a tiered system that restricts the amount of impact and establishes acceptable best management practices (NOAA Fisheries 2014).

5.3.3 Local Funding Mechanisms can Drive Place-Based Restoration and Protection

Sustained funding is an essential element for any habitat restoration or protection policy. Several local efforts were identified in interviews as being important for habitat protection in a local or regional area. Measure AA, or the San Francisco Bay Clean Water, Pollution Prevention and Habitat Restoration Measure, was passed in 2016. It is a parcel tax of $12/year for properties in nine counties surrounding the San Francisco Bay Area projected to generate approximately $25 million annually for 20 years to fund restoration projects, flood management projects, and public access in San Francisco Bay (MyParcelTax.com n.d.). The letters AA in Measure AA do not appear to stand for any acronym. The San Francisco Bay Restoration Authority has prioritization and project selection criteria that direct the funding. Florida local governments have also been active in securing funding for preservation. Brevard and Miami Dade County Environmentally Endangered Lands (EEL) is a local effort started in 1990 that started with a local tax to create a funding mechanism for preservation (FL interview data). To date, EEL has purchased 28,000 acres of natural areas and protected 37 miles of natural shoreline along the Indian River Lagoon and its major tributaries.

5.4 Defining the Components of Successful Restoration is Challenging

Effective policies need benchmarks for restoration success that incorporate current restoration science and recognize the impacts of climate change.

5.4.1 Habitat Management that Addresses Multiple Habitats Could have Synergistic Benefits, but some Habitats are in Direct Competition

The literature suggests that habitats can benefit each other. For example, mangroves and seagrasses may have positive interactions, including increased resilience to threats and increased species and habitat quality benefits (Carlson et al. 2021). The health and spatial extent of Florida's seagrass beds are connected to the improved water quality resulting from filtration services provided by salt marsh (Radabaugh et al. 2017). The California interviews suggested that oyster and eelgrass restoration should be conducted with the goal of enhancing both habitats. In contrast, the Florida interviews suggested that balancing oyster restoration and seagrass presents challenges. For all those reasons, a comprehensive or multihabitat approach may be more effective than a singular focus on a habitat or threat. This could also address inequities in protection between habitats. For example, the Massachusetts interviews suggested that state policy is less

protective of eelgrass than of salt marshes. Considering the potential synergistic interactions between healthy salt marshes and adjacent seagrass areas, states could address these disparities by creating a comprehensive habitat approach that considers multiple habitats.

Adjacent coastal habitats can also be in competition, particularly as a result of climate change impacts such as warming temperatures and sea level rise. Mangrove encroachment into salt marsh habitat was the most often cited habitat conflict in the interview data. Mangrove habitat does not extend into areas that have a hard freeze (Volk et al. 2017). As the climate shifts and the hard freeze line migrates north, hardier black mangrove is moving north as well. Both Florida and Texas observe a northward migration of mangroves and the mangroves' encroachment into salt marsh. This habitat conflict can create competing management interests, which is not addressed by either state's policy frameworks (Florida and Texas interview data). According to interviewees, state government agencies are monitoring the migration and observing encroachment into salt marsh habitat but have not yet passed any state-level policies to address it. On a project-by-project basis, however, mangrove restoration is not prioritized, and salt marsh restoration is reconsidered because it is assumed mangroves will inhabit a given salt marsh area anyway so it may be a large investment that is ultimately not necessary. This sentiment is not captured in the literature but was heard from experts in the affected states.

5.4.2 Limited Restoration Science for Marine Ecosystems

Another dimension critical for understanding policy efficacy is measurable benchmarks for restoration success. The limited literature review included several analyses on the state of the science for marine systems. They generally indicate that restoration success is hard to define and demonstrate (Abelson et al. 2020; Beck et al. 2019; DeAngelis 2020; Powell et al. 2019). The four focal habitats experience a variety of stressors and threats that vary spatially and geographically. Successful threat mitigation might be measured by a return of ecosystem function, spatial extent, or generally improved water quality. Restoration goals might also be set to a defined period by the project—for example, the establishment of plants within five years. While these goals are tied to specific environmental criteria, a restoration project might include other goals. This study's literature review suggests that stakeholders have different interests in the successful restoration of coastal habitat and large-scale restoration benefits from stakeholder understanding of the threats and declining habitat (Abelson et al. 2020, DeAngelis et al. 2021). Broadening the criteria for success to include ecosystem services, however, may make setting benchmarks for restoration success harder (Beck et al. 2019). In addition to the challenges of setting measurable benchmarks, restoration has primarily focused on small-scale projects and may need to scale up to realize the benefits of restoration (Knowlton 2021). Finally, restoration science continues to evolve and lack of information about what causes restoration efforts to fail may pose challenges in identifying clear, measurable benchmarks for success. For example, Massachusetts noted several unsuccessful eelgrass restoration projects despite successful efforts in other areas (EEA 2015b).

5.4.3 Climate Change and Related Sea Level Rise are Two of the Most Significant Threats to all Coastal Habitats; Limitations on the Ability to Adapt Creates Barriers that Policy Levers may Struggle to Address

Climate change impacts, including sea level rise, ocean acidification, and subsidence, are occurring in all of the study states, albeit with differing impacts. In areas that are experiencing

or will experience accelerated sea level rise or subsidence, the coastal habitats will need to adapt to the changing coastal landscape. For salt marsh and mangroves, adaptation to sea level rise is limited to increasing elevations through processes such as adding sediment and protecting accommodation areas to allow upland migration (Wigand et al. 2017; A. Watson et al. 2017; Petek 2019). The level of development may limit the opportunity for upland migration potential for both habitats through coastal squeeze. In the absence of coastal development and its related effects on habitat extent and health, coastal habitats would have the potential to migrate in response to sea level rise (Reece et al. 2018). Expert interviews in Florida and Texas indicate that while Florida's level of development is already limiting some migration corridors, Texas is still relatively undeveloped and may have opportunities for preserving habitat migration corridors. The literature review highlighted the potential use of rolling easements that might maintain protection for natural areas as the habitats migrate landward. Texas, Massachusetts, and North Carolina were all mentioned as having existing legal interpretations that might be actual or de facto rolling easements, which is the legally enforceable expectation that the shore or human access along the shore can migrate inland instead of being squeezed between an advancing sea and a fixed property line or physical structure (Naismith 2020). Texas has the most commonly cited rolling easement, which arises from the Texas Open Beaches Act (TOBA). TOBA protects public beaches by prohibiting development that interferes with public access. The area available to the public is not spatially fixed and can move. Court cases have upheld the rolling easement but have stated that a storm event does not automatically move the line between public and private areas of the beach. (Naismith 2020; Spencer-Davis 2020) As discussed in more detail in this report, the Massachusetts WPA imposes stringent restrictions or prohibitions on building in areas that contain certain coastal habitats, including salt marsh. One scholar categorizes these restrictions as a de facto rolling easement (Graikoski and Hoagland 2017).

Another example is the impact from increased frequency and intensity of storms. In Massachusetts, the long-standing protections for salt marshes may be at risk, as the anticipated impacts from climate change include the increased frequency of storm events. Massachusetts salt marsh acreage declined by 89 acres between 1990 and 2005 (Rhodes et al. 2019). This decline is associated with impacts from storms. As the frequency and intensity of storm events is expected to increase in Massachusetts, the climate change adverse impacts on salt marsh may begin to outpace the protections provided by the Massachusetts WPA (Rhodes et al. 2019). These examples illustrate the need to update coastal habitat protection and management policies to address emerging challenges related to climate change.

6 CONCLUSION

The four focal habitats in this study are threatened by coastal development, changes in environmental and water quality, and the accelerated impacts associated with climate change. Identifying state-level policies that are effective across geographies and state governance is challenging. This study conducted a nonexhaustive review to find examples of effective state-level policies that address impacts to four focal habitats. Even using broad qualitative criteria to identify effective policy did not reveal a significant number of policies. The study had several limitations that, when taken together, make the identification of promising policies illustrative.

The illustrative examples, however, also offer insight into state-level habitat protections generally. The CWA and the CZMA are the backbone for the many of the successful policies identified by this study. While not all the study states used innovative mechanisms, the state interviews and the literature review found that the CWA and the CZMA provide substantial state-level authority and that, even without innovation, states have effective policy tools within these two cooperative, federal programs. In addition, local efforts are also organized by the NERRS and National Estuary Program, which are authorized by the CZMA and CWA, respectively. Local programs illustrate both the layered policy framework and distinct mechanisms for improving protection and restoration of the four focal habitats. Finally, long-term, sustained monitoring is critical for understanding the evolving impacts from climate change and to mark whether the coastal policy framework is achieving sufficient habitat protection. Further research is needed to identify gaps in each state's policy framework, ineffective policy mechanisms and each state's capacity for full implementation of existing authority, including enforcement, monitoring, and permitting.

REFERENCES

Abelson, A., D. C. Reed, G. J. Edgar, C. S. Smith, G. A. Kendrick, R. J. Orth, L. Airoldi, B. Silliman, M. W. Beck, G. Krause, N. Shashar, N. Stambler, and P. Nelson. 2020. "Challenges for Restoration of Coastal Marine Ecosystems in the Anthropocene." *Frontiers in Marine Science* 7: 544105. doi:10.3389/fmars.2020.544105.

Ackerman K. V, D. Zafer, and G. N. Kamal. 2021. *Geospatial Characterization of Salt Marshes for Massachusetts*. Woods Hole, MA: Woods Hole Coastal and Marine Science Center. https://www.usgs.gov/data/geospatial-characterization-salt-marshes-massachusetts.

Adam, P. 2002. "Saltmarshes in a Time of Change." *Environmental Conservation* 29(1): 39–61. doi:10.1017/S0376892902000048.

Adaptation Clearinghouse. 2016. "San Francisco Bay Clean Water, Pollution Prevention and Habitat Restoration Measure." https://www.adaptationclearinghouse.org/resources/san-francisco-bay-clean-water-pollution-prevention-and-habitat-restoration-measure.html.

Alber, M., E. M. Swenson, S. C. Adamowicz, and I. A. Mendelssohn. 2008. "Salt Marsh Dieback: An Overview of Recent Events in the US." *Estuarine, Coastal and Shelf Science* 80(1): 1–11. doi:10.1016/j.ecss.2008.08.009.

Allen, J., Q. Grady, D. Koenigsberg, C. McEwen, M. Meredith, and J. St. Clair. 2014. *The Oyster Banks: A Dive into the Political, Scientific, and Social Realms of Oysters and Oyster Aquaculture in North Carolina*, 1–14. Chapel Hill, NC: University of North Carolina at Chapel Hill. https://ie.unc.edu/wp-content/uploads/sites/277/2015/12/OBXFS_2014_Capstone.pdf.

Altstatt, J., R. Ambrose, J. Carroll, J. Coyer, J. Wible, and J. Engle. 2014. "Eelgrass Meadows Return to Frenchy's Cove, Anacapa Island: Recovery Ten Years after Successful Transplantation. *Monographs of the Western North American Naturalist* 7(1): 500–17. doi:10.3398/042.007.0139.

Angelo, M. J., and J. W. Glass. 2021. "Integrated Estuary Governance." *William & Mary Environmental Law and Policy Review* 45(2): 455. https://scholarship.law.wm.edu/wmelpr/vol45/iss2/5.

Ashton, A. D., J. P. Donnelly, and R. L. Evans. 2008. "A Discussion of the Potential Impacts of Climate Change on the Shorelines of the Northeastern USA." *Mitigation and Adaptation Strategies for Global Change* 13(7): 719–43. doi:10.1007/s11027-007-9124-3.

Bailey, B., T. Jennings, and A. Jennings. 2003. *Estuary Management in the Pacific Northwest: An Overview of Programs and Activities in Washington, Oregon, and Northern California*. Corvallis, OR: Oregon State University. https://ir.library.oregonstate.edu/concern/defaults/r494vq52x.

Bailey, R., and K. Fletcher. 2013. "Forty Years of the CZMA: Impacts and Innovations." *Coastal Management* 41(3): 193–7. doi:10.1080/08920753.2013.787845.

Baillie, C. J., and J. H. Grabowski. 2019. "Factors Affecting Recruitment, Growth and Survival of the Eastern Oyster *Crassostrea virginica* cross an Intertidal Elevation Gradient in Southern New England." *Marine Ecology Progress Series* 609: 119–32. doi:10.3354/meps12830.

Ballanti, L., K. B. Byrd, I. Woo, and C. Ellings. 2017. "Remote Sensing for Wetland Mapping and Historical Change Detection at the Nisqually River Delta." *Sustainability* 9(11): 1919. doi:10.3390/su9111919.

Barbier, E. B. 2011. "Coastal Wetland Restoration and the Deepwater Horizon Oil Spill." *Vanderbilt Law Review* 64: 1819. https://scholarship.law.vanderbilt.edu/vlr/vol64/iss6/4.

Barbier, E. B. 2013. "Valuing Ecosystem Services for Coastal Wetland Protection and Restoration: Progress and Challenges." *Resources* 2(3): 213–30. doi:10.3390/resources2030213.

Barsh, R. L. 2003. The Importance of Human Intervention in the Evolution of Puget Sound Ecosystems. In *Proceedings of the 2003 Georgia Basin/Puget Sound Ecosystems Research Conference*, 1–11. Vancouver: Working Together for the Georgia Basin/Puget Sound Action Team. https://www.kwiaht.org/images/terrbiodiversity/ancientgardens/PSRC%202003%20Barsh.pdf.

BCDC. 2016. *Policies for a Rising Bay Project: Final Report*. San Francisco: San Francisco Bay Conservation and Development Commission. https://bcdc.ca.gov/prb/Policies-for-a-Rising-Bay.pdf.

BCDC. 2022. "Fill for Habitat Amendment Fact Sheet." San Francisco: San Francisco Bay Conservation and Development Commission. https://bcdc.ca.gov/BPAFHR/FillHabitatFaqs.html.

Beck, M. W., R. D. Brumbaugh, L. Airoldi, A. Carranza, L. D. Coen, C. Crawford, Omar Defeo, Graham J. Edgar, Boze Hancock, Matthew C. Kay, Hunter S. Lenihan, Mark W. Luckenbach, Caitlyn L. Toropova, Guofan Zhang, and X. Guo. 2011. "Oyster Reefs at Risk and Recommendations for Conservation, Restoration, and Management." *BioScience* 61(2): 107–16. doi:10.1525/bio.2011.61.2.5.

Beck, M. W., E. T. Sherwood, J. R. Henkel, K. Dorans, K. Ireland, and P. Varela. 2019. "Assessment of the Cumulative Effects of Restoration Activities on Water Quality in Tampa Bay, Florida." *Estuaries and Coasts* 42(7): 1774–91. doi:10.1007/s12237-019-00619-w.

Bemelmans-Videc, M. L., R. C. Rist, and E. Vedung, eds. 1998. *Carrots, Sticks and Sermons: Policy Instruments and their Evaluation*. New Brunswick, NJ: Transaction Publishers. doi:10.4324/9781315081748.

Berry, W., A. Zivian, M. R. McCutcheon, and S. Cooley. 2021. International and domestic leadership by US states on ocean acidification. *Coastal Management* 49(5): 547–54. doi:10.1080/08920753.2021.1947166.

Bersoza Hernández, A., R. D. Brumbaugh, P. Frederick, R. Grizzle, M. W. Luckenbach, C. H. Peterson, and C. Angelini. 2018. "Restoring the Eastern Oyster: How Much Progress Has Been Made in 53 Years?" *Frontiers in Ecology and the Environment* 16(8): 463–71. doi:10.1002/fee.1935.

Beseres Pollack, J., A. Cleveland, T. A. Palmer, A. S. Reisinger, and P. A. Montagna. 2012. "A Restoration Suitability Index Model for the Eastern Oyster (*Crassostrea virginica*) in the Mission-Aransas Estuary, TX, USA." *PLOS ONE* 7(7): e40839. doi:10.1371/journal.pone.0040839.

Bin, O., C. Dumas, B. Poulter, and J. Whitehead, J. 2007. *Measuring the Impacts of Climate Change on North Carolina Coastal Resources*. Washington, DC: National Commission on Energy Policy. https://econ.appstate.edu/climate/NC-NCEP%20final%20report.031507.pdf.

Blake, B., and A. Bradbury. 2012. *Washington Department of Fish and Wildlife plan for Rebuilding Olympia Oyster (*Ostrea lurida*) Populations in Puget Sound with a Historical*

and Contemporary Overview, 25. Brinnon, WA: Washington Department of Fish and Wildlife, Point Whitney Shellfish Laboratory. https://restorationfund.org/wp-content/uploads/2019/02/olympia_oyster_restoration_plan_final.pdf.

