

VIII. ADAPTING TO THE EFFECTS OF CLIMATE CHANGE IN THE MARINE & COASTAL ENVIRONMENT

This section presents adaptation actions culled from the published scientific literature, grey literature, and interviews with experts.

In this report, “adaptation” refers to the IPCC’s definition: “adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.”¹²⁹¹

Climate change is now widely acknowledged as a global problem that threatens marine and coastal conservation, management, and policy.¹²⁹² Adaptation is one of two major ways in which climate-related risks can be managed (the other is mitigation, which includes strategies to reduce greenhouse gas sources and emissions, and enhance greenhouse gas sinks).¹²⁹³ Even if global greenhouse gas emissions were to be stabilized near their current levels, atmospheric concentrations would increase throughout the 21st century, and might well continue to increase slowly for several hundred years after that.¹²⁹⁴ Thus, mitigation can reduce climate-related risks only in the longer term.¹²⁹⁵ Adaptation has emerged as a necessary response to and preparation for the unavoidable impacts of global climate change.¹²⁹⁶

Adaptation is in its infancy and the field is developing in a rapid and *ad hoc* fashion.¹²⁹⁷ However, general and specific approaches to adaptation action are emerging, as are common tenets of adaptation action.¹²⁹⁸ Along with these, existing conservation activities are being applied to climate change adaptation, and new activities are also being developed.¹²⁹⁹ The states, provinces, and tribal governments of the NPLCC region are developing climate change adaptation strategies. Each of these topics is covered in turn:

- **Framework for Adaptation Actions:** A general approach and specific planning and management approaches to adaptation action, derived from published and grey literature.
- **Common Tenets of Adaptation Action:** Adaptation principles derived from the literature.
- **Climate Adaptation Actions:** Adaptation actions are organized into five broad categories, including information gathering and capacity building; monitoring and planning; infrastructure and development; governance, policy, and law; and, conservation, restoration, protection and natural resource management. The actions described represent the range of ideas suggested by the scientific literature on climate change adaptation. They are not intended as recommendations.
- **Status of Adaptation Strategies and Plans:** Brief descriptions of the development and implementation of state, provincial, and selected tribal adaptation strategies in the NPLCC region.

¹²⁹¹ *IPCC. *Climate Change 2007: Impacts, Adaptation and Vulnerability: Introduction*. (2007b, p. 6)

¹²⁹² *Gregg et al. *The State of Marine and Coastal Adaptation in North America: A Synthesis of Emerging Ideas (Final Report)*. (2011, p. 30)

¹²⁹³ Asian Development Bank (ADB). *Climate Proofing: A risk-based approach to adaptation*. (2005, p. 7); Information on mitigation available from Parry et al. (2007, p. 878)

¹²⁹⁴ *ADB. (2005, p. 7)

¹²⁹⁵ ADB. (2005, p. 7)

¹²⁹⁶ *Gregg et al. (2011, p. 30)

¹²⁹⁷ *Gregg et al. (2011, p. 30)

¹²⁹⁸ ADB (2005); Gregg et al. (2011); Heller and Zavaleta (2009); NOAA. *Adapting to Climate Change: A Planning Guide for State Coastal Managers*. (2010)

¹²⁹⁹ See, for example, Baron et al. (2009); Heller and Zavaleta (2009); Mawdsley, O’Malley, and Ojima (2009); NOAA. (2010); U.S. EPA. (2009).

1. FRAMEWORK FOR ADAPTATION ACTIONS

General Approach to Adaptation Action

Adaptation actions are undertaken either to avoid or take advantage of actual and projected climate change impacts either by decreasing a system's vulnerability or increasing its resilience.¹³⁰⁰ This may entail reprioritizing current efforts as well as identifying new goals and objectives to reduce overall ecosystem vulnerability to climate change.¹³⁰¹ The former – reprioritizing current efforts – is known as a “bottom-up” or “project-based” approach and involves integrating climate change considerations into existing management and program structures.¹³⁰² The latter – identifying new goals and objectives – is known as a “top-down” or “landscape-based” approach and is particularly useful for broad-scale efforts, such as those conducted at regional, state, or national levels for one or more sectors.¹³⁰³

General approaches to and principles of adaptation action in both human and natural systems have been addressed in past reports.¹³⁰⁴ A review of these reports indicates the approaches and adaptation principles are consolidated typically into four broad steps:

1. **Assess current and future climate change impacts and conduct a vulnerability assessment.**¹³⁰⁵ The vulnerability assessment may focus on a species, place, program, community, or anything else of concern to those doing the assessment, and should include exposure (the nature and degree to which a system is exposed to significant climatic variations), sensitivity (the degree to which a system is affected, either adversely or beneficially, by climate-related stimuli), and adaptive capacity (ability of the system to respond effectively), as well as interactions with other factors, such as existing stressors or possible changes in human resource use patterns.¹³⁰⁶ In all cases, the assessment should begin with the overall goal of those carrying it out (e.g. sustainable fisheries management, coastal habitat protection).¹³⁰⁷ Further information on conducting vulnerability assessments is provided in Section 3 of this Chapter.
2. **Select conservation targets and course of action.**¹³⁰⁸ This step includes identifying, designing, prioritizing, and implementing management, planning, or regulatory actions and policies that reduce the vulnerabilities and/or climate change effects identified in Step 1.¹³⁰⁹ *Note that Steps 1 and 2 are interchanged in some reports (CIG 2007; Heller & Zavaleta 2009), and are considered iterative by others (Glick et al. 2009).*

¹³⁰⁰ *Gregg et al. (2011, p. 29). The authors cite ADB (2005), Levin & Lubchenco (2008), Lawler (2009). Pew Center (2009).

¹³⁰¹ *Glick et al. (2011a, p. 7)

¹³⁰² Glick et al. (2011a, p. 7); Glick et al. (2011b, Box 1.1, p. 13)

¹³⁰³ Glick et al. (2011a, p. 8); Glick et al. (2011b, Box 1.1, p. 13)

¹³⁰⁴ *Gregg et al. (2011, p. 30)

¹³⁰⁵ Gregg et al. (2011); Glick et al. (2009); Heller & Zavaleta (2009); NOAA (2010); U.S. AID (2009); CIG (2007); ADB (2005); Pew Center. (2009)

¹³⁰⁶ *Gregg et al. (2011, p. 30)

¹³⁰⁷ *Gregg et al. (2011, p. 30)

¹³⁰⁸ Gregg et al. (2011); Glick et al. (2009); Heller & Zavaleta (2009); NOAA (2010); U.S. AID (2009); CIG (2007); Pew Center. (2009)

¹³⁰⁹ Gregg et al. (2011); Glick et al. (2009); Heller & Zavaleta (2009); NOAA (2010); U.S. AID (2009); CIG (2007)

3. **Measure, evaluate, and communicate progress** through the design and implementation of monitoring programs that assess changes in the chosen parameters of management and/or policy effectiveness.¹³¹⁰
4. **Create an iterative process to reevaluate and revise the plan, policy, or program**, including assumptions.¹³¹¹