Blakely, E., and A. Carbonell. 2012. *Resilient Coastal City Regions: Planning for Climate Change in the United States and Australia*. Cambridge, MA: Lincoln Institute of Land Policy.

Blizzard, A. F., and W. R. Mangun. 2008. "Intergovernmental Influences on the Implementation of Coastal Zone Management in the United States: Public Shoreline Access in the Southeast." *Ocean & Coastal Management* 51(6):443–9. doi:10.1016/j.ocecoaman.2008.04.002.

Borchert, S. M., M. J. Osland, N. M. Enwright, and K. T. Griffith. 2018. "Coastal Wetland Adaptation to Sea Level Rise: Quantifying Potential for Landward Migration and Coastal Squeeze." *Journal of Applied Ecology* 55(6): 2876–87. doi:10.1111/1365-2664.13169.

Bowen, J. L., C. J. Baillie, J. H. Grabowski, A. R. Hughes, S. B. Scyphers, K. R. Gilbert, and K. A. Geigley, K. A. (2019). "Boston Harbor, Boston, Massachusetts, USA: Transformation from 'The Harbor of Shame' to a Vibrant Coastal Resource." *Regional Studies in Marine Science*, 25: 100482. doi:10.1016/j.rsma.2018.100482.

Brockmeyer, R. E., M. Donnelly, J. R. Rey, D. B. Carlson. 2021. "Manipulating, Managing and Rehabilitating Mangrove-Dominated Wetlands along Florida's East Coast (USA): Balancing Mosquito Control and Ecological Values." *Wetlands Ecology and Management*, 1–19. doi:10.1007/s11273-021-09843-3.

Brown, E. 2016. "Socioeconomic Impact of the Decline in Oyster Population on Apalachicola Bay Oystermen." Honors Thesis, Florida State University. http://purl.flvc.org/fsu/fd/FSU_libsubv1_scholarship_submission_1481237154.

Brown, S. C., and P. L. M. Veneman. 2001. "Effectiveness of Compensatory Wetland Mitigation in Massachusetts, USA." *Wetlands* 21(4): 508–18. doi:10.1672/0277-5212(2001)021[0508:EOCWMI]2.0.CO;2.

California Landscape Stewardship Network. 2020. Cutting Green Tape: Regulatory Efficiencies for a Resilient Environment. https://calandscapestewardshipnetwork.org/sites/default/files/2020-12/CGT_FINAL_hires.pdf.

California Department of Parks and Recreation. 2022. "Elkhorn Slough Marine Conservation Area." http://www.parks.ca.gov/?page_id=27205.

California Water Boards. 2021. "Wetland Riparian Area Protection Policy." https://www.waterboards.ca.gov/water_issues/programs/cwa401/wrapp.html.

Callihan, R., B. Depro, D. Lapidus, T. Sartwell, and C. Viator. 2016. Economic Analysis of the Costs and Benefits of Restoration and Enhancement of Shellfish Habitat and Oyster Propagation in North Carolina. Raleigh, NC: Albemarle-Pamlico National Estuary Partnership. https://ncseagrant.ncsu.edu/ncseagrant_docs/oysters/RTI-APNEP_04-02-final.pdf.

Camp, E. V., W. E. Pine III, K. Havens, A. S. Kane, C. J. Walters, T. Irani, A. B. Lindsey, and J. G. Morris Jr. 2015. "Collapse of a Historic Oyster Fishery: Diagnosing Causes and Identifying Paths toward Increased Resilience." *Ecology and Society* 20(3): 45. doi:10.5751/ES-07821-200345.

Cape Cod Commission. 2015. *Cape Cod Area Wide Water Quality Management Plan Update.* Barnstable, MA: Cape Cod Commission. https://www.capecodcommission.org/resource-library/file/?url=/dept/commission/team/208/208%20Final/Cape_Cod_

Area_Wide_Water_Quality_Management_Plan_Update_June_15_2015.pdf.
Carlson, D. B., P. E. Dale, N. Kurucz, P. G. Dwyer, J. M. Knight, P. I. Whelan, and D. D. Richards. 2019. "Mosquito Control and Coastal Development: How they have Coexisted and Matured in Florida and Australia." *Journal of the American Mosquito Control Association*, 35(2): 123–134. doi:10.2987/18-6807.1.
Carlson, R. R., L. J. Evans, S. A. Foo, B. W. Grady, J. Li, M. Seeley, Y. Xu, and G. P. Asner. 2021. "Synergistic Benefits of Conserving Land-Sea Ecosystems." *Global Ecology and Conservation* 28: p.e01684. doi:10.1016/j.gecco.2021.e01684.
Cavanaugh, K. C., J. R. Kellner, A. J. Forde, D. S. Gruner, J. D. Parker, W. Rodriguez, and I. C. Feller. 2014. "Poleward Expansion of Mangroves is a Threshold Response to Decreased Frequency of Extreme Cold Events." Proceedings of the National Academy of Sciences, 111(2), 723–7. doi:10.1073/pnas.131580011.
CCC. 2021. *Coastal Management Program Final 309 Assessment and Strategy: 2021 to 2025 Enhancement Cycle*. Sacramento, CA: California Coastal Commission. https://documents.coastal.ca.gov/assets/strategicplan/CoastalComm_Final_309AssessmentandStrategy_approved02-2021.pdf.
CDFW. 2022. "Regional MPA Statistics." Sacramento, CA: California Department of Fish and Wildlife. https://wildlife.ca.gov/Conservation/Marine/MPAs/Statistics.
Center for Coastal Studies. 2022. "Threats to the Bay and Sound." https://coastalstudies.org/cape-cod-bay-monitoring-program/threats-to-the-bay/.
Chabreck, R. H. 1970. "Marsh Zones and Vegetative Types in the Louisiana Coastal Marshes." LSU Historical Dissertations and Theses. 1773. https://digitalcommons.lsu.edu/gradschool_disstheses/1773.
Chapple, D., and I. Dronova. 2017. "Vegetation Development in a Tidal Marsh Restoration Project during a Historic Drought: A Remote Sensing Approach." *Frontiers in Marine Science* 4: 243. doi:10.3389/fmars.2017.00243.
Christiaen, B., L. Ferrier, P. Dowty, J. Gaeckle, and H. Berry. 2019. *Puget Sound Seagrass Monitoring Report: Monitoring Year 2016–2017*. Olympia, WA: Washington State Department of Natural Resources, Nearshore Habitat Program. https://www.dnr.wa.gov/publications/aqr_nrsh_svmp_report_2016_2017_data.pdf.
Christie, P., D. Fluharty, H. Kennard, R. Pollnac, B. Warren, and T. Williams. 2018. "Policy Pivot in Puget Sound: Lessons Learned from Marine Protected Areas and Tribally-Led Estuarine Restoration." *Ocean and Coastal Management* 163: 72–81. doi:10.1016/j.ocecoaman.2018.05.020.
City of Newport Beach. 2015. *Eelgrass Protection and Mitigation Plan for Shallow Waters in Lower Newport Bay: An Ecosystem Based Management Program*. Newport Beach, CA: Public Works Department, Harbor Resources Division. https://www.newportbeachca.gov/home/showpublisheddocument/21830/635883861309930000.
Coastal Conservancy, State of California, 2018. "San Francisco Bay Living Shorelines Project." https://scc.ca.gov/climate-change/climate-ready-program/san-francisco-bay-living-shorelines-project/.
Conger, T., and S. E. Chang. 2019. "Developing Indicators to Identify Coastal Green Infrastructure Potential: The Case of the Salish Sea Region." *Ocean and & Coastal Management* 175: 53–69. doi:10.1016/j.ocecoaman.2019.03.011.
Craig, R. K. 2008. "Climate Change, Regulatory Fragmentation, and Water Triage." FSU College of Law, Public Law Research Paper No. 288. *University of Colorado Law Review*

79(3): 825–927. https://ssrn.com/abstract=1016521.
D'Anna, L. M. 2016. "Concern is in the Eye of the Stakeholder: Heterogeneous Assessments of the Threats to Oyster Survival and Restoration in North Carolina." *Society & Natural Resources* 29(2): 131–47. doi:10.1080/08941920.2015.1058998.
David, A. T., C. A. Simenstad, J. R. Cordell, J. D. Toft, C. S. Ellings, A. Gray, and H. B. Berge. 2016. "Wetland Loss, Juvenile Salmon Foraging Performance, and Density Dependence in Pacific Northwest Estuaries." *Estuaries and Coasts* 39(3): 767–80. doi:10.1007/s12237-015-0041-5.
DeAngelis, B. M., A. E. Sutton-Grier, A. Colden, K. K. Arkema, C. J. Baillie, R. O. Bennett, J. Benoit, S. Blitch, A. Chatwin, A. Dausman, R. K. Gittman, H. S. Greening, J. R. Henkel, R. Houge, R. Howard, A. R. Hughes, J. Lowe, S. B. Scyphers, E. T. Sherwood, S. Westby, and J. H. Grabowski. 2020. "Social Factors Key to Landscape-Scale Coastal Restoration: Lessons Learned from Three U.S. Case Studies." *Sustainability* 12(3): 869. doi:10.3390/su12030869.
Dedekorkut-Howes, A., E. Torabi, and M. Howes. 2020. "When the Tide gets High: A Review of Adaptive Responses to Sea Level Rise and Coastal Flooding." *Journal of Environmental Planning and Management* 63(12): 2102–43. doi:10.1080/09640568.2019.1708709.
Delta Conservancy. 2022. "Delta Carbon Program." http://deltaconservancy.ca.gov/delta-carbon-program/#:~:text=Through%20thousands%20of%20years%20of,be%20planted%20in%20wet%20soil.
Diana, Z., T. Vegh, R. Karasik, J. Bering, J. D. L. Caldas, A. Pickle, D. Rittschof, W. Lau, and J. Virdin. 2022. The evolving global plastics policy landscape: An inventory and effectiveness review. *Environmental Science & Policy* 134: 34–45. doi:10.1016/j.envsci.2022.03.028.
Dugan, J. E., K. A. Emery, M. Alber,C. R. Alexander, J. E. Byers, A. M. Gehman, N. McLenaghan, and S. E. Sojka. 2018. Generalizing ecological effects of shoreline armoring across soft sediment environments. *Estuaries and Coasts* 41(1): 180–96. doi:10.1007/s12237-017-0254-x.
Duarte, C. M., ed. 2009. *Global Loss of Coastal Habitats: Rates, Causes and Consequences*. Madrid: Fundación BBVA. https://www.biophilia-fbbva.es/wp-content/uploads/sites/3/2019/07/DE_2009_Global_Loss.pdf.
Dunton, K. H., and D. A. Tomasko. 1994. "In Situ Photosynthesis in the Seagrass *Halodule wrightii* in a Hypersaline Subtropical Lagoon." *Marine Ecology Progress Series* 107: 281-293. https://www.jstor.org/stable/24842684.
EEA. 2015a. *2015 Massachusetts Ocean Management Plan: Volume 1—Management and Administration*. Boston: The Commonwealth of Massachusetts, Executive Office of Energy and Environmental Affairs. https://www.mass.gov/doc/2015-ocean-plan-v1-complete-low-respdf/download.
EEA. 2015b. *2015 Massachusetts Ocean Management Plan: Volume 2—Baseline Assessment and Framework*, BA-4. Boston: The Commonwealth of Massachusetts, Executive Office of Energy and Environmental Affairs. https://www.mass.gov/files/documents/2016/08/pp/2015-ocean-plan-v2-complete.pdf.
Ehler, C. N. 2021. "Two Decades of Progress in Marine Spatial Planning." *Marine Policy* 132: 104134. doi:10.1016/j.marpol.2020.104134.
Eisemann, E. R., C. C. Thomas, M. T. Balazik, D. Acevedo-Mackey, and S. Altman. 2021.

Environmental Factors Affecting Coastal and Estuarine Submerged Aquatic Vegetation (SAV). Vicksburg, MS: US Army Engineer Research and Development Center. https://erdc-library.erdc.dren.mil/jspui/bitstream/11681/42185/1/ERDC-EL%20SR-21-6.pdf.

Elkhorn Slough. 2015. "Elkhorn Slough Tidal Marsh Restoration Receives $3 Million Grant." https://www.elkhornslough.org/tidal-marsh-restoration-receives-grant/.

Elkhorn Slough. n.d. "Who We Are." https://www.elkhornslough.org/who-we-are/.

Elkhorn Slough. 2019. News Release: USFWS Grants $1 Million to Expand Restoration at Elkhorn Slough. https://www.elkhornslough.org/news-release-usfws-grants-1million-190509/

Elliott, M. L., D. Jongsomjit, S. Veloz, and J. Jahncke. 2020. Ocean Research and Management Priorities off the U.S. West Coast. Petaluma, CA: Point Blue Conservation Science. https://www.pointblue.org/wp-content/uploads/2020/05/Ocean_Priorities_Report_Full.pdf.

EPA. 2017. *Coastal Wetland Loss Analysis. Summary Findings of Pilot Studies Conducted by the Interagency Coastal Wetlands Workgroup*. https://media.fisheries.noaa.gov/dam-migration/pilotstudies_wetlands_loss_analysis_july2017_508.pdf.

Erftemeijer, P. L., and R. R. R. Lewis III. 2006. "Environmental Impacts of Dredging on Seagrasses: A Review." *Marine Pollution Bulletin* 52(12): 1553–72. doi:10.1016/j.marpolbul.2006.09.006.

ESA PWA. 2014. *Elkhorn Slough Tidal Marsh Restoration Project: Existing Conditions Report*. Watsonville, CA: Elkhorn Slough Foundation. http://elkhornslough.org/tidalwetland/downloads/ElkhornExistingConditionReport_Final_1Jul2014.pdf.

Fancy, S. G., and R. E. Bennetts. 2012. Institutionalizing an Effective Long-Term Monitoring Program in the US National Park Service. In *Design and Analysis of Long-Term Ecological Monitoring Studies*, edited by R. A. Gitzen, J. J. Millspaugh, A. B. Cooper, and D. S. Licht: 481-497. doi:10.1017/CBO9781139022422.029.

Fernández Robledo, J. A., G. R. Vasta, and N. R. Record. 2014. "Protozoan Parasites of Bivalve Molluscs: Literature Follows Culture." *PLoS ONE* 9(6): e100872. doi:10.1371/journal.pone.0100872.

FFWCC and FDEP. 2018. *Florida Gulf Environmental Benefit Fund Restoration Strategy*. Tallahassee, FL: Florida Fish and Wildlife Conservation Commission and Florida Department of Environmental Protection. https://floridadep.gov/sites/default/files/Gulf%20Environmental%20Benefit%20Fund%20Restoration%20Strategy%20Report%20FINAL.pdf.

Field, D., J. Kenworthy, and D. Carpenter. 2021. *Extent of Submerged Aquatic Vegetation High-Salinity Estuarine Waters Metric Report (REVISED*)*. Raleigh, NC: Albemarle-Pamlico National Estuary Partnership. https://apnep.nc.gov/media/1448/open.

Florida Coastal Management Program. 2020. *Final Assessment and Strategies FY 2021–FY 2025*. Tallahassee, FL: Florida Department of Environmental Protection. https://floridadep.gov/sites/default/files/Florida_FY21-26_309_Assessment_and_Strategies.pdf.

Florida DEP. 2022a. "Florida Forever." Tallahassee, FL: Florida Department of Environmental Protection. https://floridadep.gov/lands/environmental-services/content/florida-forever.