In some reports, a wider planning process and team-building activities precede Step 1 above. For example, the process outlined in NOAA's *Adapting to Climate Change: A Planning Guide for State Coastal Managers* (2010) begins with a planning process that includes scoping the level of effort and responsibility; assessing resource needs and availability; assembling a planning team and establishing responsibilities; and, educating, engaging & involving stakeholders.¹³¹² The Climate Impacts Group *Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments* (2007) includes similar steps: scope climate change impacts in major sectors; build and maintain support to prepare for climate change by identifying a "champion" and audience, and developing and spreading a message; and, build a climate change preparedness team.¹³¹³ The Asian Development Bank's (2005) approach begins with capacity building and provision, enhancement, and application of data, tools, and knowledge.¹³¹⁴

Specific Planning and Management Approaches to Adaptation Action

Two of many approaches to adaptation planning and management in the coastal and marine environment are:

- **The U.S. EPA's National Estuary Program – Climate Ready Estuaries**

There are five critical elements in an adaptation plan that earns recognition as a "Climate Ready Estuary:"

- **Assessment of vulnerability to climate change**, which includes a description of the specific effects from climate change (and interactions of climate change with existing stressors) that are likely to affect key management goals, the timeframe for the predicted effects, and consideration of uncertainty or other factors needed to set planning priorities.¹³¹⁵
- **Summary of considerations used to set priorities and select actions**, including the timing and severity of projected impacts, the probability of occurrence of different impacts, the economic or social value of endpoints in concern, and the capacity of the community to undertake the action compared to the scale of impacts.¹³¹⁶
- **Description of specific adaptation actions for implementation**, which is a limited set of essential actions and a preliminary schedule and approach to achieving those actions.¹³¹⁷

¹³¹⁰ Gregg et al. (2011); Glick et al. (2009); Heller & Zavaleta (2009); NOAA (2010); U.S. AID (2009); CIG (2007); ADB (2005)

¹³¹¹ Gregg et al. (2011); Glick et al. (2009); NOAA (2010); U.S. AID (2009); CIG (2007); ADB (2005)

¹³¹² NOAA. (2010)

¹³¹³ CIG. (2007)

¹³¹⁴ ADB. (2005, p. 95)

¹³¹⁵ *U.S. EPA. *Adaptation Planning for the National Estuary Program*. (2009, p. 2)

¹³¹⁶ *U.S. EPA. *Adaptation Planning for the National Estuary Program*. (2009, p. 3)

¹³¹⁷ *U.S. EPA. *Adaptation Planning for the National Estuary Program*. (2009, p. 4)

The crucial need is to select realistic actions to address known risks and identify the needs to implement those actions.¹³¹⁸ In the style of adaptive management, the plan should recognize the need to proceed without complete information and acknowledge the need to revisit and update the plan.¹³¹⁹

- ***Plan for communicating with stakeholders and decision-makers***, which may include new communication techniques and strategies to address unfamiliar concerns in addition to existing communications strategies.¹³²⁰
- ***Plan for monitoring and evaluating results***, that outlines the process that will be used to periodically monitor and evaluate (1) climate-driven changes in the estuary, and (2) the effectiveness of adaptation actions in lessening the negative impacts of those climate-driven changes.¹³²¹

- **The U.S. NOAA's Planning Guide for State Coastal Managers**

This document is structured to help guide managers through the planning process from establishing the planning team to implementing the plan.¹³²² The major components of developing a plan are:

- ***The planning process***, which involves scoping the level of effort and responsibility of those involved, assessing resource needs and availability, assembling the planning team and establishing responsibilities, and educating, engaging, and involving stakeholders.¹³²³
- ***The vulnerability assessment***, in which climate change phenomena, impacts, and consequences are identified, the sensitivity, exposure, and adaptive capacity of systems is assessed, scenarios are developed to simulate changes, and focus areas are identified.¹³²⁴
- ***Developing the adaptation strategy***, which includes setting goals, identifying actions, evaluating, selecting, and prioritizing actions, and writing the action plan.¹³²⁵
- ***Implementing and maintaining the plan***, which includes adopting and implementing the plan, integrating the plan into other state planning efforts and programs, tracking, evaluating, and communicating progress, and updating the plan.¹³²⁶

¹³¹⁸ *U.S. EPA. *Adaptation Planning for the National Estuary Program*. (2009, p. 4)

¹³¹⁹ *U.S. EPA. *Adaptation Planning for the National Estuary Program*. (2009, p. 4)

¹³²⁰ *U.S. EPA. *Adaptation Planning for the National Estuary Program*. (2009, p. 5)

¹³²¹ *U.S. EPA. *Adaptation Planning for the National Estuary Program*. (2009, p. 6)

¹³²² *NOAA. *Adapting to Climate Change: A Planning Guide for State Coastal Managers*. (2010, p. 4)

¹³²³ *NOAA. *Adapting to Climate Change: A Planning Guide for State Coastal Managers*. (2010, p. 16-25)

¹³²⁴ *NOAA. *Adapting to Climate Change: A Planning Guide for State Coastal Managers*. (2010, p. 26-44)

¹³²⁵ *NOAA. *Adapting to Climate Change: A Planning Guide for State Coastal Managers*. (2010, p. 45-101)

¹³²⁶ *NOAA. *Adapting to Climate Change: A Planning Guide for State Coastal Managers*. (2010, p. 102-106)

2. COMMON TENETS OF ADAPTATION ACTION

No single element or component of adaptation is a solution on its own, and there is no universally best set of solutions.¹³²⁷ Successfully adapting to climate change relies on a mixture of approaches as well as perpetual review and modification as new information comes to light, new ideas are generated, and additional changes take place.¹³²⁸ Scientists are increasingly emphasizing the concepts of maintaining or improving ecosystem resistance and resilience,¹³²⁹ as well as enabling or facilitating the ability of a species or ecosystem to change,¹³³⁰ e.g. via response or realignment.¹³³¹ A review of the published and grey literature indicates the following are common tenets of adaptation action:

- Remove other threats and reduce non-climate stressors that interact negatively with climate change or its effects.¹³³²
- Establish or increase habitat buffer zones and corridors, including adjustments to protected area design and management such as expanding reserve networks.¹³³³
- Increase monitoring and facilitate management under uncertainty, including scenario-based planning and adaptive management (Box 18).¹³³⁴

Four additional tenets were also found in the literature, although they were not cited universally:

- Manage for ecological function and protection of biological diversity, including restoration of habitat and system dynamics.¹³³⁵
- Implement proactive management and restoration strategies, which may include translocations.¹³³⁶
- Reduce local and regional climate change, e.g. via restoration, planting vegetation.¹³³⁷
- Reduce greenhouse gas emissions.¹³³⁸

¹³²⁷ *Gregg et al. (2011, p. 30)

¹³²⁸ *Gregg et al. (2011, p. 30)

¹³²⁹ *Glick et al. (2009, p. 12)

¹³³⁰ *Glick et al. (2009, p. 13)

¹³³¹ *U.S. Fish and Wildlife Service. *Rising to the urgent challenge: strategic plan for responding to accelerating climate change (pdf)*. (2010, Sec1:16). The authors cite Millar et al. (2007) for information on realignment.

¹³³² Gregg et al. (2011); Lawler (2009); Glick et al. (2009)

¹³³³ Gregg et al. (2011); Lawler (2009); Glick et al. (2009)

¹³³⁴ Gregg et al. (2011); Lawler (2009); Glick et al. (2009)

¹³³⁵ Glick et al. (2009); Lawler (2009)

¹³³⁶ Glick et al. (2009); Lawler (2009)

¹³³⁷ *Gregg et al. (2011, p. 32)

¹³³⁸ *Gregg et al. (2011, p. 33)

Box 18. Managing uncertainty: Scenario-based planning and adaptive management.

Scenario-based planning: Scenario planning is a concept developed by Peterson, Cumming, & Carpenter (2003).¹³³⁹ It is a systematic method for thinking creatively about possible complex and uncertain futures.¹³⁴⁰ The central idea of scenario planning is to consider a variety of possible futures that include many of the important uncertainties in the system rather than to focus on the accurate prediction of a single outcome.¹³⁴¹ In this context, the scenarios are not predictions or forecasts but, rather, a set of *plausible* alternative future conditions.¹³⁴² Scenario planning is appropriate for systems in which there is a lot of uncertainty that is not controllable.¹³⁴³ This approach is used by the IPCC (see Box 2 for an explanation).

Adaptive management: Adaptive management is a systematic approach for improving resource management by learning from management outcomes.¹³⁴⁴ It puts management actions into an experimental framework, specifying what information is needed to evaluate management success and how and when it will be used to adjust management actions.¹³⁴⁵ In theory, adaptive management allows for the management of highly uncertain systems.¹³⁴⁶ It is useful not only when the future is uncertain, but when there is uncertainty about which management approach is best or how the system being managed functions even under today's conditions.¹³⁴⁷ It may be particularly useful in cases where immediate action is required to address short-term and/or potentially catastrophic long-term consequences or where management actions are likely to have no regrets near-term benefits.¹³⁴⁸ While it is a common complaint that current environmental rules and regulations lack the flexibility needed for true adaptive management, the U.S. Department of the Interior's technical guide to adaptive management provides both suggestions for and examples of effective adaptive management in the federal context.¹³⁴⁹

¹³³⁹ Glick et al. (2009, p. 18)

¹³⁴⁰ *Peterson, Cumming and Carpenter. *Scenario planning: a tool for conservation in an uncertain world*. (2003, p. 359)

¹³⁴¹ Peterson, Cumming and Carpenter. (2003, p. 359)

¹³⁴² Glick et al. (2009, p. 18)

¹³⁴³ *Peterson, Cumming and Carpenter. (2003, p. 365)

¹³⁴⁴ Williams et al. *Adaptive Management: The U.S. Department of the Interior Technical Guide*. (2009, p. 1). The authors cite Sexton et al. (1999) for this information.

¹³⁴⁵ *Gregg et al. (2011, p. 32)

¹³⁴⁶ Lawler. (2009, p. 85)

¹³⁴⁷ *Glick et al. *Restoring the Great Lakes' Coastal Future: Technical Guidance for the Design and Implementation of Climate-Smart Restoration Projects*. (2011a, p. 39)

¹³⁴⁸ *Glick et al. (2011a, p. 39). The authors cite Ojima and Corell (2009) and Climate Change Wildlife Action Plan Working Group (2008) for this information.

¹³⁴⁹ *Glick et al. *Scanning the Conservation Horizon: A Guide to Climate Change Vulnerability Assessment*. (2011b, Box 1.2, p. 15). The authors cite Williams et al. (2007) for the technical guide.

Box 19. Adaptation and Adaptive Management: Complementary but Distinct Concepts.

Adaptation and adaptive management are distinct concepts that are frequently confused with one another.¹³⁵⁰ As described earlier, adaptation refers to strategies designed to prepare for and cope with the effects of climate change.¹³⁵¹ In contrast, adaptive management is one particular approach to management in the face of uncertainty, and is not necessarily tied to climate change (see Box 18).¹³⁵²

Adaptation to climate change is characterized by making decisions in the face of uncertainty.¹³⁵³ Because of the uncertainties associated with predicting the effects of future climates on species and ecosystems, flexible management will almost certainly be a component of well-designed adaptation strategies.¹³⁵⁴ However, while the adaptive management framework is structured to enable managers to act in the face of uncertainty, other management approaches and philosophies are also designed to address different levels of uncertainty (e.g. scenario-based planning).¹³⁵⁵

To summarize, adaptive management can be an important component of adaptation efforts, but not all adaptive management is climate change adaptation, nor is all climate change adaptation necessarily adaptive management.¹³⁵⁶

¹³⁵⁰ *Glick et al. (2011b, Box 1.2, p. 15)

¹³⁵¹ *Glick et al. (2011b, Box 1.2, p. 15)

¹³⁵² *Glick et al. (2011b, Box 1.2, p. 15)

¹³⁵³ *Glick et al. (2011b, Box 1.2, p. 15)

¹³⁵⁴ *Glick et al. (2011b, Box 1.2, p. 15)

¹³⁵⁵ *Glick et al. (2011b, Box 1.2, p. 15)

¹³⁵⁶ *Glick et al. (2011b, Box 1.2, p. 15)

3. CLIMATE ADAPTATION ACTIONS – INFORMATION GATHERING AND CAPACITY BUILDING

Building capacity in organizations, managers, practitioners, decision-makers, and the public can increase the ability to plan, develop, and implement adaptation strategies.¹³⁵⁷ There are multiple factors that can affect capacity to engage in adaptation, including generic factors such as economic resources and more specific factors such as quality and quantity of information, and training and technological resources.¹³⁵⁸ The sections below describe components of information gathering and capacity building.

Conduct/gather additional research, data, and products

Gathering research, data, and products on actual and projected climate change impacts is critical to supporting adaptation action.¹³⁵⁹ Models and research products have predicted a range of plausible scenarios; as these tools are refined, many indicate that the extent and magnitude of climate impacts may be greater than previously thought.¹³⁶⁰ Incorporating the best available science, traditional ecological knowledge, and citizen science efforts may improve climate adaptation decisions.¹³⁶¹ For example, the general maintenance and restoration of wetlands in a changing climate may benefit from:

- **Mapping intact coastal wetland systems in the region** using field surveys, together with remote sensing imagery (where available) to distinguish salt-tolerant species from freshwater species.¹³⁶²
- **Analyzing the vulnerability of the wetland to storms and sea level rise** to establish priorities for protection and restoration.¹³⁶³ Post-storm evaluation of wetlands and adjacent land impacts provides valuable information on the resilience of wetlands and their storm buffer capacities.¹³⁶⁴
- **Determining freshwater flow requirements** and potential climate change impacts on freshwater flows to support the maintenance of brackish water wetlands.¹³⁶⁵

Create/enhance technological resources

Technological resources can make adaptation action easier and more accessible.¹³⁶⁶ These resources include the tools that can support information exchange, modeling of vulnerability and risk, and decision-making.¹³⁶⁷ These resources can help planners, managers, scientists, and policy makers to identify priority species and areas for conservation, generate inundation and hazard maps, and ascertain organizations and communities that have successfully implemented adaptation strategies.¹³⁶⁸