Florida DEP. 2022b. "Florida's Mangroves." Tallahassee, FL: Florida Department of Environmental Protection. https://floridadep.gov/rcp/rcp/content/floridas-

mangroves.
Florida DEP. 2022c. "Mapping and Monitoring Seagrass Communities." Tallahassee, FL: Florida Department of Environmental Protection. https://floridadep.gov/rcp/rcp/content/mapping-and-monitoring-seagrass-communities.
Florida FWC. 2019. Florida's Wildlife Legacy Initiative: Florida's State Wildlife Action Plan. Tallahassee, FL: Florida Fish and Wildlife Conservation Commission. https://myfwc.com/conservation/special-initiatives/swap/.
Florida SeaGrant. 2012. *Tackling the Oyster Collapse in Apalachicola Bay*. https://www.flseagrant.org/news/2012/12/oyster-collapse-apalachicola/.
Giri, C., and J. Long. 2016. "Is the Geographic Range of Mangrove Forests in the Conterminous United States Really Expanding?" *Sensors* 16(12): 2010. doi:10.3390/s16122010.
Gittman R. K., C. J. Baillie, K. K. Arkema, R. O. Bennett, J. Benoit, S. Blitch, J. Brun, A. Chatwin, A. Colden, A. Dausman, B. DeAngelis, N. Herold, J. Henkel, R. Houge, R. Howard, A. R. Hughes, S. B. Scyphers, T. Shostik, A. Sutton-Grier, and J. H. Grabowski. 2019. "Voluntary Restoration: Mitigation's Silent Partner in the Questto Reverse Coastal Wetland Loss in the USA." *Frontiers in Marine Science* 6: 511. doi:10.3389/fmars.2019.00511.
Graikoski, M., and P. Hoagland. 2017. "Comparing Policies for Encouraging Retreat from the Massachusetts Coast." *Sea Grant Law & Policy Journal* 8(1): 116–47. https://par.nsf.gov/servlets/purl/10046815.
Grason, E. W., P. S. McDonald, J. Adams, K. Litle, J. K. Apple, and A. Pleus. 2018. "Citizen Science Program Detects Range Expansion of the Globally Invasive European Green Crab in Washington State (USA)." *Management of Biological Invasions* 9(1): 39. doi:10.3391/mbi.2018.9.1.04.
Grays Harbor CD. 2019. "CREP Project." Grays Harbor Conservation District. https://www.graysharborcd.org/project/crep-project/.
Green, L., C. Magel, and C. Brown. 2021. "Management Pathways for the Successful Reduction of Nonpoint Source Nutrients in Coastal Ecosystems." *Regional Studies in Marine Science* 45: 101851. doi:10.1016/j.rsma.2021.101851.
Goals Project. 1999. Baylands Ecosystem Habitat Goals. A Report of Habitat Recommendations Prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. San Francisco: US Environmental Protection Agency/Oakland, CA: S.F. Bay Regional Water Quality Control Board. https://www.sfei.org/sites/default/files/biblio_files/sfbaygoals031799.pdf.
Gottlieb, A., J. A. Muramoto, K. Andres, D. Keeran, and K. Johnson. 2020. State of the Waters: Cape Cod. Dennis, MA: Association to Preserve Cape Cod. https://capecodwaters.org/wp-content/uploads/2020/10/2020-WATER-HEALTH-REPORT-AND-ACTION-PLAN-Final_1.pdf.
Haddaway, N. R., P. Woodcock, B. Macura, and A. Collins. 2015. "Making Literature Reviews More Reliable through Application of Lessons from Systematic Reviews." *Conservation Biology* 29(6): 1596–605. doi:10.1111/cobi.12541.
Hamilton, S. E., and D. Casey. 2016. "Creation of a High Spatio□Temporal Resolution Global Database of Continuous Mangrove Forest Cover for the 21st Century (CGMFC□21)." *Global Ecology and Biogeography* 25(6): 729–38. doi:10.1111/geb.12449.
Handley, L., and C. Lockwood. 2020. *Seagrass Status and Trends Update for the Northern*

Gulf of Mexico: 2002-2017. Final Report to the Gulf of Mexico Alliance for Contract No.: 121701-00. Ocean Springs, MS. https://open-data-portal-gomalliance.hub.arcgis.com/documents/gomacommunity::executive-summary-seagrass-status-trends-2020/explore.

Harenčár, J. G., G. A. Lutgen, Z. M. Taylor, N. P. Saarman, and J. M. Yost. 2018. "How Population Decline can Impact Genetic Diversity: A Case Study of Eelgrass (*Zostera marina*) in Morro Bay, California." *Estuaries and Coast*s 41(8): 2356–67. doi:10.1007/s12237-018-0421-8.

Hauxwell, J., J. Cebrián, and I. Valiela. 2003. "Eelgrass *Zostera marina* Loss in Temperate Estuaries: Relationship to Land-Derived Nitrogen Loads and Effect of Light Limitation Imposed by Algae." *Marine Ecology Progress Series* 247: 59–73. doi:10.3354/meps247059.

Heady, W. N., B. S. Cohen, M. G. Gleason, J. N. Morris, S. G. Newkirk, K. R. Klausmeyer, H. Walecka, E. Gagneron, and M. Small. 2018. *Conserving California's Coastal Habitats: A Legacy and a Future with Sea Level Rise*. San Francisco: The Nature Conservancy/Oakland, CA: California State Coastal Conservancy. https://www.scienceforconservation.org/assets/downloads/TNC_SCC_CoastalAssessment_2018.pdf.

Herbert, R. J. H., J. Humphreys, C. J. Davies, C. Roberts, S. Fletcher, and T. P. Crowe. 2016. "Ecological Impacts of Non-Native Pacific Oysters (*Crassostrea gigas*) and Management Measures for Protected Areas in Europe." *Biodiversity and Conservation* 25(14): 2835–65. doi:10.1007/s10531-016-1209-4.

Hilke, C., J. Ritter, J. Ryan-Henry, E. Powell, A. Fuller, B. Stein, and B. Watson. 2020. Softening Our Shorelines: Policy and Practice for Living Shorelines along the Gulf and Atlantic Coasts. Washington, DC: National Wildlife Federation. https://www.nwf.org/-/media/Documents/PDFs/NWF-Reports/2020/Softening-Our-Shorelines.ashx.

Hintenlang L. 2020. "2012 Oyster Fishery Collapse in Apalachicola." https://storymaps.arcgis.com/stories/15ffc57d7c2f4d858c5355bd510d22e1.

Honig, S. E., B. Mahoney, J. S. Glanz, and B. B. Hughes. 2017. "Are Seagrass Beds Indicators of Anthropogenic Nutrient Stress in The Rocky Intertidal?" *Marine Pollution Bulletin* 114(1): 539–46. doi:10.1016/j.marpolbul.2016.10.020.

Horowitz, J., and L. Hoberecht. (n.d.). *Washington: A Shellfish State*. Washington Shellfish Initiative. https://www.governor.wa.gov/sites/default/files/WSI%20factsheet.pdf.

Hough, P., and R. Harrington. 2019. "Ten Years of the Compensatory Mitigation Rule: Reflections on Progress and Opportunities." *Environmental Law and Reporter: News and Analysis* 49: 10018. https://www.eli.org/sites/default/files/elr/featuredarticles/Jan19FA.pdf.

Hovis, M., J. C. Hollinger, F. Cubbage, T. Shear, B. Doll, J. J. Kurki-Fox, D. Line, A. Fox, M. Baldwin, T. Klondike, M. Lovejoy, B. Evans, J. West, and T. Potter. 2021. "Natural Infrastructure Practices as Potential Flood Storage and Reduction for Farms and Rural Communities in the North Carolina Coastal Plain." *Sustainability* 13(16): 9309. doi:10.3390/su13169309.

Howard, J., E. McLeod, S. Thomas, E. Eastwood, M. Fox, L. Wenzel, and E. Pidgeon. 2017. "The Potential to Integrate Blue Carbon into MPA Design and Management." *Aquatic Conservation: Marine and Freshwater Ecosystems* 27:100–15. doi:10.1002/aqc.2809.

Humberg, M. 2021. "Floodplains by Design Grants Available." Washington Department of

Ecology. https://ecology.wa.gov/Blog/Posts/November-2021/Floodplains-by-Design-grants-available.
Hutto, S. H., M. Brown, and E. Francis. 2021. Blue Carbon in Marine Protected Areas: Part 1—A Guide to Understanding and Increasing Protection of Blue Carbon. National Marine Sanctuaries Conservation Science Series ONMS-21-07. Washington, DC: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service, Office of National Marine Sanctuaries. https://nmssanctuaries.blob.core.windows.net/sanctuaries-prod/media/docs/blue-carbon-in-marine-protected-areas-part-1.pdf.
Jones, J., P. Keller, and E. van der Flier Keller. 2021. "Review of Official Responsibility for the Salish Sea Marine Environment." *Ocean & Coastal Management* 211: 105748. doi:10.1016/j.ocecoaman.2021.105748.
Kaeding, L. 2020. "A Resource Management Analysis of Olympia and Pacific Oysters in Puget Sound" Master's Thesis, Central Washington University. https://digitalcommons.cwu.edu/etd/1362.
Karasik, R., T. Vegh, Z. Diana, J. Bering, J. Caldas, A. Pickle, D. Rittschof, and J. Virdin. 2020. *20 Years of Government Responses to the Global Plastic Pollution Problem: The Plastics Policy Inventory*. NI X 20-05. Durham, NC: Duke University. https://nicholasinstitute.duke.edu/sites/default/files/publications/20-Years-of-Government-Responses-to-the-Global-Plastic-Pollution-Problem-New_1.pdf.
Kelly, J. J., D. Orr, and J. Y. Takekawa. 2019. Quantification of damage to eelgrass (*Zostera marina*) beds and evidence-based management strategies for boats anchoring in San Francisco Bay. *Environmental Management* 64(1): 20–6. doi:10.1007/s00267-019-01169-4.
Kennish, M. J. 2001. "Coastal Salt Marsh Systems in the U.S.: A Review of Anthropogenic Impacts." *Journal of Coastal Research* 17(3): 731–48. https://www.jstor.org/stable/4300224.
Kihslinger, R., C. Libre, K. R. Ma, E. Okuno, and R. C. Gardner. 2019. In-Lieu Fee Mitigation: Review of Program Instruments and Implementation Across the Country. Washington, DC: Environmental Law Institute. https://www.eli.org/sites/default/files/eli-pubs/lieu-fee-mitigation-review-program-instruments-and-implementation-across-country.pdf.
Kornbluth, A., B. D. Perog, S. Crippen, D. Zacherl, B. Quintana, E. D. Grosholz, and K. Wasson. 2022. "Mapping Oysters on the Pacific Coast of North America: A Coast-Wide Collaboration to Inform Enhanced Conservation." *PLoS ONE* 17(3): e0263998. doi:10.1371/journal.pone.0263998.
Kyzar, T., I. Safak, J. Cebrian, M. W. Clark, N. Dix, K. Dietz, R. K. Gittman, J. Jaeger, K. R. Radabaugh, A. Roddenberry, C. S. Smith, E. L. Sparks, B. Stonen, G. Sundinn, M. Taublero, and C. Angelinibo. 2021. "Challenges and Opportunities for Sustaining Coastal Wetlands and Oyster Reefs in the Southeastern United States." *Journal of Environmental Management* 296: 113178. doi:10.1016/j.jenvman.2021.113178.
Landis, J. R., and G. G. Koch. 1977. "An Application of Hierarchical Kappa-Type Statistics in the Assessment of Majority Agreement Among Multiple Observers." *Biometrics* 33(2): 363–74.
Larinto, T., ed. 2010. *Status of the Fisheries Report: An Update Through 2008*. Sacramento, CA: California Department of Fish and Game. https://nrm.dfg.ca.gov/FileHandler.

ashx?DocumentID=34430.
Leeper, R., B. Rhodes, M. Kirby, K. Scharer, J. Carlin, E. Hemphill-Haley, S. Avnaim-Katav, G. MacDonald, S. Starratt, and A. Aranda. 2017. "Evidence for Coseismic Subsidence Events in a Southern California Coastal Saltmarsh." *Scientific Reports* 7: 44615. doi:10.1038/srep44615.
Leo, K. L., C. L. Gillies, J. A. Fitzsimons, L. Z. Hale, and M. W. Beck. 2019. "Coastal Habitat Squeeze: A Review of Adaptation Solutions for Saltmarsh, Mangrove and Beach Habitats." *Ocean & Coastal Management* 175: 180–90. doi:10.1016/j.ocecoaman.2019.03.019.
Leschen, A. S., K. H. Ford, and N. T. Evans. 2010. "Successful Eelgrass (*Zostera marina*) Restoration in a Formerly Eutrophic Estuary (Boston Harbor) Supports the Use of a Multifaceted Watershed Approach to Mitigating Eelgrass Loss." *Estuaries and Coasts* 33: 1340–54. doi:10.1007/s12237-010-9272-7.
Levina, E., J. Jacob, L. E. Ramos Bustillos, and I. Ortiz. 2007. "Policy Frameworks for Adaptation to Climate Change in Coastal Zones: The Case of the Gulf of Mexico." *OECD Papers* 7(1): 1–68. https://www.oecd.org/env/cc/38574805.pdf.
Logan, J. M., A. Davis, C. Markos, and K. H. Ford. 2018. "Effects of Docks on Salt Marsh Vegetation: An Evaluation of Ecological Impacts and the Efficacy of Current Design Standards." *Estuaries and Coasts* 41: 661–75. doi:10.1007/s12237-017-0323-1.
Lund, P., and L. Hoberecht. 2016. *Shellfish Interagency Permitting Team: Phase I Report*. Olympia, WA: Washington Shellfish Initiative. https://ecology.wa.gov/DOE/files/44/446c9a20-fe38-4a23-85ba-f25b87da05b8.pdf.
Mague S. T., S. J. McFarland, and M. Borrelli. 2020. *Increasing Coastal Resiliency Through Intermunicipal Shoreline Management. Phase 1 Final Report Prepared for the Towns of Eastham, Wellfleet, Truro, and Provincetown.* Publication 20-CL-04, p. 33. Provincetown, MA: Coastal Processes and Ecosystems Lab at the Center for Coastal Studies. https://www.eastham-ma.gov/DocumentCenter/View/1233/2020_czm_ism_report-final2?bidId=.
Marcoe, K., and S. Pilson. 2017. "Habitat Change in the Lower Columbia River Estuary, 1870–2009." *Journal of Coastal Conservation* 21(4): 505–25. doi:10.1007/s11852-017-0523-7.
Marshall, D. A., S. M. Casas, W. C. Walton, F. S. Rikard, T. A. Palmer, N. Breaux, M. K. La Peyre, J. Beseres Pollack, M. Kelly, and J. F. La Peyre. 2021. "Divergence in Salinity Tolerance of Northern Gulf of Mexico Eastern Oysters under Field and Laboratory Exposure." *Conservation Physiology* 9(1): coab065. doi:10.1093/conphys/coab065.
Massachusetts CZM. 2020. *Section 309 Assessment and Five-Year Strategy for CZM Program Enhancement (FY2021–2025)*. Boston: Massachusetts Office of Coastal Zone Management. https://www.mass.gov/doc/section-309-assessment-and-five-year-strategy-for-czm-program-enhancement-fy2021-2025/download.
Massachusetts CZM. 2022a. "Massachusetts Ocean Sanctuaries." https://www.mass.gov/service-details/massachusetts-ocean-sanctuaries.
Massachusetts CZM. 2022b. "Sea Level Affecting Marshes Model (SLAMM)." Boston: Massachusetts Office of Coastal Zone Management. https://www.mass.gov/service-details/sea-level-affecting-marshes-model-slamm.
Massachusetts Shellfish Initiative. 2021. *Massachusetts Shellfish Initiative: 2021–2025 Strategic Plan*. Boston: State of Massachusets. https://www.mass.gov/doc/msi-strategic-plan/download.