¹³⁵⁷ *Gregg et al. (2011, p. 46)

¹³⁵⁸ *Gregg et al. (2011, p. 46)

¹³⁵⁹ *Gregg et al. (2011, p. 53)

¹³⁶⁰ *Gregg et al. (2011, p. 53)

¹³⁶¹ *Gregg et al. (2011, p. 53)

¹³⁶² *U.S. AID (2009, p. 76)

¹³⁶³ *U.S. AID (2009, p. 76)

¹³⁶⁴ *U.S. AID (2009, p. 76)

¹³⁶⁵ *U.S. AID (2009, p. 76)

¹³⁶⁶ *Gregg et al. (2011, p. 70)

¹³⁶⁷ *Gregg et al. (2011, p. 70)

¹³⁶⁸ *Gregg et al. (2011, p. 70)

Conduct vulnerability assessments and studies

Vulnerability assessments help practitioners evaluate potential effects of climatic changes on ecosystems, species, human communities, and other areas of concern.¹³⁶⁹ Vulnerability assessments and studies can identify impacts of concern, a range of scenarios that depend on the frequency and magnitude of changes, who and what is at risk from these impacts, and what can be done to reduce vulnerability and increase resilience.¹³⁷⁰ Specifically, climate change vulnerability assessments provide two essential components to adaptation planning:

- Identifying *which* species or ecosystems are likely to be most strongly affected by projected changes; and
- Understanding *why* these resources are likely to be vulnerable, including the interaction between climate shifts and existing stressors.¹³⁷¹

Determining *which* resources are most vulnerable enables managers to better set priorities for conservation action, while understanding *why* they are vulnerable provides a basis for developing appropriate management and conservation responses.¹³⁷² In other words, they can provide a factual underpinning for differentiating between species and systems likely to decline and likely to thrive, but do not in themselves dictate adaptation strategies and management responses.¹³⁷³

Vulnerability is a function of exposure and sensitivity to change as well as adaptive capacity, which can all vary greatly depending on geography, genetic or species diversity, resources, and other factors.¹³⁷⁴ Vulnerability assessments are, therefore, structured around assessments of these distinct components.¹³⁷⁵ The key steps and associated actions for assessing vulnerability to climate change are listed in Table 22.

The EPA's Climate Ready Estuaries program compiled best practices and lessons learned for vulnerability assessment efforts including:

- Recognize that non-climate drivers, such as development, pollution, and population growth, often exacerbate climate change vulnerabilities.¹³⁷⁶
- When working with limited data, use readily available scientific best professional judgment to help support decision-making.¹³⁷⁷ Surveying both local and regional experts and stakeholders can assist in building knowledge, as they have access to some of the most up-to-date information and research.¹³⁷⁸
- Focus on emergency and disaster management, which is one area National Estuary Programs can work with local and state governments to incorporate climate change issues.¹³⁷⁹ *For further information on emergency and disaster management, please see "Invest in/enhance emergency*

¹³⁶⁹ *Gregg et al. (2011, p. 54)

¹³⁷⁰ *Gregg et al. (2011, p. 54)

¹³⁷¹ *Glick et al. (2011b, p. 1)

¹³⁷² *Glick et al. (2011b, p. 1)

¹³⁷³ *Glick et al. (2011b, p. 3)

¹³⁷⁴ *Gregg et al. (2011, p. 54)

¹³⁷⁵ *Glick et al. (2011b, p. 2)

¹³⁷⁶ *U.S. EPA. *Lessons Learned from the Climate Ready Estuaries Program*. (2011, p. 2)

¹³⁷⁷ *U.S. EPA. (2011, p. 2)

¹³⁷⁸ *U.S. EPA. (2011, p. 2)

¹³⁷⁹ *U.S. EPA. (2011, p. 2)

services planning and training” in this Section and “Develop a disaster preparedness plan” in Section 6 of this Chapter.

- Collaborate with and use local partners, such as universities, non-profits, Sea Grants, and National Estuarine Research Reserves to fill information gaps.¹³⁸⁰
- Determine scope – vulnerability assessments do not necessarily have to be broad in scope.¹³⁸¹ Focusing on the vulnerability of a specific resource may generate momentum for adaptation.¹³⁸² This lesson is echoed by Glick et al.’s “landscaped-based” and “project-based” approach to climate-smart conservation, described previously (see Section 1 in this Chapter).¹³⁸³

Table 22. Key Steps for Assessing Vulnerability to Climate Change	
<i>Key Steps</i>	<i>Associated Actions</i>
Determine objectives and scope	<ul style="list-style-type: none"> • Identify audience, user requirements, and needed products • Engage key internal and external stakeholders • Establish and agree on goals and objectives • Identify suitable assessment targets • Determine appropriate spatial and temporal scales • Select assessment approach based on targets, user needs, and available resources
Gather relevant data and expertise	<ul style="list-style-type: none"> • Review existing literature on assessment targets and climate impacts • Reach out to subject experts on target species or systems • Obtain or develop climatic projections, focusing on ecologically relevant variables and suitable spatial and temporal scales • Obtain or develop ecological response projections
Assess components of vulnerability	<ul style="list-style-type: none"> • Evaluate climate sensitivity of assessment targets • Determine likely exposure of targets to climatic/ecological change • Consider adaptive capacity of targets that can moderate potential impact • Estimate overall vulnerability of targets • Document level of confidence or uncertainty in assessments
Apply assessment in adaptation planning	<ul style="list-style-type: none"> • Explore why specific targets are vulnerable to inform possible adaptation responses • Consider how targets might fare under various management and climatic scenarios • Share assessment results with stakeholders and decision-makers • Use results to advance development of adaptation strategies and plans
<i>Source: Adapted from Glick et al. (2011b, Box 2.1, p. 19) by authors of this report.</i>	

Conduct scenario planning exercises

Scenario planning involves the creation of a series of scenarios specifically for the planning process in question, as well as narratives to accompany those scenarios.¹³⁸⁴ It also involves the use of those scenarios for evaluating policy/management options.¹³⁸⁵ Scenario planning allows participants to identify actions

¹³⁸⁰ *U.S. EPA. (2011, p. 2)

¹³⁸¹ *U.S. EPA. (2011, p. 2)

¹³⁸² *U.S. EPA. (2011, p. 2)

¹³⁸³ Glick et al. (2011a, p. 7)

¹³⁸⁴ *Gregg et al. (2011, p. 59)

¹³⁸⁵ *Gregg et al. (2011, p. 59)

that work well across multiple scenarios, to discover options for dealing with uncertainty, and can improve adaptive management.¹³⁸⁶

Increase organizational capacity

Sufficient organizational capacity is needed to support adaptation activities at all levels of government.¹³⁸⁷ This strategy includes improving the resources, tools, knowledge, and institutional support required to increase organizational capacity.¹³⁸⁸

Create/host adaptation training and planning workshops

While many researchers, conservation practitioners, and resource managers understand the reality of climate change, they are often still challenged by what actions to take.¹³⁸⁹ As a result, the conservation and resource management community needs assistance developing its thinking on dealing with climate change, finding the information or data it needs to make informed decisions, and finding people to interact with on this topic as individuals develop their own approaches.¹³⁹⁰ Training and planning workshops can provide context, guidance, and practical examples of how adaptation is being addressed on-the-ground.¹³⁹¹

Provide new job training for people whose livelihoods are threatened by climate change

This strategy directly addresses the potential economic consequences of global climate change.¹³⁹² Increased water temperatures and ocean acidification will severely impact fisheries, aquaculture, and ecotourism and recreation based on natural resources.¹³⁹³

Create new institutions (training staff, establishing committees)

Creating committees and advisory bodies and having properly trained staff can institutionalize climate change considerations within an organization.¹³⁹⁴ Technical experts, scientists, and other staff can contribute important knowledge and recommendations to support governmental decision-making on climate adaptation.¹³⁹⁵

Coordinate planning and management across institutional boundaries

Many climate change impacts will affect multiple jurisdictions at once whether the effects are felt at local, regional, national, or international scales.¹³⁹⁶ Because climatic variability is not confined by political or social boundaries, cross-jurisdictional coordination of planning and management can improve adaptation

¹³⁸⁶ *Gregg et al. (2011, p. 59). The authors cite Peterson (2003) for this information.

¹³⁸⁷ *Gregg et al. (2011, p. 48)

¹³⁸⁸ *Gregg et al. (2011, p. 48)

¹³⁸⁹ *Gregg et al. (2011, p. 56)

¹³⁹⁰ *Gregg et al. (2011, p. 56)

¹³⁹¹ *Gregg et al. (2011, p. 56)

¹³⁹² *Gregg et al. (2011, p. 55)

¹³⁹³ *Gregg et al. (2011, p. 55)

¹³⁹⁴ *Gregg et al. (2011, p. 46)

¹³⁹⁵ *Gregg et al. (2011, p. 46)

¹³⁹⁶ *Gregg et al. (2011, p. 49)

efforts.¹³⁹⁷ Increased cooperation may include information sharing, improved communication, and establishing formal partnerships to share resources, funds, and knowledge.¹³⁹⁸

Invest in/enhance emergency services planning and training

Climate change is expected to increase risks to public health and safety throughout North America.¹³⁹⁹ Flooding, erosion, and sea level rise will affect low-lying coastal communities by short- and long-term displacement of people and communities, salinization of potable water, and infrastructure damage.¹⁴⁰⁰ Warmer temperatures and changes in precipitation patterns will likely increase incidences of wildfires and drought, pests and diseases, and intense heat waves.¹⁴⁰¹ Integrating climate change concerns into emergency services planning and training, including police, fire and rescue, and emergency medical services, will be important to limit public health and safety risks.¹⁴⁰²

Create stakeholder engagement processes

As mentioned previously, gaining public buy-in for adaptation can be critical to ensuring the effectiveness of any strategy.¹⁴⁰³ Engaging stakeholders can occur in a variety of ways; for example, participating in meetings and workshops, one-on-one interactions, and websites, among others.¹⁴⁰⁴ Activities like interactive, participatory discussions, problem solving sessions, and role-playing exercises have been used to engage stakeholders in climate adaptation.¹⁴⁰⁵ The EPA's Climate Ready Estuaries program compiled best practices and lessons learned for stakeholder engagement efforts including:

- Leverage existing efforts.¹⁴⁰⁶
- Focus on local issues.¹⁴⁰⁷ Presenting local evidence of climate change (e.g., changes in seasonal events or animal behavior, local projections of wetland loss) to local officials and the general public is often a useful approach to build support for adaptation.¹⁴⁰⁸
- Link climate change adaptation messages to clean water supply and stormwater drainage.¹⁴⁰⁹ This can be an effective way to engage local decision-makers, as constituents are increasingly concerned about these issues.¹⁴¹⁰
- Target entities most responsible for construction and maintenance of public infrastructure (e.g., municipalities, counties or regional authorities) first to encourage greater willingness to engage

¹³⁹⁷ *Gregg et al. (2011, p. 49)

¹³⁹⁸ *Gregg et al. (2011, p. 49)

¹³⁹⁹ *Gregg et al. (2011, p. 50)

¹⁴⁰⁰ *Gregg et al. (2011, p. 50)

¹⁴⁰¹ *Gregg et al. (2011, p. 50)

¹⁴⁰² *Gregg et al. (2011, p. 50)

¹⁴⁰³ *Gregg et al. (2011, p. 57)

¹⁴⁰⁴ *Gregg et al. (2011, p. 57)

¹⁴⁰⁵ *Gregg et al. (2011, p. 57)

¹⁴⁰⁶ *U.S. EPA. (2011, p. 3)

¹⁴⁰⁷ *U.S. EPA. (2011, p. 3)

¹⁴⁰⁸ *U.S. EPA. (2011, p. 3)

¹⁴⁰⁹ *U.S. EPA. (2011, p. 3)

¹⁴¹⁰ *U.S. EPA. (2011, p. 3)

on the impacts of sea level rise due to the significant fiscal implication of infrastructure loss or damage.¹⁴¹¹

- Conduct meetings or phone calls with key stakeholders to help identify what stakeholders are already working on and their key needs for undertaking climate change adaptation.¹⁴¹²

Increase/improve public awareness, education, and outreach efforts

This strategy relates to improving the links between science, management, decision-making, and public awareness.¹⁴¹³ These efforts may be in the form of presentations and workshops, print and internet media, steering and advisory committees, and traditional educational venues.¹⁴¹⁴ More interactive approaches tend to be better at ensuring a two-way flow of information, recognizing that scientists must learn from managers, policy makers, and the public as well as vice-versa.¹⁴¹⁵ Enabling managers and decision-makers to incorporate climate adaptation into practice requires that the appropriate science be available in useable forms when needed.¹⁴¹⁶ The broader public also needs to be engaged in climate adaptation and be made aware of the potential ways that climate change may affect the economy, natural resources, livelihoods, health, and well-being.¹⁴¹⁷ Gaining public buy-in may increase political and social capital to support climate adaptation action at local, regional, national, and international levels.¹⁴¹⁸

¹⁴¹¹ *U.S. EPA. (2011, p. 3)

¹⁴¹² *U.S. EPA. (2011, p. 3)

¹⁴¹³ *Gregg et al. (2011, p. 51)

¹⁴¹⁴ *Gregg et al. (2011, p. 51)

¹⁴¹⁵ *Gregg et al. (2011, p. 51)

¹⁴¹⁶ *Gregg et al. (2011, p. 51)

¹⁴¹⁷ *Gregg et al. (2011, p. 51-52)

¹⁴¹⁸ *Gregg et al. (2011, p. 52)

4. CLIMATE ADAPTATION ACTIONS – MONITORING AND PLANNING

The sections below describe components of monitoring and planning.