MassDEP. 2022. "Eelgrass Mapping Project." Boston: Massachusetts Department of Environmental Protection. https://www.mass.gov/guides/eelgrass-mapping-project.
MassGIS. 2017. "MassGIS Data: Designated Shellfish Growing Areas." Boston: Massachusetts Bureau of Geographic Information. https://www.mass.gov/info-details/massgis-data-designated-shellfish-growing-areas.
McClure, A., X. Liu, E. Hines, and M. C. Ferner. 2016. Evaluation of Error Reduction Techniques on a LIDAR-Derived Salt Marsh Digital Elevation Model. *Journal of Coastal Research* 32(2): 424–33. doi:10.2112/JCOASTRES-D-14-00185.1.
McNeal, K. 2021. *SE CASC Coastal Resilience Working Group: Part I. Report Summary*. Raleigh, NC: North Carolina State University, Southeast Climate Adaptation Science Center. https://secasc.ncsu.edu/wp-content/uploads/sites/14/2021/08/Coastal-Resilience-WG-Report-2021.pdf.
Miami-Dade County. 2021. "Environmentally Endangered Lands Program." https://www.miamidade.gov/environment/endangered-lands.asp.
Mississippi-Alabama Sea Grant Legal Program. 2014. *Inventory of Shellfish Restoration Permitting & Programs in the Coastal States*. Oxford, MS: National Sea Grant Law Center. https://masglp.olemiss.edu/projects/files/tnc-report.pdf.
MyParcelTax.com. n.d. "San Francisco Bay Restoration Authority: Measure AA." https://www.myparceltax.com/sfbay/.
Naismith, L. 2020. "Taking Back the Beach." *Chicago-Kent Journal of Environmental and Energy Law* 10(1): 29–59. https://studentorgs.kentlaw.iit.edu/ckjeel/v10i1-2020-2021-3-naismith/.
NEP. 2022. "National Results from the National Estuary Program." Washington, DC: National Estuary Program. https://www.epa.gov/nep/national-results-national-estuary-program.
NWP 54. 2017. "Nationwide Permit (54) Living Shorelines." Washington, DC: US Army Corps of Engineers. https://www.swt.usace.army.mil/Portals/41/docs/missions/regulatory/2021%20NWP/NWP-54.pdf?ver=5LdLM2jDQyrn9GykSMxjKw%3D%3D.
NOAA. 2015a. *Assessment and Strategy of The North Carolina Coastal Management Program.* Washington, DC: National Oceanic and Atmospheric Administration. https://coast.noaa.gov/data/czm/enhancement/media/nc309-2016.pdf.
NOAA. 2015b. *Final Evaluation Findings: Texas Coastal Management Program, January 2007 to June 2014*. https://coast.noaa.gov/data/czm/media/texascmp2015.pdf.
NOAA. 2017. *Final Evaluation Findings: Washington Coastal Management Program, October 2009 to June 2017.* Washington, DC: National Oceanic and Atmospheric Administration. https://coast.noaa.gov/data/czm/media/waevaluation.pdf.
NOAA. 2019a. *Final Evaluation Findings: California Coastal Management Program, January 2009 to June 2018*. Washington, DC: National Oceanic and Atmospheric Administration. https://coast.noaa.gov/data/czm/media/california-cmp.pdf.
NOAA 2019b. *Report on the U.S. Ocean and Great Lakes Economy*. Washington, DC: National Oceanic and Atmospheric Administration. https://coast.noaa.gov/data/digitalcoast/pdf/econ-report-2016.pdf.
NOAA. 2020. *Final Evaluation Findings: Florida Coastal Zone Management Program, August 2015 to September 2020.* Washington, DC: National Oceanic and Atmospheric Administration. https://coast.noaa.gov/data/czm/media/florida-cmp.pdf.
NOAA. 2021. *Final Evaluation Findings: North Carolina Coastal Management Program,*

September 2011 to October 2020. Washington, DC: National Oceanic and Atmospheric Administration. https://coast.noaa.gov/data/czm/media/nc-cmp.pdf.
NOAA. 2022. *Final Evaluation Findings: Massachusetts Coastal Zone Management Program, June 2014 to April 2021*. https://coast.noaa.gov/data/czm/media/mass-cmp.pdf.
NOAA Fisheries. 2014. *California Eelgrass Mitigation Policy and Implementing Guidelines*. Washington, DC: National Oceanic and Atmospheric Administration. https://media.fisheries.noaa.gov/dam-migration/cemp_oct_2014_final.pdf.
NOAA Fisheries. 2022a. "Oyster Reef Habitat." Washington, DC: National Oceanic and Atmospheric Administration. https://www.fisheries.noaa.gov/national/habitat-conservation/oyster-reef-habitat.
NOAA Fisheries. 2022b. "Seagrass on the West Coast." Washington, DC: National Oceanic and Atmospheric Administration. https://www.fisheries.noaa.gov/west-coast/habitat-conservation/seagrass-west-coast.
North Carolina Coastal Federation. 2019. *State of the Oyster: Progress Report on the Oyster Restoration and Protection Plan for North Carolina*. Newport, NC: North Carolina Coastal Federation. https://ncoysters.org/wp-content/uploads/2019/10/State-of-the-Oyster-2018-web-FINAL.pdf.
North Carolina Coastal Federation. 2022. "North Carolina Oyster Blueprint." Newport, NC: North Carolina Coastal Federation. https://ncoysters.org/.
NC DEQ. 2016. *North Carolina Coastal Habitat Protection Plan—Source Document*. Raleigh, NC: North Carolina Department of Environmental Quality. https://deq.nc.gov/media/26813/open.
NC DEQ. 2016. *North Carolina Coastal Habitat Protection Plan*. Raleigh, NC: North Carolina https://files.nc.gov/ncdeq/Marine-Fisheries/public-info-education/habitat/completed-chpp/08-2016-CHPP-DEQ-final.pdf
NC DEQ. 2017. *North Carolina's Coastal Habitat Protection Plan: 2018–2020 Biennial Implementation Plan*. Raleigh: North Carolina Department of Environmental Quality. https://files.nc.gov/ncdeq/Marine-Fisheries/public-info-education/habitat/chpp-implementation-plans/2018-2020-CHPP-Implementation-Plan.pdf.
NC DEQ. 2019. "Coastal Permit Now Available for Marsh Sill Living Shorelines." Raleigh, NC: North Carolina Department of Environmental Quality. https://deq.nc.gov/news/press-releases/2019/04/02/coastal-permit-now-available-marsh-sill-living-shorelines.
NC DEQ. 2021. *North Carolina Coastal Habitat Protection Plan: 2021 Amendment Enhancing Coastal Fisheries through Habitat Protection and Restoration*. Raleigh, NC: North Carolina Department of Environmental Quality. https://deq.nc.gov/media/26810/open.
NC DEQ. n.d.a. "Shell Bottom." Raleigh: North Carolina Department of Environmental Quality. https://deq.nc.gov/about/divisions/marine-fisheries/habitat-information/coastal-habitat-types/shell-bottom.
NC DEQ. n.d.b. "Submerged Aquatic Vegetation." Raleigh: North Carolina Department of Environmental Quality. https://deq.nc.gov/about/divisions/marine-fisheries/habitat-information/coastal-habitat-types/submerged-aquatic-vegetation.
NPS. 2018. "Salt Marsh Dieback on Cape Cod." https://www.nps.gov/caco/learn/nature/salt-marsh-dieback.htm.
NPS. 2022. Washington, State Submerged Resources. Accessed at: https://www.nps.gov/

archeology/sites/statesubmerged/washington.htm.
Ocean Acidification Commission. 2021. *Report on the Ocean Acidification Crisis in Massachusetts*. Boston: Commonwealth of Massachusetts, Massachusetts Special Legislative Commission on Ocean Acidification. https://www.mass.gov/files/documents/2021/12/15/massachusetts-ocean-acidification-report-feb-2021.pdf.
OPC. 2022. "About the Council." Sacramento, CA: California Ocean Protection Council. https://www.opc.ca.gov/about/.
Office of Coastal Management. 2022. "The Coastal and Estuarine Land Conservation Program." Washington, DC: National Oceanic and Atmospheric Administration. https://coast.noaa.gov/czm/landconservation/.
Osland, M. J., L. C. Feher, J. López-Portillo, R. H. Day, D. O. Suman, J. M. Guzmán Menéndez, V. H. Rivera-Monroy. 2018. "Mangrove Forests in a Rapidly Changing World: Global Change Impacts and Conservation Opportunities along the Gulf of Mexico Coast." *Estuarine, Coastal and Shelf Science* 214: 120–40. doi:10.1016/j.ecss.2018.09.006.
OysterNet. n.d. "Native Olympia Oyster Collaborative." https://oysternet.sf.ucdavis.edu/.
Patten, K., C. O'Casey, and C. Metzger. 2017. "Large-Scale Chemical Control of Smooth Cordgrass (*Spartina alterniflora*) in Willapa Bay, WA: Towards Eradication and Ecological Restoration." *Invasive Plant Science and Management* 10(3): 284–92. doi:10.1017/inp.2017.25.
Petek, G. 2019. *Preparing for Rising Seas: How the State Can Help Support Local Coastal Adaptation Efforts*. Sacramento, CA: Legislative Analyst's Office. https://lao.ca.gov/reports/2019/4121/coastal-adaptation-121019.pdf.
Peters, J. W., D. B. Eggleston, B. J. Puckett, and S. J. Theuerkauf. 2017. "Oyster Demographics in Harvested Reefs vs. No-Take Reserves: Implications for Larval Spillover and Restoration Success." *Frontiers in Marine Science* 4: 326. doi:10.3389/fmars.2017.00326.
Perry, E. S., S. N. Smith, and K. K. Mulvaney. 2020. "Designing Solutions for Clean Water on Cape Cod: Engaging Communities to Improve Decision Making." *Ocean & Coastal Management* 183: 104998. doi:10.1016/j.ocecoaman.2019.104998.
Pettengill, T. M., S. M. Crotty, C. Angelini, and M. D. Bertness. 2018. "A Natural History Model of New England Salt Marsh Die-Off." *Oecologia* 186(3): 621–32. doi:10.1007/s00442-018-4078-6.
Phillips, J., W. Berry, H. Carter, L. Whiteman, and A. L. Chornesky. 2018. *State of California Ocean Acidification Action Plan*. San Diego: California Ocean Protection Council. https://www.opc.ca.gov/webmaster/_media_library/2018/10/California-OA-Action-Plan-Final.pdf.
Pontoriero, C. 2016. "12 Ways the U.S. is Using Nature to Protect Against Natural Disasters." *PropertyCasualty360* August 4. New York: ALM Media. https://www.propertycasualty360.com/2016/08/04/12-ways-the-u-s-is-using-nature-to-protect-against/.
Polk, M. A., and D. O. Eulie. 2018. Effectiveness of Living Shorelines as an Erosion Control Method in North Carolina. *Estuaries and Coasts* 41(8): 2212–22. doi:10.1007/s12237-018-0439-y.
Polk, M. A., R. K. Gittman, C. S. Smith, and D. O. Eulie, D. O. 2022. "Coastal Resilience Surges as Living Shorelines Reduce Lateral Erosion of Salt Marshes." *Integrated Environmental Assessment and Management* 18(1):82–98. doi:10.1002/ieam.4447.

Powell, E. J., M. C. Tyrrell, A. Milliken, J. M. Tirpak, and M. D. Staudinger. 2019. "A Review of Coastal Management Approaches to Support the Integration of Ecological and Human Community Planning for Climate Change." *Journal of Coastal Conservation* 23(1): 1–18. doi:10.1007/s11852-018-0632-y.

Powers, S. P., C. H. Peterson, J. H. Grabowski, and H. S. Lenihan. 2009. "Success of Constructed Oyster Reefs in No-Harvest Sanctuaries: Implications for Restoration." *Marine Ecology Progress Series*, 389: 159–70. doi:10.3354/meps08164.

Puget Sound Partnership. 2019. *State of the Sound*. Olympia, WA: Puget Sound Partnership. www.stateofthesound.wa.gov

Puget Sound Restoration Fund. 2021. "Olympia Oyster Restoration." https://restorationfund.org/programs/olympiaoysters/.

Radabaugh K. R., R. P. Moyer, S. P. Geiger, eds. 2019. *Oyster Integrated Mapping and Monitoring Program Report for the State of Florida*. FWRI Technical Report 22. St. Petersburg, FL: Fish and Wildlife Research Institute, Florida Fish and Wildlife Conservation Commission. https://static1.squarespace.com/static/5f846d5a4adb627cffa90b1d/t/606628df8cebda1030360633/1617307886866/oimmp-report-2019.pdf.

Radabaugh, K. R., C. E. Powell, and R. P. Moyer, eds. 2017. *Coastal Habitat Integrated Mapping and Monitoring Program Report for the State of Florida*. FWRI Technical Report No. 21. St. Petersburg, FL: Fish and Wildlife Research Institute, Florida Fish and Wildlife Conservation Commission. https://ocean.floridamarine.org/CHIMMP/Resources/CHIMMP_Report_061317.pdf.

Raposa, K. B., S. Lerberg, C. Cornu, J. Fear, N. Garfield, C. Peter, R. L. J. Weber, G. Moore, D. Burdick, and M. Dionne. 2018. "Evaluating Tidal Wetland Restoration Performance using National Estuarine Research Reserve System Reference Sites and the Restoration Performance Index (RPI)." *Estuaries and Coasts* 41(1): 36–51. doi:10.1007/s12237-017-0220-7.

Rasmussen, D. J., R. E. Kopp, R. Shwom, and M. Oppenheimer. 2021. "The Political Complexity of Coastal Flood Risk Reduction: Lessons for Climate Adaptation Public Works in the U.S." *Earth's Future* 9: e2020EF001575. doi:10.1029/2020EF001575.

Reece, J. S., A. Watson, P. S. Dalyander, C. K. Edwards, L. Geselbracht, M. K. LaPeyre, B. E. Tirpak, J. M. Tirpak, and M. Woodrey. 2018. "A Multiscale Natural Community and Species-Level Vulnerability Assessment of the Gulf Coast, USA." *PLoS ONE* 13(6): e0199844. doi:10.1371/journal.pone.0199844.

Reiblich, J., E. Hartge, and C. Sito. 2018. *Coastal Adaptation Policy Brief: Living Shorelines*. Monterey, CA: Stanford Center for Ocean Solutions. https://oceansolutions.stanford.edu/sites/g/files/sbiybj13371/f/living_shorelines_web.pdf.

Reynolds, P. 2018. "Seagrass and Seagrass Beds." Washington, DC: Smithsonian Institution. https://ocean.si.edu/ocean-life/plants-algae/seagrass-and-seagrass-beds.

Rhodes, L., M. McHugh, and T. Gruszkos. 2019. *Inland and Coastal Wetlands of Massachusetts: Status and Trends*. Boston: Massachusetts Department of Environmental Protection Wetland Program. https://www.mass.gov/doc/inland-and-coastal-wetlands-of-massachusetts-status-and-trends/download.

Rick, T. C., D. J. Kennett, and J. M. Erlandson. 2005. "Preliminary Report on the Archaeology and Paleoecology of the Abalone Rocks Estuary, Santa Rosa Island, California." In *Proceedings of the Sixth California Islands Symposium* pp. 55–63. Arcata, CA: Institute

for Wildlife Studies.
Ridge, J. T., A. B. Rodriguez, and F. J. Fodrie. 2017. "Evidence of Exceptional Oyster Reef Resilience to Fluctuations in Sea Level." *Ecology and Evolution* 7(23): 10409–20. doi:10.1002/ece3.3473.
Robinson, L. n.d. "Oysters in Texas Coastal Waters." Austin: Texas Parks and Wildlife Division. https://tpwd.texas.gov/fishboat/fish/didyouknow/coastal/oysterarticle.phtml.
Romañach, S. S., D. L. DeAngelis, H. L. Koh, Y. Li, S. Y. Teh, R. S. R. Barizan, and L. Zhai. 2018. "Conservation and Restoration of Mangroves: Global Status, Perspectives, and Prognosis." *Ocean and Coastal Management* 154: 72–82. doi:10.1016/j.ocecoaman.2018.01.009.
Rotman, R. M., A. A. Hollis, and K. M. Trauth. 2021. "Realigning the Clean Water Act: Comprehensive Treatment of Nonpoint Source Pollution." *Ecology Law Quarterly* 48(101). https://scholarship.law.missouri.edu/facpubs/1004.
Rosencranz, J. A. 2017. "Assessing the Vulnerability of Salt Marsh Habitats to Sea-Level Rise in California." Doctoral Dissertation, University of California, Los Angeles. https://escholarship.org/uc/item/96x6r1zv.
Rubin, S., I. M. Miller, M. M. Foley, H. D. Berry, J. J. Duda, B. Hudson, N. E. Elder, M. M. Beirne, J. A. Warrick, M. L. McHenry, A. W. Stevens, E. F. Eidam, A. S. Ogston, G. Gelfenbaum, and R. Pedersen. 2017. "Increased Sediment Load During a Large-Scale Dam Removal Changes Nearshore Subtidal Communities." *PLOS ONE* 12(12). doi:10.1371/journal.pone.0187742.
Rutledge, K. M., T. Alphin, and M. Posey. 2018. "Fish Utilization of Created vs. Natural Oyster Reefs (*Crassostrea virginica*)." *Estuaries and Coasts* 41(8): 2426–32. doi:10.1007/s12237-018-0433-4.
San Francisco Bay Restoration Authority. 2018. *Annual Report 2017–2018*. Oakland, CA: San Francisco Bay Restoration Authority. https://www.sfbayrestore.org/sites/default/files/2019-08/item_10_sfbra_fy_17-18_annual_report.pdf.
San Francisco Bay Restoration Authority. 2021. *2020/21 Annual Levy Report For: Measure AA Special Parcel Tax*. Oakland, CA: San Francisco Bay Restoration Authority. https://www.sfbayrestore.org/sites/default/files/2021-02/Item%2010_SFBRA%20Measure%20AA%20Annual%20Report%2020-21.pdf.
Sanger, D., A. Blair, G. DiDonato, T. Washburn, S. Jones, G. Riekerk, E. Wirth, J. Stewart, D. White, L. Vandiver, and A. F. Holland. 2015. "Impacts of Coastal Development on the Ecology of Tidal Creek Ecosystems of the US Southeast Including Consequences to Humans." *Estuaries and Coasts* 38(Suppl. 1): 49–66. doi:10.1007/s12237-013-9635-y.
Sanger, D., and C. Parker. 2016. *Guide to the Salt Marshes and Tidal Creeks of the Southeastern United States*. Columbia, SC: South Carolina Department of Natural Resources. https://www.saltmarshguide.org/wp-content/uploads/2016/11/SaltMarshTidalCreekGuide.pdf.
Sapkota, Y., and J. R. White. 2020. "Carbon Offset Market Methodologies Applicable for Coastal Wetland Restoration and Conservation in the United States: A Review." *Science of The Total Environment* 701: 134497. doi:10.1016/j.scitotenv.2019.134497.
Schmidt, C. E., E. Monroy, M. Cantwell, J. King, and C. Roman. 2020. *A Synthesis of Case Studies from Narragansett Bay (RI/MA, USA) Emphasizing Implementation of the US Clean Water Act using Adaptive Management*. Providence, RI: Narragansett Bay