Develop climate change indicators

The U.S. EPA’s Climate Ready Estuaries Program notes that the development of climate change indicators for estuaries is still an evolving field, but there have already been a number of lessons learned from the Climate Ready Estuaries partners.¹⁴¹⁹ They include:

- Identify desired climate change information outputs prior to the beginning of the indicator selection process.¹⁴²⁰
- Consider conducting a climate change vulnerability assessment prior to developing climate change indicators.¹⁴²¹ A vulnerability assessment may be useful in order to ensure that the candidate list of indicators is comprehensive and to identify variables that are indicative of consequences rather than drivers.¹⁴²² *For further information on conducting vulnerability assessments, please see “Conduct vulnerability assessments and studies” in Section 3 of this Chapter.*
- Explore the development of conceptual ecological models of climate change prior to developing indicators.¹⁴²³ These models are organized in a hierarchical way among drivers, stressors, ecological effects, key attributes, and measures.¹⁴²⁴ The measures point the way to key indicators of climate change.¹⁴²⁵
- Draw up a universe of candidate indicators from which to consider.¹⁴²⁶ Identify any factors that are uncertain (such as the direct tie to climate change or available monitoring), as these factors will be important to consider later.¹⁴²⁷
- Obtain as much public and scientific input as possible on selecting a subset of indicators for more intense review.¹⁴²⁸ *For further information on stakeholder engagement, please see “Create stakeholder engagement processes” in Section 3 of this Chapter.*
- Recognize that regional efforts that cross state lines often require additional involvement from government agencies and other key stakeholders.¹⁴²⁹ The involvement of key local, state, and regional organizations will be important to discuss during the initial stages of any indicator development process.¹⁴³⁰

¹⁴¹⁹ *U.S. EPA. (2011, p. 3)

¹⁴²⁰ *U.S. EPA. (2011, p. 3)

¹⁴²¹ *U.S. EPA. (2011, p. 3)

¹⁴²² *U.S. EPA. (2011, p. 3)

¹⁴²³ *U.S. EPA. (2011, p. 3)

¹⁴²⁴ *U.S. EPA. (2011, p. 3)

¹⁴²⁵ *U.S. EPA. (2011, p. 3)

¹⁴²⁶ *U.S. EPA. (2011, p. 3)

¹⁴²⁷ *U.S. EPA. (2011, p. 3)

¹⁴²⁸ *U.S. EPA. (2011, p. 3)

¹⁴²⁹ *U.S. EPA. (2011, p. 3)

¹⁴³⁰ *U.S. EPA. (2011, p. 3)

Evaluate existing monitoring programs for wildlife and key ecosystem components

Monitoring systems provide information that managers can use to adjust or modify their activities through the process of adaptive management.¹⁴³¹ This approach would evaluate the current state of the systems that collect, analyze, and interpret environmental information.¹⁴³² It would determine how programs will need to be modified to provide management-relevant information on the effects of climate change and what new monitoring systems will need to be established in order to address gaps in knowledge of climate effects.¹⁴³³ The costs to adapt existing monitoring systems and develop new monitoring systems are likely to be high.¹⁴³⁴ In many cases this will probably require new legislation and regulations, and possibly new tools and approaches to monitoring.¹⁴³⁵ It will also require better integration and coordination across existing monitoring programs.¹⁴³⁶

Incorporate predicted climate change impacts into species and land management

Information about actual and potential climate change impacts can be of benefit to land and natural resource managers in making decisions and taking actions.¹⁴³⁷ Climate change is not addressed in many existing natural resource plan documents.¹⁴³⁸ This strategy would use existing natural resource planning mechanisms to inform decision-making on a broad spectrum of natural resource management topics.¹⁴³⁹ Many existing natural resource plans already contain provisions for updates and revisions, which could provide a mechanism for incorporating information about climate change effects and adaptation strategies.¹⁴⁴⁰ The problems with this approach are mainly practical at present: there is a definite cost associated with revisiting and revising management plans; in practice, many resource management plans are updated infrequently.¹⁴⁴¹ Also, detailed predictions of potential climate change effects are currently only available for a small subset of species and areas,¹⁴⁴² as shown by the Information Gaps identified throughout this report.

¹⁴³¹ *Heinz Center (2008, p. 29). The authors cite Walters (1986), Margoluis and Salafsky (1998), and Williams, Szaro, and Shapiro (2007) for this information.

¹⁴³² *Heinz Center (2008, p. 29). The authors cite Walters (1986), Margoluis and Salafsky (1998), and Williams, Szaro, and Shapiro (2007) for this information.

¹⁴³³ *Heinz Center (2008, p. 29)

¹⁴³⁴ *Heinz Center (2008, p. 30)

¹⁴³⁵ *Heinz Center (2008, p. 30)

¹⁴³⁶ *Heinz Center (2008, p. 30). The authors cite The Heinz Center (2006) for this information.

¹⁴³⁷ *Heinz Center (2008, p. 30)

¹⁴³⁸ *Heinz Center (2008, p. 30). The authors cite Hannah, Midgley and Millar (2002) for information on existing natural resource plan documents, and Mawdsley (unpublished data) for information on endangered species recovery plans and State Wildlife Action Plans.

¹⁴³⁹ *Heinz Center (2008, p. 30)

¹⁴⁴⁰ *Heinz Center (2008, p. 30)

¹⁴⁴¹ *Heinz Center (2008, p. 30-31)

¹⁴⁴² *Heinz Center (2008, p. 31). The authors cite The Heinz Center (2007) for this information.

Develop dynamic landscape conservation plans

Dynamic landscape conservation plans include information on fixed and dynamic spatial elements, along with management guidelines for target species, genetic resources, and ecosystems within the planning areas.¹⁴⁴³ Fixed spatial elements include protected areas where the land use is fully natural.¹⁴⁴⁴ Dynamic spatial elements include all other areas within the landscape matrix, where land use may change over time.¹⁴⁴⁵ The plan includes a desired future condition for each element, based on predicted shifts in distribution of species and other ecosystem components, as well as any intermediate steps that may be necessary to transition between current and future condition.¹⁴⁴⁶ The management guidelines suggest mechanisms and tools for management (such as land acquisition, riparian plantings, or other wildlife-friendly farming practices) and specific government agencies responsible for implementation.¹⁴⁴⁷ The actual planning activities required to develop these plans are likely to be compatible with other local or regional-scale planning projects such as State Wildlife Action Plans or watershed management plans.¹⁴⁴⁸ However, planning efforts can be resource-intensive.¹⁴⁴⁹ Recommendations such as suggesting that certain spatial elements (i.e., areas of land or water) will need to be converted from human uses to “natural” management are likely to prove controversial.¹⁴⁵⁰

Changes to land use planning and zoning

This may include restricting or prohibiting development in erosion zones, redefining riverine flood hazard zones, or increasing shoreline setbacks.¹⁴⁵¹ Restricting development in erosion zones allows for more land available to protect estuaries, but will not help areas already developed.¹⁴⁵² It may be difficult to attain agreement among all parties.¹⁴⁵³

Case Study 1. Ecosystem-Based Management and Climate Change Adaptation in Humboldt Bay, CA.

Climate stressors addressed: Ocean acidification. Increased sea surface temperature. Altered hydrology and ocean currents. Increased frequency and severity of storms. Sea level rise. Coastal erosion, upwelling, hypoxia and anoxia.