Estuary Program. doi:10.6084/m9.figshare.12311840.
SCWRP. 2022. Southern California Wetland Recovery Project. https://scwrp.org/.
SCWRP. n.d. "San Diego Bay Native Oyster Living Shoreline." Southern California Wetlands Recovery Project. https://scwrp.org/projects/san-diego-bay-native-oyster-living-shoreline/.
SEACAR. 2022. *SEACAR Data Discovery Interface*. Tallahassee, FL: Statewide Ecosystem Assessment of Coastal and Aquatic Resources. https://data.florida-seacar.org/.
Sherman, K., and L.A. DeBruyckere. 2018. *Eelgrass Habitats on the U.S. West Coast. State of the Knowledge of Eelgrass Ecosystem Services and Eelgrass Extent*. Arlington County, VA: The Nature Conservancy. https://www.pacificfishhabitat.org/wp-content/uploads/2017/09/EelGrass_Report_Final_ForPrint_web.pdf.
Shi, L. 2020. "Beyond Flood Risk Reduction: How can Green Infrastructure Advance both Social Justice and Regional Impact?" *Socio-Ecological Practice Research* 2(4): 311–20. doi:10.1007/s42532-020-00065-0.
Smith, H., and X. Basurto. 2019. "Defining Small-Scale Fisheries and Examining the Role of Science in Shaping Perceptions of Who and What Counts: A Systematic Review." *Frontiers in Marine Science* 6. doi:10.3389/fmars.2019.00236.
Smith, S. M. 2020. "Salt Marsh Migration Potential at Cape Cod National Seashore (Massachusetts, USA) in Response to Sea-Level Rise." *Journal of Coastal Research* 36(4): 771–9. doi:10.2112/JCOASTRES-D-19-00075.1.
Smythe, T. C., and J. McCann. 2018. "Lessons Learned in Marine Governance: Case Studies of Marine Spatial Planning Practice in the US." *Marine Policy* 94: 227–37. doi:10.1016/j.marpol.2018.04.019.
Solek, C. W., M. A. Sutula, E. D. Stein, C. Roberts, R. Clark, K. O'Connor, and K. J. Ritter. 2011. "Determining the Health of California's Coastal Salt Marshes using Rapid Assessment." *Southern California Coastal Water Research Project Annual Report*: 83–97. http://ftp.sccwrp.org/pub/download/DOCUMENTS/AnnualReports/2011AnnualReport/ar11_083_097_abstract.pdf.
Spencer-Davis, C. 2020. "Hold the High-Water Line: A Transnationally Informed Coastline Protection Scheme in the United States." *Vanderbilt Journal of Transnational Law* 53(2): 713. https://scholarship.law.vanderbilt.edu/vjtl/vol53/iss2/7.
Stedman, S. M., and T.W. Dahl. 2008. *Status and Trends of Wetlands in the Coastal Watersheds of the Eastern United States, 1998 to 2004*. Washington, DC: National Oceanic and Atmospheric Administration, National Marine Fisheries Service and U.S. Department of the Interior, Fish and Wildlife Service. https://www.fws.gov/wetlands/documents/Status-and-Trends-of-Wetlands-in-the-Coastal-Watersheds-of-the-Eastern-United-States-1998-to-2004.pdf.
Stephens T. 2021. "UCSC Leads Multicampus Initiative on Coastal Resilience and Climate Adaptation." *UC Santa Cruz News Center*. https://news.ucsc.edu/2021/03/coastal-adaptation.html.
Stockton, M. B., and C. J. Richardson. 1987. "Wetland Development Trends in Coastal North Carolina, USA, from 1970 to 1984." *Environmental Management* 11(5): 649–57. doi:10.1007/BF01880164.
Stralberg, D., M. Brennan, J. C. Callaway, J. K. Wood, L. M. Schile, D. Jongsomjit, M. Kelly, V. T. Parker, and S. Crooks. 2011. "Evaluating Tidal Marsh Sustainability in the Face of Sea-Level Rise: A Hybrid Modeling Approach Applied to San Francisco Bay." *PlOS*

ONE 6(11):e27388. doi:10.1371/journal.pone.0027388.
Sudol, M. F., and R. F. Ambrose. 2002. "The US Clean Water Act and Habitat Replacement: Evaluation of Mitigation Sites in Orange County, California, USA." *Environmental Management* 30(5): 727–34. doi:10.1007/s00267-002-2787-3.
Surfrider Foundation. 2020. *2020 State of the Beach Report*. San Clemente, CA: Surfrider Foundation. https://ee5-files.s3-us-west-2.amazonaws.com/publications/State%20of%20the%20Beach%20Report%20-%202020.pdf
Texas CMP. 2020. *Section 309 Assessment and Strategies Report: 2021–2025*. Austin: Texas General Land Office, Texas Coastal Management Program. https://www.glo.texas.gov/coast/grant-projects/forms/cmp-309-assessment-and-strategies-2021-2025.pdf.
Texas GLO. 2019. *Texas Coastal Resiliency Master Plan: Technical Report.* Austin: Texas General Land Office. https://coastalstudy.texas.gov/resources/files/crmp-technical-report-05-21-2019.pdf.
Texas GLO. n.d. "Coastal Management Program." https://www.glo.texas.gov/coast/grant-projects/cmp/.
Thorhaug, A., C. Belaire, J. J. Verduin, A. Schwarz, W. Kiswara, A. Prathep, J. B. Gallagher, X. P. Huang, G. Berlyn, T.-K. Yap, and S. Dorward. 2020. "Longevity and Sustainability of Tropical and Subtropical Restored Seagrass Beds among Atlantic, Pacific, and Indian Oceans." *Marine Pollution Bulletin* 160. Erratum in: *Mar Pollut Bull*. 2021;163. doi:10.1016/j.marpolbul.2020.111544.
Tomasko, D., M. Alderson, R. Burnes, J. Hecker, J. Leverone, G. Raulerson, and E. Sherwood. 2018. "Widespread Recovery of Seagrass Coverage in Southwest Florida (USA): Temporal and Spatial Trends and Management Actions Responsible for Success." *Marine Pollution Bulletin* 135: 1128–37. doi:10.1016/j.marpolbul.2018.08.049.
TPWD. 2012a. *Seagrass Conservation Plan for Texas: Ten-Year Review and Update – 2012*. Austin: Texas Parks and Wildlife, Resource Protection Division. https://tpwd.texas.gov/publications/pwdpubs/media/pwd_bk_v3400_0041_2012.pdf.
TPWD. 2012b. *Texas Conservation Action Plan 2012–2016: Gulf Coast Prairies and Marshes Handbook*. W. Connally, editor. Austin: Texas Parks and Wildlife Division. https://tpwd.texas.gov/landwater/land/tcap/documents/gcpm_tcap_2012.pdf.
TPWD. n.d. "Seagrass Protection: A Summary of Seagrass Management in Texas." Austin: Texas Parks and Wildlife Division. https://tpwd.texas.gov/landwater/water/habitats/seagrass/redfish-bay.
Turner, J., P. Gassett, C. Dohrn, H. Miller, C. Boylan, and E. Laschever. 2021. "Opportunities for U.S. State Governments and In-Region Partners to Address Ocean Acidification through Management and Policy Frameworks." *Coastal Management* 49(5): 436–57. doi:10.1080/08920753.2021.1947126.
QSR International. 2022. *NVivo*. Doncaster, Australia: QSR International. https://www.qsrinternational.com/nvivo-qualitative-data-analysis-software/home.
Valiela, I., J. Lloret, T. Bowyer, S. Miner, D. Remsen, E. Elmstrom, C. Cogswell, and E. R. Thieler. 2018. Transient Coastal Landscapes: Rising Sea Level Threatens Salt Marshes. *Science of The Total Environment* 640: 1148–56. doi:10.1016/j.scitotenv.2018.05.235.
Vermillion, A. 2016. "The 5 Oysters You Meet in Washington." *Seattle Met*. https://www.seattlemet.com/eat-and-drink/2016/03/the-five-oysters-you-meet-in-washington.
Vincent, J. R. 2016. "Impact Evaluation of Forest Conservation Programs: Benefit-Cost Analysis, Without the Economics." *Environmental and Resource Economics* 63: 395. doi:10.1007/s10640-015-9896-y.

Volk, M. I., T. S. Hoctor, B. B. Nettles, R. Hilsenbeck, F. E. Putz, and J. Oetting. 2017. "Florida Land Use and Land Cover Change in the Past 100 Years." In *Florida's Climate: Changes, Variations, & Impacts*, edited by E. P. Chassignet, J. W. Jones, V. Misra, and J. Obeysekera. Gainesville, FL: Florida Climate Institute.

Wagner, A. 2021. "What is a Living Shoreline and How Can it Save One of NC's Most Valuable Ecosystems?" *News and Observer*. https://www.newsobserver.com/news/weather-news/article254819557.html.

Washington Department of Ecology. 2018. Marine Spatial Plan for Washington's Pacific Coast. Publication #17-06-027. Olympia, WA: Washington Department of Ecology. https://apps.ecology.wa.gov/publications/documents/1706027.pdf.

Washington Department of Ecology. 2021. Washington Coastal Zone Management: Section 309 Assessment & Strategy, 2021–2025. Publication #21-06-005. Olympia, WA: Washington Department of Ecology. https://apps.ecology.wa.gov/publications/documents/2106005.pdf.

Washington Department of Ecology. n.d. "Washington State Coastal Atlas Map." https://apps.ecology.wa.gov/coastalatlas/tools/Map.aspx.

Washington Invasive Species Council. 2022. "Spartina Cordgrass." https://invasivespecies.wa.gov/priorityspecies/spartina-cordgrass/.

Washington Sea Grant. 2015. *Shellfish Aquaculture in Washington State. Final Report to the Washington State Legislature*. 84 p. Seattle, WA: Washington Sea Grant. https://app.leg.wa.gov/ReportsToTheLegislature/Home/GetPDF?fileName=WSGShellfishResearchFinalReportRevised_f6498d40-24b7-491e-8e1f-297faeef6a53.pdf.

Washington State Department of Natural Resources. n.d.a. "Summary Time Line of Bush and Callow Act Land Issues." https://wsg.washington.edu/wordpress/wp-content/uploads/bivalve-workshop-2009/Bush,%20Callow%20Act%20Handout.pdf.

Watson, A., J. Reece, B. E. Tirpak, C. K. Edwards, L. Geselbracht, M. Woodrey, M. K. LaPeyre, and P. S. Dalyander. 2017. *The Gulf Coast Vulnerability Assessment: Mangrove, Tidal Emergent Marsh, Barrier Islands, and Oyster Reef*. Forest and Wildlife Research Center, Research Bulletin WFA421. 98 p. Starkville, MS: Mississippi State University. https://pubs.er.usgs.gov/publication/70189000.

Watson, E. B., K. B. Raposa, J. C. Carey, C. Wigand, and R. S. Warren. 2017. "Anthropocene Survival of Southern New England's Salt Marshes." *Estuaries and Coasts* 40(3): 617–25. doi:10.1007/s12237-016-0166-1.

Waycott, M., C. M. Duarte, T. J. Carruthers, R. J. Orth, W. C. Dennison, S. Olyarnik, A. Calladine, J. W. Fourqurean, K. L. Heck Jr., A. R. Hughes, G. A. Kendrick, W. J. Kenworthy, F. T. Short, and S. L. Williams. 2009. "Accelerating Loss of Seagrasses across the Globe Threatens Coastal Ecosystems." *Proceedings of the National Academy of Sciences* 106(30): 12377–81. doi:10.1073/pnas.090562010.

Weldon, B. L. 2021. "Should Mangrove Forests be Used as Coastal Protection for the Gulf of Mexico from Future Climate Effects: A Look at the Houston Galveston Area." Master's Thesis. *Master's Projects and Capstones*. 1191. https://repository.usfca.edu/capstone/1191.

Wigand, C., R. Ardito, C. Chaffee, W. Ferguson, S. Paton, K. Raposa, C. Vandemoer, and E. Watson. 2017. "A Climate Change Adaptation Strategy for Management of Coastal Marsh Systems." *Estuaries and Coasts* 40(3): 682–93. doi:10.1007/s12237-015-0003-y.

Wilbur, A. R. 2007. *Field Study of Water Quality in Support of Eelgrass Habitat Restoration Planning in the Annisquam River*. Boston: Massachusetts Office of Coastal Zone Management. https://www.mass.gov/files/documents/2016/08/so/annisquam-eelgrass-wq.pdf.

Wood, V. R. 2018. "The Effect of Sedimentation on Oysters (*Ostrea lurida*) Adjacent to Eelgrass Beds (*Zostera marina*)." Master's Thesis. California State University, Fullerton. https://olympiaoysternet.ucdavis.edu/sites/g/files/dgvnsk6466/files/resources/CA14_Upper_Newport_Bay_Living_Shorelines_Project_Wood_thesis.pdf.

Wyatt, K. H., R. Griffin, A. D. Guerry, M. Ruckelshaus, M. Fogarty, and K. K. Arkema. 2017. "Habitat Risk Assessment for Regional Ocean Planning in the U.S. Northeast and Mid-Atlantic." *PLOS ONE* 12(12): e0188776. doi:10.1371/journal.pone.0188776.

Yarbro, L. A., and P. R. Carlson Jr., eds. 2016. *Seagrass Integrated Mapping and Monitoring Program: Mapping and Monitoring Report No. 2*. Fish and Wildlife Research Institute Technical Report TR-17 version 2. 281 p. Tallahassee, FL: Florida Fish and Wildlife Conservation Commission. http://manatee.wateratlas.usf.edu/upload/documents/SIMM_Report_2-2017-FWC.pdf.

Zhou, X., G. Wang, K. Wang, H. Liu, H. Lyu, and M. J. Turco. 2021. "Rates of Natural Subsidence along the Texas Coast Derived from GPS and Tide Gauge Measurements (1904–2020)." Journal of Surveying Engineering 147(4): 04021020. doi:10.1061/(ASCE)SU.1943-5428.0000371.

Zotero. n.d. Vienna, VA: Corporation for Digital Scholarship. www.zotero.org.

APPENDIX A: FULL METHODOLOGY

A.1 Inventory Development: Policy Documents and Secondary Literature

The project team adapted systematic review methods from Haddaway et al. (2015) to collect, assess, and evaluate the coastal habitat status and policy landscape for the six states using primary and secondary sources. Primary sources refer to the formal policy documents (e.g., statutes, ordinances, laws, management plans, etc.) that hold legal legitimacy in their jurisdiction. In this report, policy documents and primary sources will be used interchangeably. Secondary sources include academic literature, grey literature, legal literature (law reviews), congressional reports, and, at times the background section of management plans or strategies that identify and characterize the status and trends of relevant habitats and assesses the impacts of policies. Secondary sources in this study do not include public comments, testimony, permit documents (applications), congressional debates, or meeting minutes. These distinctions are not always clear and the types of documents that were included and excluded are outlined in Table A1. These represent the types of documents that were included in the initial inventory, but not all were ultimately included in the analysis.

The project team conducted searches for policy documents (considered primary data) from policy databases (e.g., LexisNexis), search engines (Google), and government websites (more detail follows). At the same time, the team collected supporting literature (considered secondary sources) from academic and legal literature search engines, as well as government websites. For each database or search engine used, different search functions and criteria were established with the support of a research librarian to optimize output. The information generated in the inventories was then crosschecked with experts in 60-minute interviews. The general methodology is outlined in Figure 1, previously in this report.

Table A1. Included and excluded documents in the literature review

	Primary Sources (Document Types)	Secondary Sources (Document Types)
Include	Bills Statutes and codes Ordinances Supreme Court decisions Management plans	Academic literature Grey literature Legal literature Congressional reports Municipal comprehensive plans
Exclude		Public comments Testimony Permit documents (applications) Congressional debates Meeting minutes

The project team consulted with Duke University research librarians with expertise in law, policy, and environmental studies for guidance on search string development and use of Boolean operators in each search engine for optimizing relevant search terms. The research librarians recommended iteratively testing tailored search strings for each database given differences in search algorithms and choosing the search strings that produced consistently relevant results in the first 20% of the search results. Combinations of terms were iteratively tested in the following nine databases to analyze the returned results for habitat assessment or policy relevancy: (1) Google Scholar, (2) Hein Online, (3) Web of Science, (4) NexisUni, (5) Google, (6) NexisUni: Political Science, (7) Proquest, (8) Westlaw, and (9) LexisNexis.

After testing search strings in these nine databases and search engines, five search tools returned both primary and secondary outputs of sufficient quality and quantity that covered a wide range of relevant resources from both the natural and social sciences as well as legal literature, and state and local level policy documents including statutes and management plans. These were (1) Google, (2) Google Scholar, (3) LexisNexis, (4) HeinOnline, and (5) Proquest. In addition, the project team also input search terms into individual state and respective environmental agency websites that plainly featured codified law such as general statutes and other habitat management policies and reports that may not be returned through searches in the databases and search engines.

The project team developed tailored search strings for each of the five search engines (Google, Google Scholar, ProQuest, HeinOnline, and LexisNexis) and state government websites to capture both primary and secondary sources to characterize habitat status and trends and governance mechanisms. Each search string is comprised of a combination of terms that apply to habitat and/or policy. These are described in the following sections.

A.2 Search Strings

The following search strings were used in each database. Each of the six states and four habitats and their synonyms were put in the place of "STATE" AND "HABITAT*" OR "HABITAT SYNONYM*". In some cases, databases were used to identify and pull out primarily policy documents, and in other cases, they were primarily used to pull secondary literature. Some search engines and databases produced both primary and secondary literature of relevance, which is indicated in parenthesis next to each search engine/database.

Google Scholar (Secondary Literature)

Search string 1: "STATE" AND ("HABITAT*" OR "HABITAT SYNONYM*") AND (legis* OR law OR regulat* OR rule) AND (protect* OR status OR condition OR trend OR manag* OR monitor* OR assess*) AND (coast* OR habitat OR marine OR shore OR estuar* OR wetland)

Search string 2: "STATE" AND ("HABITAT*" OR "HABITAT SYNONYM*") AND (coastal OR habitat OR ecosystem OR shoreline OR wetland OR estuar* OR protect* OR status) AND (extent OR loss OR coastal development OR erosion OR baseline OR degradation OR anthropogenic)

Google (Primary Policy Documents and Secondary Literature)

Search string: "STATE" AND ["HABITAT*" OR "HABITAT SYNONYM*") AND (coastal OR habitat OR ecosystem OR wetland OR estuar* OR protect*) AND (management plan OR comprehensive plan)

LexisNexis (Primary Policy Documents)

Filters: Jurisdiction filter

Source categories: Cases, statutes and legislation, secondary materials, administrative codes and regulations

Search string: "STATE" AND (oyster reef* OR sea grass* OR seagrass* OR salt marsh* OR mangrove* OR marsh OR wetland OR estuar*) AND (protect* OR conserv* OR restor* OR manag* OR maintain* OR recov*)

Hein Online (Primary Policy Documents and Secondary Literature)

Filters: Code of Federal Regulations, US Federal Agency Documents, Decisions, and Appeals, US Congressional Serial Set, GAO Reports, US Code, US Statutes at Large

Search string: "STATE" AND (sea grass* OR seagrass* OR oyster reef* OR oyster bed* OR salt marsh* OR mangrove* OR wetland OR coastal wetland OR estuar*) AND (status OR assess* OR historic*) AND (habitat OR ecosystem) AND (protect* OR threat* OR extent OR loss OR coastal development OR baseline OR fragment* OR erosion)

ProQuest (Secondary Literature)

Filters: NOT (newspapers AND magazines AND wire feeds AND historical newspapers AND blogs, podcasts, & websites AND dissertations & theses AND encyclopedias & reference works AND historical periodicals AND reports

Search string: FT("STATE") AND (((seagrass OR seagrasses) OR (oyster reef OR oyster reefs) OR (salt marsh OR salt marshes) OR (mangrove OR mangroves)) AND (wetland OR estuar* OR coast* OR shoreline) AND (policy OR manag* OR plan OR law))

State Websites (Primary Policy Documents and Secondary Literature)

In addition, each state's general statute and dominant environmental agency's website (e.g., North Carolina Department of Environmental Quality) were searched by individual terms or short phrases, since the sites do not accept Boolean terms. The following search terms were used: restor*, conserv*, estuar, and wetland*.

Note, the terms manag*, maintain*, and enhance* typically were not useful because they refer to so many policy realms beyond coastal habitat and environmental management at large.

State-Specific Terms

In the searches described previously, the following general habitat search terms were used: oyster reef, oyster bed, seagrass, sea grass, saltmarsh, salt marsh, coastal wetland, and mangrove. Only relevant habitat terms were used for searches of each state (e.g., mangrove was not entered in Washington State, where there are no mangroves).

Additionally, the project team identified state-specific terminology from state agency websites to discern relevant search terms that were unique to states. For instance, North Carolina uses the term "living shoreline" throughout many of its regulations and permits, but Florida does not. The following are state-specific search terms that were included in the searches described in the following section for each state in addition to the terms (such as saltmarsh or restor*) used across all states.

- California-specific search terms
  - Eelgrass
  - Baylands
  - Living shoreline
- Florida-specific search terms
  - N/A
- Massachusetts-specific search terms
  - Eelgrass
  - Nature-based coastal protection
- North Carolina–specific search terms
  - Coastal plain
  - Living shoreline
- Texas-specific search terms
  - N/A
- Washington-specific search terms
  - Shoreline
  - Eelgrass

Table A2. Number of secondary literature documents by state

State	No. of Secondary Literature Documents[a]
Massachusetts	114
North Carolina	170
Florida	248
Texas	126
California	234
Washington	118

[a] Secondary literature documents may cover more than one state.

A.3 Screening of Secondary Literature

Secondary literature that was deemed relevant because it discussed either status of and threats or characterized, assessed, and recommended policy approaches to coastal habitats in the states of interest, was saved in Zotero and as a PDF. Each document in Zotero was tagged with at least one of the following indicators: federal policy, policy effectiveness, policy evaluation, policy recommendation, water quality, Massachusetts, North Carolina, Florida, Texas, California, Washington, National, oyster reef, salt marsh, seagrass, mangroves, or kelp. The search strings were applied to each of the databases for every state and relevant habitat. Searches were considered exhausted when no relevant documents were returned in 10 consecutive pages (or within 100 results) or after 20% of the search string had been exhausted, per Diana et al. (2022). In total, 1,165 secondary literature files were saved for review. Not all of these were included in the final analysis.

A.4 Literature review

A.4.1 Secondary Literature Random Sampling and Analysis

Because of the large quantity of secondary source documents included in the inventories, a random sample of literature was selected for inclusion in the literature analysis. The literature review ultimately occurred in four phases.

In the first phase, a random sample of 50 secondary literature documents were coded using quantitative analysis software NVivo to capture information about habitat status and threats, policy evaluations, mentions of effectiveness, and recommendations. These were used as the basis for a literature review, from which remaining gaps were identified and subsequently filled in using the remainder of the literature files. Coded text was extracted and formed the basis of the literature review describing status and threats to coastal habitats and effectiveness of policy interventions. During phase 2, all the literature tagged as effectiveness (n = 42 documents) in Zotero was read, which formed as the basis for the policy effectiveness review.

This literature review method, which was not time-bound, resulted in factual inaccuracies and gaps in the knowledge base of coastal habitat status and threats and relevant policy approaches. To address the gaps in information and maximize the amount of relevant information collected from existing literature, the research team then reviewed policy documents, government reports and white papers that explicitly and comprehensively address the four coastal habitats of interest in the six focal states as the third phase of the literature review. These are outlined in Table A3.

Table A3. Third-phase literature review documents

Title	Lead Author	Year	Type of Publication	State
Seagrass Conservation Plan for Texas: Ten-Year Review and Update—2012	TCEQ	2012	Policy document	Texas
Texas Conservation Action Plan State/Multi-Region Handbook	TPWD	2012	Policy document	Texas
California Eelgrass Mitigation Policy and Implementing Guidelines	NOAA Fisheries	2014	Policy document	California
2015 Massachusetts Ocean Management Plan—Volume 1 (Management and Administration) and Volume 2 (Baseline Assessment and Science Framework)	Executive Office of Energy and Environmental Affairs	2015	Policy document	Massachusetts
Section 309 Assessment and Five-Year Strategy for CZM Program Enhancement (FY2016–2020)	Massachusetts Office of Coastal Zone Management	2015	Government report	Massachusetts
Wetland Program Plan	Washington Department of Ecology	2015	Policy document	Washington
Assessment and Strategy of the North Carolina Coastal Management Program FY 2016–2020 Performed Under the Coastal Zone Enhancement Grants Program Section 309 Coastal Zone Management Act	NOAA	2015	Government report	North Carolina
Gulf Coast Vulnerability Assessment: Mangrove, Tidal Emergent Marsh, Barrier Islands, and Oyster Reef	Amanda Watson	2016	Government report	Florida, Texas
North Carolina Coastal Habitat Protection Plan	North Carolina Department of Environmental Quality	2016	Policy document	North Carolina
North Carolina Coastal Habitat Protection Plan—Source Document	North Carolina Department of Environmental Quality	2016	Government report	North Carolina

Title	Lead Author	Year	Type of Publication	State
Seagrass Integrated Mapping and Monitoring Program Mapping and Monitoring Report No. 2	Laura Yarbro	2016	White paper	Florida
Assessing the Vulnerability of Salt Marsh Habitats to Sea-Level Rise in California	Jordan Alexander Rosencranz	2017	Dissertation	California
Coastal Habitat Integrated Mapping and Monitoring Program Report for the State of Florida	Kara Radabaugh	2017	White paper	Florida
Florida Land Use and Land Cover Change in the Past 100 Years	Michael Volk	2017	Textbook chapter	Florida
Eelgrass Habitats on the U.S. West Coast: State of the Knowledge of Eelgrass Ecosystem Services and Eelgrass Extent	Kate Sherman	2018	White paper	Washington, California
Florida Adaptation Planning Guidebook	Florida DEP	2018	Government report	Florida
Florida's Wildlife Legacy Initiative: Florida's State Wildlife Action Plan	Florida Fish and Wildlife Conservation Commission	2019	Policy document	Florida
Inland and Coastal Wetlands of Massachusetts Status and Trends	Lisa Rhodes	2019	Government report	Massachusetts
Oyster Integrated Mapping and Monitoring Report for the State of Florida	Kara Radabaugh	2019	White paper	Florida
Preparing For Rising Seas: How the State Can Help Support Local Coastal Adaptation Efforts	Gabriel Petek	2019	Government report	California
State of the Oyster: Progress Report on the Oyster Restoration and Protection Plan For North Carolina	North Carolina Coastal Federation	2019	White paper	North Carolina
State of the Sound Report	Puget Sound Partnership	2019	White paper	Washington
Texas Coastal Resiliency Master Plan, Technical Report—May 2019	George P. Bush	2019	Government report	Texas
2020 State of the Beach Report	Surfrider Foundation	2020	White paper	All
Final Assessment and Strategies FY 2021–FY 2025	Florida Coastal Management Program	2020	Government report	Florida

Title	Lead Author	Year	Type of Publication	State
Texas Coastal Management Program: Section 309 Assessment and Strategies Report: 2021–2025	Texas Coastal Management Program	2020	Government report	Texas
Seagrass Status and Trends Update for the Northern Gulf of Mexico: 2002-2017. Final Report to the Gulf of Mexico Alliance for Contract No.: 121701-00	Lawrence Handley	2020	White paper	Texas
Washington Coastal Zone Management: Section 309 Assessment and Strategy, 2021–2025	Washington Department of Ecology	2020	Government report	Washington
Coastal Management Program 2011 to Assessment and Strategy 2021 to 2025 Enhancement Cycle	California Coastal Commission	2021	Government report	California

In the fourth phase, secondary source documents published after January 1, 2016, in the inventory were put into a separate folder. A stratified random sample based on methods applied by Smith and Basurto (2019) was used to select those for deeper reading and analysis. The sample was stratified by year and by state, ultimately selecting five publications per state for each year between 2016 and 2021. For those states with less than five publications in a given year, all the documents were reviewed. This approach allowed literature from each state to be considered in the analysis without oversampling from those with a larger number of publications. For the policy effectiveness, all secondary source documents published after January 1, 2016, in the inventor were screened by title and abstract for policy effectiveness review. Fifty-five documents were selected for analysis. The information from each phase of this literature review was subsequently folded into the report.

A.5 Policy Analysis

In total, 1,437 primary policy documents (including state- and local-level policy documents) were saved for review. Table A4 indicates how many policy documents were found for each state.

A.5.1 Policy Coding

Every state-level policy from the inventory was uploaded into NVivo and screened for relevance. The project team developed a codebook to characterize the design of instruments within the policy document. The codebook (Table A.5) was developed and iteratively tested and refined between three coders for interrater reliability. The codebook was considered complete when the interrater reliability (IRR) kappa score between the three coders remained above 0.4, per Landis and Koch (1977). In total, five IRR tests were conducted over the course of coding, showing increased interrater reliability over the course of coding.

Table A4. Quantity of total and state-level policies for each state

State	Total Policies	State-Level Policies
Massachusetts	98	63
North Carolina	92	83
Florida	251	83
Texas	131	76
California	175	144
Washington	176	65

Table A5. Policy codebook

Coder Pairs	IRR 1	IRR 2	IRR 3	IRR 4	IRR 5
Coder 1&2	0.38	0.49	0.51	0.51	0.60
Coder 1&3	0.47	0.37	0.52	0.50	0.57
Coder 2&3	0.37	0.58	0.65	0.67	0.70

Each policy instrument identified within the policy document was coded for the following categories used to describe the design of the policy:

- Goals and objectives, including mentions of science-based targets, ecological goals, or socioeconomic goals (ecosystem services)
- Expected cost
- Habitats covered
- Regulated entity, including government entities, the public, or specific stakeholder groups
- Mention of federal policy (indication of cooperative federalism)
- Instrument type, including regulatory affirmative, regulatory prohibitive, economic incentives or disincentives, and information-based instruments.

A *policy instrument*, as defined here, is part of a policy document that outlines at least one element of governance that is considered to have a direct or indirect impact on coastal habitat. Policy instruments can be coded for multiple goals and objectives, habitats, regulated entities, and instrument types.

This codebook was used to code every state-level policy document in NVivo. Parent and grandparent nodes in gray represent coding categories. For each policy instrument, relevant grandchild nodes were used. At least one grandchild node under parent nodes 1–5 was coded. At least one regulatory- (6a), economic- (6b), or information-based (6c) instrument was also coded.

A.5.2 Policy Queries

Because of the large number of policies included in the inventory, the researchers extracted coded content along a range of broad-to-specific policy approaches regarding coastal habitat. The categories of approaches and their queries included those listed in Table A7.

Because of the wealth of information, only coded content extracted from habitat-specific policy query categories (those in green) was assessed. Relevant information from those policy documents (e.g., policies that demonstrated an intent on behalf of decision makers to support specific habitat protection and restoration or onramps for increased policy engagement by researchers and advocacy groups) was included in the report.