In the NPLCC region, the San Juan Initiative (WA), Port Orford Ocean Resource Team (OR), and Humboldt Bay Initiative (CA) represent three of six community-based initiatives comprising the West Coast EBM network, which is a partnership focused on the successful implementation of EBM along the coasts of Washington, Oregon, and California. The Humboldt Bay Initiative (HBI) is currently planning a coordinated response to climate change for the Humboldt Bay ecosystem. In early 2010, HBI organized a meeting of local, state and federal agencies, along with public stakeholders, to identify and inventory all climate change activities underway in Humboldt Bay in order to leverage common approaches, address gaps, and avoid redundancy in research and management efforts.

Source: West Coast EBM Network (2010)

¹⁴⁴³ *Heinz Center (2008, p. 31). The authors cite Hannah and Hansen (2005) for this information.

¹⁴⁴⁴ *Heinz Center (2008, p. 31).

¹⁴⁴⁵ *Heinz Center (2008, p. 31).

¹⁴⁴⁶ *Heinz Center (2008, p. 31).

¹⁴⁴⁷ *Heinz Center (2008, p. 31).

¹⁴⁴⁸ *Heinz Center (2008, p. 31).

¹⁴⁴⁹ *Heinz Center (2008, p. 31).

¹⁴⁵⁰ *Heinz Center (2008, p. 31).

¹⁴⁵¹ *U.S. EPA. *Synthesis of Adaptation Options for Coastal Areas*. (2009, p. 14)

¹⁴⁵² *U.S. EPA. (2009, p. 14)

¹⁴⁵³ *U.S. EPA. (2009, p. 14)

Redefining riverine flood hazard zones to match projected expansion of flooding frequency and extent protects riverine systems and zones, but may impact flood insurance or require changing zoning ordinances, which can be difficult.¹⁴⁵⁴

Create a regional sediment management (RSM) plan

There is not a simple relationship between sea level rise and horizontal movement of the shoreline, and sediment budget approaches are most useful to assess beach response to climate change.¹⁴⁵⁵ A RSM considers the entire watershed, including upstream reaches, but requires more coordination across regions, including private lands.¹⁴⁵⁶ Any regional sediment management effort should include an emphasis on the beneficial use of dredged material.¹⁴⁵⁷ A sediment management program that recognizes sediment as a valuable resource and links needs with appropriate opportunities will be the most effective at reducing economic and environmental losses associated with climate change.¹⁴⁵⁸ Beneficial use of dredged material involves using sediment dredged from waterways for a productive purpose, such as beach nourishment, habitat restoration and development, public access facilities, and shore protection structures (e.g., levees and dikes), among other things.¹⁴⁵⁹

Integrate coastal management into land use planning

Integrating coastal management into land use planning allows conservation and management goals to be incorporated into land use planning, although it can be difficult to have local and state agencies agree or to address private property rights.¹⁴⁶⁰ Ecosystem-Based Management (EBM), Integrated Coastal Zone Management (ICZM), and Coastal and Marine Spatial Planning (C(MSP)) are common coastal management systems:

- **Ecosystem-Based Management (EBM)** is an integrated approach to management that considers the entire ecosystem, including humans.¹⁴⁶¹ The goal of ecosystem-based management is to maintain an ecosystem in a healthy, productive and resilient condition so that it can provide the services humans want and need.¹⁴⁶² Ecosystem-based management differs from current approaches that usually focus on a single species, sector, activity or concern; it considers the cumulative impacts of different sectors.¹⁴⁶³ Specifically, ecosystem-based management:
 - Emphasizes the protection of ecosystem structure, functioning, and key processes;
 - Is place-based in focusing on a specific ecosystem and the range of activities affecting it;

¹⁴⁵⁴ *U.S. EPA. (2009, p. 14)

¹⁴⁵⁵ *Nicholls et al. (2007, p. 324). The authors cite Cowell et al. (2006) for this information.

¹⁴⁵⁶ *U.S. EPA. (2009, p. 15)

¹⁴⁵⁷ *NOAA. (2010, p. 84)

¹⁴⁵⁸ *NOAA. (2010, p. 84)

¹⁴⁵⁹ *NOAA. (2010, p. 84)

¹⁴⁶⁰ *U.S. EPA. (2009, p. 10)

¹⁴⁶¹ *West Coast Ecosystem-Based Management Network. *Community-based management of coastal ecosystems: Highlights and lessons of success from the West Coast Ecosystem-Based Management Network (pdf; website)*. (2010, p. 2)

¹⁴⁶² *West Coast Ecosystem-Based Management Network. (2010, p. 2)

¹⁴⁶³ *West Coast Ecosystem-Based Management Network. (2010, p. 2)

- Explicitly accounts for the interconnectedness within systems, recognizing the importance of interactions between many target species or key services and other non-target species;
 - Acknowledges interconnectedness among systems, such as between air, land and sea; and
 - Integrates ecological, social, economic, and institutional perspectives, recognizing their strong interdependences.¹⁴⁶⁴
- **Integrated Coastal Zone Management, (ICZM)** is a mechanism for bringing together the multiplicity of users, stakeholders, and decision-makers in the coastal zone in order to secure more effective ecosystem management whilst achieving economic development and intra- and inter-generational equity through the application of sustainability principles.¹⁴⁶⁵ It considers all stakeholders in planning and balancing objectives, and can address all aspects of climate change.¹⁴⁶⁶ However, stakeholders willing to compromise and more effort in planning are needed.¹⁴⁶⁷ The ICZM approach is generally facilitated through existing terrestrial and marine territorial planning legislation and mechanisms, where these exist.¹⁴⁶⁸
 - **(Coastal and) Marine Spatial Planning, (C(MSP))** is a public process of analyzing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic, and social objectives that are usually specified through a political process.¹⁴⁶⁹ Partners and stakeholders in The Pacific North Coast Integrated Management Area (PNCIMA), located along the Central and North Coast of British Columbia, are incorporating CMSP into their integrated management approach.¹⁴⁷⁰ Characteristics of effective marine spatial planning include:
 - Ecosystem-based, balancing ecological, economic, and social goals and objectives toward sustainable development;
 - Integrated, across sectors and agencies, and among levels of government;
 - Place-based or area-based;
 - Adaptive, capable of learning from experience;
 - Strategic and anticipatory, focused on the long-term;
 - Participatory, stakeholders actively involved in the process.¹⁴⁷¹

Community planning

Local-level planning and involvement are key to achieving on-the-ground implementation of adaptation strategies.¹⁴⁷² Although international and national action are needed to address broad policies and reform, community planning and management have greater effects on local resources through land use planning

¹⁴⁶⁴ *West Coast Ecosystem-Based Management Network. (2010, p. 2). The authors cite McLeod et al. (2005) for this information.