Table A6. Policy analysis codebook

1. Goals and objectives
1a. Measurable objective identified
Identification of specific, measurable objective included
Identification of specific, measurable objective not included
1b1. Ecological goals
General (e.g., improve ecosystems)
Habitat loss mitigation
Habitat or species protection or conservation
Habitat or species restoration
1b2. Socioeconomic goals
Blue carbon
Cultural value preservation
Development, urbanization, infrastructure
Economic value to stakeholders (including blue economy)
Education and research
Equity
Existence value
Food
General (unspecified)
Public health
Recreation and tourism
Responding to climate change (adaptation, resilience)
Water quality management
2. Expected cost
Expected cost in primary literature included
Expected cost in primary literature not included
3. Habitats covered
Kelp
Mangroves
Oyster reefs or oyster beds
Salt marsh
Seagrass or bayland or eelgrass
Unspecified—coastal
Unspecified—estuary
Unspecified—general or noncoastal
Unspecified—wetland
4. Regulated entity
4a. Government actors
Local governments

State agencies
Tribal
Unspecified

4b. Individuals

General public

4c. Stakeholder groups

Agriculture
Commercial fishing
Developers
Energy
Forestry
General (unspecified)
Property- or landowners
Recreation and tourism
Shipping

5. Federalism

Explicit mention of federal policy within instrument

6. Instrument type

6a. Affirmative regulation

Compensatory mitigation
Designating area for form of protection
Develop new or improve existing process or product
Guidance on administrative oversight
Plan or commitment
Rules around permitting, siting, and zoning

6b. Prohibitive regulation

Limit or ban of activity in area
Pollutant ban or limitation

6c. Instrument type: Economic instrument

Economic costs or disincentive (fee, tax, levy, duty)
Incentives (subsidy, financial assistance, cost-sharing program)

6d. Instrument type: Information-based

Compliance and data management
Data collection for internal assessment
Public-facing (education, outreach, labels, and placards)

Table A7. Approaches and queries

Category	NVivo Query
Non–habitat-specific + generally applicable	{[All of the unspecified habitat] NOT [all of the specified habitat]} + rules around permitting OR guidance on administrative oversight NOT [every other instrument type]
Non–habitat-specific + distinct instruments	{[All of the unspecified habitat] NOT [all of the specified habitat]} + [every other instrument type] NOT rules around permitting OR guidance on administrative oversight
Non–habitat-specific + All Instruments	{[All of the unspecified habitat] NOT [all of the specified habitat]} + {rules around permitting OR guidance on administrative oversight AND [every other instrument type]}
Habitat-specific + generally applicable	[Oysters OR salt marsh OR seagrass OR mangrove OR kelp] + [rules around permitting OR guidance on administrative oversight NOT [every other instrument type]
Habitat-specific + all instruments	[Oysters OR salt marsh OR seagrass OR mangrove OR kelp] + [rules around permitting OR guidance on administrative oversight AND [every other instrument type]
Habitat-specific + distinct instruments	[Oysters OR salt marsh OR seagrass OR mangrove OR kelp] + [every other instrument type] NOT rules around permitting OR guidance on administrative oversight
Features of interest	[Blue carbon OR equity OR cultural value preservation OR existence value OR expected cost included OR included: identification of specific, measurable objective OR pollutant ban or limitation OR tribal

A.5.3 Informal Consultations

Consultations with coastal habitat management experts were conducted in three rounds with state- or region-specific experts in fields ranging from habitat management to government to academia. To generate a comprehensive list of experts to contact, the project team relied on internal and external contacts from the Pew Charitable Trusts and Duke University, identified experts who first authored secondary source literature documents in the inventory at least two times, and reviewed state agency websites for coastal program managers. The interviewee list included those whose expertise and perspectives on coastal habitat and policy would be relevant and significant for our study from the following sectors: (1) academia, (2) government agencies, (3) NGOs, and (4) private industry (e.g., consulting firms and those with permitting knowledge). In total, 152 names were identified. Each person's professional website and, if relevant, most recent publications were reviewed. Each person was labelled by their affiliation, which habitats they had expertise in, their geographic areas of focus, and whether they had more expertise in habitat status or policy. From this screening process, a subset of individuals with the most relevant experience and expertise were selected to be contacted for an interview with the project team per state. The criteria in Table A8 demonstrate how individuals were selected from the initial list to be asked for an interview.

Table A8. Individual selection criteria

Sector	Criteria
Academia	At least one journal article in the last five years directly relevant to coastal habitats and policies of interest
NGO	At least one white paper in the last five years directly relevant to coastal habitats and policies of interest, or current active work in coastal habitats of interest
Government	At least one government report in in the last five years directly relevant to coastal habitats and policies of interest, or current active work in coastal habitats of interest.
Private sector	Permitting expertise

The first phase of expert interviews was conducted during the early stages of content analysis, after all documents from the searches had been collected but the coding of the collected content in NVivo was only partially complete. Therefore, the first round of consultations was focused on broad threats and trends within the topic state and relevant habitats. The interview format followed a specified list of broad questions, grouped as either habitat- or policy-related, that were augmented or supplemented to fit each state and expert topic area.

Following the completion of qualitative coding of all documents in NVivo and the initial stage of coherent report synthesis, a second phase of informal interviews was conducted. The intent of this second round of consultations was to ask much more targeted questions about the effectiveness, implementation, replicability, or reception of specific policies or programs on specific habitats and to fill in any gaps identified in the research.

In the third round of interviews, the first three phases of literature review had been conducted. The purpose of the final round of interviews was to crosscheck the findings from the literature review and identify any effective policies, bright spots, or emerging information that may not have come up in the literature. In total, 62 people were interviewed, the most of which represented Florida and the least of which came from Massachusetts and North Carolina. Additional appendices in this report include interview questions used in each phase of interviews. Table A9 describes metadata of the interviewees for each state in each round of informal consultations.

Table A9. Interviews by sector and state

State	Academia	NGO	Government	Private	Total
		Phase 1			
California	1	1	1	—	3
Florida	1	—	2	—	3
Massachusetts	1	—	1	—	2
North Carolina	2	—	1	—	3
Texas	—	—	1	—	1
Washington	—	—	3	—	3
Generalist	—	—	—	—	0
		Phase 2			
California	—	1	1	—	2
Florida	—	2	1	—	3
Massachusetts	—	—	2	1	3
North Carolina	—	—	—	—	0
Texas	—	—	1	—	1
Washington	1	3	—	—	4
Generalist	1	—	—	—	1
		Phase 3			
California	—	1	4	—	5
Florida	1	1	6	1	9
Massachusetts	—	1	2	—	3
North Carolina	—	2	3	—	5
Texas	6	1	1	1	9
Washington	—	—	2	—	2
Generalist	—	—	—	—	0
Total	14	13	32	3	62

APPENDIX B: INTERVIEW TEMPLATES

Each phase of interviews was generally divided into three parts: (1) information on coastal habitat status and threats, (2) policy landscape, and (3) policy effectiveness. Interview questions for phase 1 were broad, as the researchers had not yet begun their policy analysis and literature review, and thus were the same for interviewees across every state. Interview questions for phase 2 were largely developed as a result of initial policy analysis and literature review. Interview questions from phase 3 were largely developed as a result of more in-depth and comprehensive literature review. The interview template examples are modified to remove any potential identifying information about interviewees. Phase 2 and 3 interview templates were tailored for each interviewee, so the following are examples of the types of questions asked.

B.1 Phase 1 Interview Template Example

(1) Can you tell me a little bit more about where you work and your role in it, as well as other hats that you have worn that relate to coastal habitat?

B.1.1 General Habitat Questions

(2) Which trends or threats to the habitat are uniform across the entire state? Which are specific to one estuary or region?

(3) What additional data/information is needed to define the status and trends of the coastal habitats in your state?

(4) What do you see as the biggest threat to health of coastal habitats in your state in 5 years? 20 years? 50 years?

B.1.2 General Policy Questions

(5) Do you know of any policies in your state that have set specific, science-based goals for habitat protection and or restoration (e.g., 5000 acres of seagrass by 2025) or water quality (e.g., implemented nutrient loading criteria, chlorophyll a targets)? If so, how are they monitoring success and are they likely to achieve these goals?

(6) Which habitat areas are cooperatively managed by state and federal agencies (e.g., APNEP)? Are these mostly intact habitat areas that are protected, or do they include newly restored areas as well? Are these partnerships effective in your opinion? If no, do you have any opinions about why these partnerships aren't or haven't been working, and do you think there is anything unique about your state/habitat that leads to this ineffectiveness?

(7) If your state has designated counties and municipalities to develop their own coastal zone management program, are there any that stand out as particularly unique or innovative?

B.2 Phase 2 Interview Templates

B.2.1 Phase 2 California Template

(1) Can you tell me a little bit more about where you work and your role, as well as other hats that you have worn that relate to coastal habitat?

(2) Before we discuss any of our findings, we'd love to know if you can think of any local or state-specific management programs or policies that you think have been particularly harmful, innovative, or impactful for wild oyster reefs, salt marsh, and seagrass habitats in California?

(3) Are there any threats to coastal habitats in X area that are unique or exacerbated compared to the rest of the state?

(4) To what extent does federal designations of NERRS, NEPs, and NMSs provide protections or benefits to the area? How are federal programs interacting with local and county level management of coastal habitats? What about nonprofits?

(5) We have seen that the Greenhouse Gas Reduction Fund has funded some tidal wetland restoration projects. Have other state level policies, such as the Marine Life Protection Act, resulted in increased funding, support, or protection for coastal habitats?

(6) Can you think of a new policy or policy augmentation that you would recommend to improve a specific aspect of habitat protection or the larger framework of conservation and restoration throughout the state?

B.2.2 Phase 2 Florida Template

(1) Can you tell me a little bit more about where you work and your role, as well as other hats that you have worn that relate to coastal habitat?

(2) Before we discuss any of our findings, we'd love to know if you can think of any local or state-specific management programs or policies that you think have been particularly harmful, innovative, or impactful for wild oyster reefs, salt marsh, and seagrass habitats in Florida?

(3) Like many other states, the combined threat of sea level rise and coastal development threatens long-term salt marsh habitat. How true is this for Florida? Is mangrove encroachment a bigger threat?

(4) How are efforts to restore oysters in Apalachicola Bay going? I know Florida is developing an oyster management plan. What is the status of this plan and to what extent does it focus on Apalachicola?

(5) The Mangrove Trimming Act is one of the only policies we found directly addressing our habitats of interest. Has the Mangrove Trimming Act been sufficient to address the threats to mangroves?

(6) In terms of existing protection programs such as the Aquatic Reserves program, do you think these have been effective policy strategies?

(7) Florida seems to have a number of funds dedicated to habitat protection and restoration: the Land Acquisition Trust Fund, State Park Trust Fund, Florida Coastal Protection Trust Fund, Lifetime Fish and Wildlife Trust Fund, and the Florida Forever Trust Fund. What is your knowledge on how well-executed these programs are?

(8) Are any of the seven water management districts engaging on coastal habitat in a way that is particularly innovative? Any county comprehensive plans?

(9) How effective are protections for the Areas of Critical State Concern (ACSCs)? Is lobbying to designate more areas as ACSCs potential tool for increased protection?

(10) Though there are oyster and shellfish restoration programs and mitigation programs in Florida, we have not seen Florida use shellfish restoration as a mitigation strategy. Likewise, coastal habitat restoration is not widely used for climate mitigation. Is that an accurate assessment of what is happening in Florida and is there an appetite to move more in that direction?

B.2.3 Phase 2 Massachusetts Template

(1) Can you tell me a little bit more about where you work and your role, as well as other hats that you have worn that relate to coastal habitat?

(2) Before we discuss any of our findings, we'd love to know if you can think of any local or state-specific management programs or policies that you think have been particularly harmful, innovative, or impactful for wild oyster reefs, salt marsh, and seagrass habitats in Massachusetts?

(3) We've heard a little bit about local programs to motivate septic-to-sewer, such as in Falmouth. Have these programs been helpful for reducing nutrient inputs into coastal waters?

(4) Are there any threats to coastal habitats to specific areas in coastal Massachusetts that are unique or exacerbated compared to the rest of the state?

(5) How effective are protections for the Areas of Critical Environmental Concern (ACECs)? Is lobbying to designate more areas as ACECs potential tool for increased protection?

(6) To what extent does the review and permitting process set up under the Wetlands Protection Act or CZMA facilitate coastal protection in Massachusetts?

(7) Our research indicates that coastal development and nutrient pollution and eutrophication are the biggest threats to coastal habitats in Massachusetts. Is this true? What about invasives, sea level rise, oil spills, or threats from storms?

B.2.4 Phase 2 North Carolina Template

We had no phase 2 interviews for North Carolina.

B.2.5 Phase 2 Texas Template

(1) Can you tell me a little bit more about where you work and your role, as well as other hats that you have worn that relate to coastal habitat?

(2) Before we discuss any of our findings, we'd love to know if you can think of any local or state-specific management programs or policies that you think have been particularly harmful, innovative, or impactful at protecting wild oyster reefs, salt marsh, and seagrass, mangrove

(3) Our research indicates that the largest threats to coastal habitat in Texas and the Gulf of Mexico are coastal development, subsidence, and sea level rise. Is this true? Are other threats such as oil spills, invasives, and hurricanes having significant impacts as well?

(4) In terms of existing protection programs such as the Dune Protection Act, Coastal Preserve Program, and the Coastal Restoration and Improvement Fund, do you think these have been effective policy strategies?

(5) To what extent are rolling easements used in Texas?

(6) How do you see the Ike Dike affecting coastal habitat in Galveston Bay?

(7) Are there other federal, regional, state, or local policy levers besides the Galveston Bay Estuary Plan and RESTORE/NRDA/GOMESA funding that have had an impact on coastal habitat in Galveston Bay?

(8) Though there are oyster and shellfish restoration programs and mitigation programs in Texas, we have not seen Texas use shellfish restoration as a mitigation strategy beyond a case-by-case basis. Is that an accurate assessment of what is happening in Texas and is there an appetite to move more in that direction?

(9) We have not found much in terms of policy effectiveness, other than example restoration projects such as Half Moon Reef and the adaptive management approach at Neuces Estuary. Are there other case studies or examples where a government policy or program has been assessed for any effectiveness?

B.2.6 Phase 2 Washington Template

(1) Can you tell me a little bit more about where you work and your role, as well as other hats that you have worn that relate to coastal habitat?

(2) Before we discuss any of our findings, we'd love to know if you can think of any local or state-specific management programs or policies that you think have been particularly harmful, innovative, or impactful at protecting wild oyster reefs, salt marsh, and seagrass

(3) Our research indicates that, historically, the commercial oyster industry has used herbicides and pesticides in Washington, threatening and harming coastal habitats, specifically native seagrasses and nonnative *Zostera japonica* eelgrass. Can you speak to the extent of this issue and whether or not it has been resolved?

(4) Follow-up—how much of a role did local or state governments have in facilitating or enabling any resolution?

(5) We are also finding that cordgrass, the European green crab, and the Chinese mitten crab are the dominant invasive species threatening coastal habitats in Washington. What is your experience with and knowledge of the extent of the threat from invasive species in Washington and do you know of policies that are addressing these threats?

(6) To what extent has listing various salmon species under the ESA yielded positive conservation and protection benefits for coastal habitat in Washington?

(7) In terms of existing protection programs—such as the Aquatic Reserves program, in which aquatic areas that may be underutilized and have scientific, research, educational, and recreational value are designated as aquatic reserves—do you think these have been effective policy strategies?

(8) We have come across a number of tribe-led initiatives, mostly around salmon recovery and to a smaller extent trout and oysters as well. These include the Coordinated Tribal Water Quality Program and Northwest Indian Fisheries Commission. What is your knowledge of these programs and how much of a voice do tribal groups have in coastal habitat protection in Washington?

(9) How do tribal regulations and enforcement for fisheries differ from state- and local-level policies?

(10) We are finding the shoreline master programs mostly oversee permitting and enable consistency between state-, federal-, and local-level permitting. Do you think shoreline master programs have been or could be vehicles for more coastal habitat restoration and protection?

(11) Likewise, counties are encouraged to have shellfish protection districts for water quality improvements. To what extent do they develop and maintain such programs?

(12) Though there are oyster and shellfish restoration programs and mitigation programs in Washington, we have not seen Washington use shellfish restoration as a mitigation strategy beyond a case-by-case basis. Is that an accurate assessment of what is happening in Washington and is there an appetite to move more in that direction?

(13) We have not found much in terms of policy effectiveness, other than examples of stakeholder-driven and iterative ecoengineering projects, such as the Elliott Bay seawall in Seattle. Are there other case studies or examples where a government policy or program has been assessed for any effectiveness?

B.3 Phase 3 Interview Templates

B.3.1 Phase 3 California Template

(1) Can you tell me a little bit more about where you work and your role in it, as well as other hats that you have worn that relate to coastal habitat?

Theme 1: Threats to Coastal Habitat

(2) The literature suggests that fluctuations in sediment flow may be affecting salt marsh in southern California but that this dynamic is not yet well understood. With SLR accelerating this threatens salt marsh. What can you tell us about this phenomenon?

   (a) What are some other current threats to salt marshes across California? Development? Flood control projects (historical)?

(3) We have identified the biggest threats to eelgrass are coastal development, aquaculture, and agricultural runoff. Is this correct. Are we missing anything? (Maybe sea level rise?)

(4) Is it fair to say that agriculture and coastal development are the biggest historic drivers of coastal habitat loss in California?

(5) What are specific threats to oysters and oyster reefs/beds in California? We were not able to find a lot of information about this in the literature.

Theme 2: Habitat-Specific Policies and Effectiveness

(6) Can you tell me more about efforts to naturalize or restore Pacific oysters in California?

(7) To what extent is the California Eelgrass Mitigation Policy implemented in California? Has it increased the amount/ratio of compensatory mitigation that happens in California?

   (a) Has it changed state-level regulatory oversight of development and mitigation? Or is it exclusively for NMFS and federal agencies?

(8) Are there any state-level policies explicitly working to protect or restore salt marsh or oyster reefs (not for aquaculture)?

Theme 3: General Coastal Management and Effectiveness

(9) There are some generally applicable state laws in California that are meant to protect, restore, and address threats to coastal habitats. We are hoping to talk a little bit more about them and their progress/effectiveness:

   (a) Ocean Acidification and Hypoxia Reduction Program (2016)

   (b) California Marine Protected Areas

   (c) Greenhouse Gas Reduction Funds addressing SLR and supporting BCDC (San Francisco Bay Conservation and Development Commission) and the Coastal Commission?

(10) Are there are Local Coastal Programs that are particularly effective?

(11) What is the status of the Cutting the Green Tape policy recommendations?

(12) The Southern California Wetlands Recovery Project released its regional strategy including goals for wetland restoration and protection. Can you speak to its current efforts and effectiveness?

Theme 4: Gaps in our Literature

(13) In our initial literature review, we were not able to find much information on policies and effectiveness for oysters and salt marshes. Do you know of any?

B.3.2 Phase 3 Florida Template

(1) Can you tell me a little bit more about where you work and your role in it, as well as other hats that you have worn that relate to coastal habitat?

Theme 1: Threats to Coastal Habitat

(2) We are seeing the biggest current threats to oyster reefs as overexploitation, the emergence of HABs and red tides, nutrient pollution, and freshwater flow changes. Is that correct?

   (a) Oyster reef loss in the Central Florida Coastal Plain and Southern Florida Coastal Plain estimated: 90%–99%. Is this correct?

   (b) What about disease or predators? Are these expected to change with climate change?

   (c) How much of nutrient pollution and water quality issues are results of septic systems?

   (d) Other threats? Shoreline hardening?

(3) We are seeing the biggest current threats to mangroves as extreme freeze events and SLR, particularly for mangrove islands or areas with migration barriers. Are there other notable threats?

   (a) Habitat destruction? Surface/groundwater flows? Invasives?

(4) How much of a concern is mangrove protection/restoration in light of mangrove expansion into salt marsh areas?

(5) Is it fair to say that coastal development on and impoundment of saltmarshes for mosquitoes seems like the biggest historic diver of salt marsh loss? Current threats are sea level rise, and changes in hydrologic flow. Anything else?

(6) Similarly, turbidity from stormwater runoff, dredging, and boating is a big threat to seagrass. Historical dredging as well.

(7) How big are the threats of saltwater intrusion and subsidence? They are talked about broadly but not in terms of their impact on the four habitats.

(8) Are there any threats that are specific to one of the four habitats and marginal to the others?

(9) How do these threats differ in different parts of the Florida coast? What are uniform threats, if any?

Theme 2: Habitat-Specific Policies and Effectiveness

(10) We are seeing the main oyster specific policies as harvesting regulations in designated shellfish harvesting areas. Are there others? Are there any about oyster protection or restoration?

(11) Would you say the Mangrove Trimming and Preservation Act has been effective?

Theme 3: General Coastal Management and Effectiveness

(12) Are there any local comprehensive plans that have been particularly interesting of coastal habitat restoration and protection?

(13) Florida seems to have a number of funds dedicated to habitat protection and restoration: the Land Acquisition Trust Fund, State Park Trust Fund, Florida Coastal Protection Trust Fund, Lifetime Fish and Wildlife Trust Fund, and the Florida Forever Trust Fund. What is your knowledge on how well-executed these programs are?

Theme 4: Gaps in our Literature

(14) In our initial literature review, we were not able to find much information on policy effectiveness for policies that can impact salt marsh and seagrass, beyond SIMMP, which is no longer active from what we understand. Do you know of any resources that may discuss these that would be useful to include in our report?

B.3.3 Phase 3 Massachusetts Template

(1) Can you tell me a little bit more about where you work and your role in it, as well as other hats that you have worn that relate to coastal habitat?

Theme 1: Threats to Coastal Habitat

(2) We are seeing the biggest current threats to coastal wetlands (salt marsh) as eutrophication from nutrient pollution, legacy impacts from historic diking and dredging, and sea-level rise and increased frequency of coastal storms submerging and overwashing salt marsh as the biggest threats.

(3) Emerging concerns are listed as sediment supply and changes in groundwater flows. Are these still emerging concerns or current problems?

(4) Wetland gains are due to beaver activity? Is this relevant for coastal habitat at all?

(5) It seems like investments in water quality improvements in urban areas and more targeted restoration efforts have slowed seagrass and eelgrass loss rates. Do you agree?

(6) The only current threats we have picked up from the literature on oyster reefs are HABs and ocean acidification? Are there others that are missing?

(7) How do these threats differ in different parts of the Massachusetts coast? What are uniform threats, if any?

Theme 2: Habitat-Specific Policies and Effectiveness

(8) Most oyster-specific policies seem to be about aquaculture development. Are there any policies targeted on oyster protection or restoration?

(9) What do you know about the status of the Blueprint for Tidal Marsh Resilience, and do you think this will be an effective strategy?

(10) Seagrass are listed as Special, Sensitive, or Unique (SSU) resources in the ocean plan. Does this effect how well they are protected during coastal construction and other permitting decisions?

(11) Are there other habitat-specific policies you can identify in Massachusetts?

Theme 3: General Coastal Management and Effectiveness

(12) In terms of existing protection programs such as the ACECs, do you think these have been effective policy strategies?

  (a) What about Statewide No Discharge zones?

  (b) What about the Coastal Resilience Grant program?

(13) We know general policies provide some protection, even if they are not habitat-specific. Can you tell us your view of Massachusetts's implementation of CWA and CZM for the protection/restoration of the three habitats of interest?

  (a) To what extent are these laws and programs implemented to restore or protect specific habitats (through mitigation, for example)?

(14) In 2017, CZM revised the Ocean Sanctuaries Act regulations (301 CMR 27.00), which should change how sewage outfalls in designated ocean sanctuaries are permitted. Has this had its expected impact of minimizing impacts to shellfish and fisheries?

Theme 4: Gaps in our Literature

(15) In our initial literature review, we were not able to find much information on policy effectiveness for policies that can impact salt marsh and seagrass. Do you know of any resources that may discuss these that would be useful to include in our report?

B.3.4 Phase 3 North Carolina Template

(1) Can you tell me a little bit more about where you work and your role in it, as well as other hats that you have worn that relate to coastal habitat?

Theme 1: Threats to Coastal Habitat

(2) The literature suggests that the biggest current threats to oyster reefs are overexploitation and habitat disturbances from dredging, shellfish disease, natural disasters, and water quality issues. Which of these would you consider the most threatening and are there others I am missing?

(3) Turbidity from nutrient loading, dredging, and boating is a big threat to seagrass. Which of these would you consider the most threatening and are there others I am missing?

(4) Are there any threats that are specific to one of the three habitats (oyster reefs, salt marsh, and SAV) and marginal to the others?

(5) How do these threats differ in different parts of the North Carolina coast? What are uniform threats, if any?

Theme 2: Habitat-Specific Policies and Effectiveness

(6) We are seeing the main oyster specific policies as designated oyster sanctuaries and banning oyster shells in landfills. The coastal federation offers shell recycling, but to my knowledge, this is not a policy program. Are there others?

(7) Are you familiar with the new streamlined permitting rules for living shorelines? If so, what is your sense in how often they have been used, and specifically when those living shorelines or marsh sills also included replanting of oysters?

(8) Can you identify actions proposed from past iterations of the CHPP that have yielded effective changes for coastal habitats?

Theme 3: General Coastal Management and Effectiveness

(9) North Carolina seems to have a number of funds dedicated to habitat protection and restoration: Environmental Enhancement Grant Program, North Carolina Water Resources Development Grant Program, North Carolina Natural Heritage Trust Fund, North Carolina Land and Water Fund, North Carolina Parks and Recreation Trust Fund, and North Carolina Community Conservation Assistance Program. What is your knowledge on how well-executed these programs are, especially as they relate to coastal habitats?

Theme 4: Gaps in our Literature

(10) In our initial literature review, we were not able to find much information on

(a) Specific threats to salt marshes

(b) Policies and policy effectiveness for salt marsh or SAV (seagrass)

Do you know of any resources that may discuss these that would be useful to include in our report?

B.3.5 Phase 3 Texas Template

(1) Can you tell me a little bit more about where you work and your role in it, as well as other hats that you have worn that relate to coastal habitat?

Theme 1: Threats to Coastal Habitat

(2) We are seeing the biggest current threats to oyster reefs and seagrasses as changes in sedimentation and freshwater flow from rainfall natural disasters, Vibrio and water-borne diseases, overexploitation, the emergence of HABs, and nutrient pollution. Is that correct?

(3) What about changes in sea surface temperature?

(4) How much of a threat are coastal development, subsidence, sea level rise, oil spills, and invasives, generally?

(5) How much of a concern is mangrove protection/restoration in light of mangrove expansion into salt marsh areas?

(6) Are there any threats that are specific to one of the habitats and not the others?

Theme 2: Habitat-Specific Policies and Effectiveness

(7) What do you know about the Shell Bank Oyster Shell Recycling Program and are there other policy/government related oyster recycling programs in Texas?

(8) Do you think the recent approval of oyster Mariculture in Texas (HB1300 SB682) will change the status of oyster reefs in Texas?

(9) According to the literature, the Coastal Coordination Council of the CMP the Interagency Coordination Team (consisting)TPW and TGLO coordinate with Army Corps, USFWS, and NMFS), Federal Section 404 Permits and state Section 401 Water-quality Certifications have been fairly effective at enabling seagrass protection and federal consistency through the review and permitting process in Texas. Is this accurate?

(10) Though there are oyster and shellfish restoration programs and mitigation programs in Texas, we have not seen Texas use shellfish restoration as a mitigation strategy beyond a case by case basis. Is that an accurate assessment of what is happening in Texas and is there an appetite to move more in that direction?

Theme 3: General Coastal Management and Effectiveness

(11) In terms of existing protection programs such as the Dune Protection Act, Coastal Preserve Program, Coastal Restoration and Improvement Fund, Coastal Erosion Planning and Response Act (CEPA), do you think these have been effective policy strategies, particularly the CERPA and development of Erosion Response Plans (ERPs)?

Theme 4: Gaps in our Literature

(12) In our initial literature review, we were not able to find much information on:

(a) Threats to salt marsh beyond mangrove expansion

(b) Specific policies and policy effectiveness for mangroves, salt marsh, and oyster reefs

Do you know of any resources that may discuss these that would be useful to include in our report?

B.3.6 Phase 3 Washington Template

(1) Can you tell me a little bit more about where you work and your role in it, as well as other hats that you have worn that relate to coastal habitat?

Theme 1: Threats to Coastal Habitat

(2) We are seeing the biggest current threats to seagrass in Puget Sound as water quality issues, changes in freshwater flow, wasting disease, and extreme weather events. Would you agree that these are the threats? Are we missing any others? Are these the same as threats to seagrass in other coastal areas in Washington (e.g., Willapa Bay and Grays Harbor)?

(3) Are the threats to coastal wetlands, salt marsh in particular, increasing coastal development and SLR? Are there others?

(4) According to some of the literature we reviewed, finding areas to restore coastal wetlands to mitigate/compensate for wetland loss is difficult in coastal estuarine areas. Is this true?

(5) Can you speak to the threats to oyster reefs? Are there oyster reefs that are off-limits to harvest of any kind?

(6) How do these threats differ in different parts of the Washington coast? What are uniform threats, if any?

Theme 2: Habitat-Specific Policies and Effectiveness

(7) For seagrass, we are seeing a lot of monitoring through the Submerged Vegetation Monitoring Program. Can you tell me more about this program?

(8) Seagrasses are also classified as habitats of special concern and as critical habitat—to what extent does this facilitate their protection?

(9) Specific to the Puget Sound Partnership: how far along are you in reaching the target for a 20% increase in eelgrass area by 2020? What are some of the challenges and limitations to reaching this goal?

(10) Most oyster specific policies seem to be about commercial harvest and aquaculture development. Are there any policies targeted on oyster protection or restoration?

(11) Are there other habitat-specific policies you can identify in Washington? We were not able to find any for salt marsh.

Theme 3: General Coastal Management and Effectiveness

(12) Similarly, coastal wetlands, which salt marshes are a part of, are High Priority areas for the Washington Coastal Zone Management Program. How does this facilitate, if at all, their protection and restoration?

(13) The Wetlands Program Plan is/was an interagency collaboration working to develop wetland protection and monitoring programs. What is your knowledge or this program and its 2021 update?

(14) And its suspension of reviewing the in-lieu fee program? What is your knowledge of/ thoughts about that? Or the wetlands mitigation banking act?

(15) What are your thoughts on the aquatic reserves program?

Theme 4: Gaps in our Literature

(16) In our initial literature review, we were not able to find much information on specific threats to salt marsh policy effectiveness for policies that can impact salt marsh and seagrass and oyster reefs. Do you know of any resources that may discuss these that would be useful to include in our report?

APPENDIX C: FEDERAL STATUTES

Table C1. Federal statutes

Federal Statute	Original Year Passed
Antiquities Act	1906
Watershed Protection and Flood Prevention Act	1954
National Environmental Policy Act	1970
Clean Water Act	1972
Coastal Zone Management Act	1972
Marine Mammal Protection Act	1972
National Marine Sanctuaries Act	1972
Marine Protection, Research, and Sanctuaries Act	1972
Endangered Species Act	1973
Resource Conservation and Recovery Act	1976
Magnuson–Stevens Fishery Conservation and Management Act	1976
Coastal Barriers Resource Act	1982
Emergency Wetlands Resources Act	1986
Shore Protection Act	1988
North American Wetlands Conservation Act	1989
Coastal Wetlands Planning, Protection and Restoration Act	1990
Water Resources Development Act	1992
Beaches Environmental Assessment and Coastal Health Act	2000
Estuaries and Clean Waters Act	2000
Estuary Restoration Act	2000
Resources and Ecosystems Sustainability, Tourist Opportunities, and Revived Economies of the Gulf Coast States Act (RESTORE Act)	2012
Water Infrastructure Improvements for the Nation Act	2016

Author Affiliations

Rachel Karasik, Nicholas Institute for Energy, Environment & Sustainability, Duke University
Amy Pickle, Nicholas Institute for Energy, Environment & Sustainability, Duke University
Maggie O'Shea, Nicholas School of the Environment, Duke University
Kelly Reilly, Nicholas Institute for Energy, Environment & Sustainability, Duke University
Molly Bruce, Nicholas School of the Environment, Duke University; Duke University School of Law
Rachel Earnhardt, Nicholas Institute for Energy, Environment & Sustainability, Duke University
Iqra Ahmed, Nicholas School of the Environment, Duke University

Citation

Karasik, R., A. Pickle, M. O'Shea, K. Reilly, M. Bruce, R. Earnhardt, and I. Ahmed. 2022. State of the Coast: A Review of Coastal Management Policies for Six States. NI R 22-07. Durham, NC: Duke University.

Acknowledgments

We would like to thank the following individuals for their contributions to this research: Colleen Baker, Crystal Franco, and Maria José Alarcon.

Review

This report was reviewed by experts in the field of coastal ecology, biology, tidal wetlands, and coastal landscape change.

The Nicholas Institute at Duke University would like to acknowledge The Pew Charitable Trusts for providing support for this report. Although Pew generously supported this work, it is not responsible for any inaccuracies and does not necessarily endorse the findings. Additionally, we would like to acknowledge the contributions of our peer reviewers: Molly Mitchell, PhD, Virginia Institute of Marine Science, and Keryn Gedan, PhD, The George Washington University.

Cover image: O. McCrosson, CC BY-SA 4.0 https://creativecommons.org/licenses/by-sa/4.0, via Wikimedia Commons

Published by the Nicholas Institute for Energy, Environment & Sustainability in 2022. All Rights Reserved.

Publication Number: NI R 22-07

Nicholas Institute for Energy, Environment & Sustainability

The Nicholas Institute for Energy, Environment & Sustainability advances Duke University's efforts to build a more sustainable world, working closely with Duke schools and other units. The Nicholas Institute develops transformative educational experiences; galvanizes and conducts impactful research; and engages with key decision makers at the global, national, state, and local levels. The Nicholas Institute's team of economists, scientists, lawyers, and policy experts has developed a strong reputation for delivering timely, credible analysis and for convening decision makers to advance actionable solutions to pressing energy and environmental challenges.

Contact

Nicholas Institute
Duke University
P.O. Box 90467
Durham, NC 27708

1201 Pennsylvania Avenue NW
Suite 500
Washington, DC 20004

919.613.1305
nicholasinstitute@duke.edu