¹⁴⁶⁵ *Ramsar Convention Secretariat. *Coastal management: Wetland issues in Integrated Coastal Zone Management (pdf; website)*. (2007, p. 23)

¹⁴⁶⁶ *U.S. EPA. (2009, p. 11)

¹⁴⁶⁷ *U.S. EPA. (2009, p. 11)

¹⁴⁶⁸ *Ramsar Convention Secretariat. (2007, p. 23)

¹⁴⁶⁹ *Ehler and Douvère. (2009, p. 18)

¹⁴⁷⁰ Personal interviews, April and May 2011.

¹⁴⁷¹ *Ehler and Douvère. (2009, Box 4, p. 18)

¹⁴⁷² *Gregg et al. (2011, p. 62)

and zoning.¹⁴⁷³ Building local capacity is especially important for dealing with disaster risk management and gaining stakeholder support for action.¹⁴⁷⁴

Ensure that wildlife and biodiversity needs are considered as part of the broader societal adaptation process

Modern wildlife professionals and natural resource managers are aware that management activities take place within a broader societal context, and that the broader society must be supportive in order for management to succeed.¹⁴⁷⁵ Managers can take proactive steps to engage local and regional government entities in adaptation planning, thereby ensuring that the needs of wildlife and natural resources are included at the start of these discussions.¹⁴⁷⁶

Case Study 2. Planning for Sea level Rise in Olympia, WA.

Climate stressors addressed: Sea level rise

Lower downtown Olympia sits on reclaimed land created with hydraulic fill that abuts Budd Inlet, a tidally-influenced southern arm of Puget Sound. On average, downtown Olympia is 18 to 20 ft above sea level but, Budd Inlet can have tides that reach a maximum height of 18 ft. To assess the impacts sea level rise could have on downtown Olympia, the city invested in high resolution Light Detection and Ranging (LiDAR) elevation data and used the LiDAR maps to run flooding simulations during high tides and storms at 0.5 ft incremental increases in sea level relative to its current level. The City also invested in geological monitoring equipment to monitor land subsidence or uplifting and plans to install local tide gauges. The City is considering both short- and long-term adaptation strategies to enhance their resilience to sea level rise. Short-term strategies include: consolidate the number of stormwater outfalls by half to ease future management; finer scale SLR simulations; enact a new SEPA requirement to raise floor elevations that house critical resources in all new buildings; and, continue monitoring changes in land elevation. Long-term strategies include: update City comprehensive plans to address climate change impacts, including SLR; support state and federal officials in developing guidelines/regulations to assist the adaptation of local communities; and, create an institutional framework to work on climate change problems.

Source: Climate Action Knowledge Exchange, <http://www.cakex.org/case-studies/683> (accessed 12.14.2010)

¹⁴⁷³ *Gregg et al. (2011, p. 62)

¹⁴⁷⁴ *Gregg et al. (2011, p. 62)

¹⁴⁷⁵ *Heinz Center (2008, p. 32)

¹⁴⁷⁶ *Heinz Center (2008, p. 32)

5. CLIMATE ADAPTATION ACTIONS – INFRASTRUCTURE AND DEVELOPMENT

This section addresses threats to the coastal built environment and other infrastructure from sea level rise, storms, changes in precipitation, and increased flooding.¹⁴⁷⁷

Make infrastructure resistant or resilient to climate change

This strategy involves the consideration of climate change in both the planning of new or retrofitting of existing infrastructure, including stormwater systems, transportation, water supply, or buildings.¹⁴⁷⁸

Examples include:

- **Design new coastal drainage system:** While many systems need to be restructured, planning and construction can be very costly and time-consuming.¹⁴⁷⁹
- **Incorporate climate change impacts, including sea level rise into planning for new infrastructure:** Engineering could be modified to account for changes in precipitation or seasonal timing of flows and siting decisions could take into account sea level rise.¹⁴⁸⁰ The long-term functional integrity of structures (e.g. sewage systems) is preserved and contamination of the water supply is prevented.¹⁴⁸¹ However, measures can be costly¹⁴⁸² and land owners will likely resist relocating away from prime coastal locations.¹⁴⁸³
- **Protect water supply systems from saltwater contamination:** Sea level rise and flooding will cause saltwater intrusion, increasing the salinity of surface and ground water.¹⁴⁸⁴ Increased salinity can also harm intolerant plant and animal species.¹⁴⁸⁵ Water management responses are needed to deal with saltwater intrusion and salinization of water supplies; these responses may include regulation of water quality and supply, monitoring to track saltwater intrusion, and water treatments such as desalination.¹⁴⁸⁶
- **Incorporate wetland protection into infrastructure planning:** The incorporation of wetland protection in transportation planning, sewer utilities, and other infrastructure planning helps protect infrastructure.¹⁴⁸⁷ It may also help maintain water quality and preserve habitat for vulnerable species.¹⁴⁸⁸
- **Develop adaptive stormwater management practices:** Adaptive stormwater practices such as removing impervious surface and replacing undersized culverts minimize pollutant and nutrient overloading of existing wetlands.¹⁴⁸⁹ Further, promoting natural buffers and adequately sizing

¹⁴⁷⁷ *Gregg et al. (2011, p. 61)

¹⁴⁷⁸ *Gregg et al. (2011, p. 61)

¹⁴⁷⁹ *U.S. EPA. (2009, p. 19)

¹⁴⁸⁰ *U.S. EPA. (2009, p. 11)

¹⁴⁸¹ *U.S. EPA. (2009, p. 20)

¹⁴⁸² *U.S. EPA. (2009, p. 20)

¹⁴⁸³ *U.S. EPA. (2009, p. 11)

¹⁴⁸⁴ *Gregg et al. (2011, p. 63)

¹⁴⁸⁵ *Gregg et al. (2011, p. 63)

¹⁴⁸⁶ *Gregg et al. (2011, p. 63)

¹⁴⁸⁷ *U.S. EPA. (2009, p. 13)

¹⁴⁸⁸ *U.S. EPA. (2009, p. 13)

¹⁴⁸⁹ *U.S. EPA. (2009, p. 20)

culverts preserves natural sediment flow and protects water quality of downstream reaches.¹⁴⁹⁰ However, they may require costly improvements.¹⁴⁹¹

- **Manage realignment and deliberately realign engineering structures:** Realignment of engineering structures affecting rivers, estuaries, and coastlines could reduce engineering costs, protect ecosystems and estuaries, and allow for natural migration of rivers.¹⁴⁹² However, it can be costly.¹⁴⁹³

Create or modify shoreline management measures

Planners and developers often use shoreline hardening to address erosion and sea level rise issues.¹⁴⁹⁴ Shoreline armoring structures, such as rip-rap, concrete, and bulkheads, can require the removal of native vegetation and soils, and can also impede natural processes and the movement of wildlife that utilize the shoreline as migration corridors.¹⁴⁹⁵ Alternatives include land or structure elevation (e.g., rebuilding or modifying infrastructure in high-risk coastal areas) and constructing “living shorelines” (e.g., planting vegetation to stabilize banks and reduce erosion).¹⁴⁹⁶ This strategy involves removing shoreline hardening structures, restoring coastal vegetation to minimize erosion, and encouraging low impact development along shorelines.¹⁴⁹⁷ Living shorelines are described next, while the remaining strategies are discussed in Section 7 of this Chapter: “*Climate adaptation actions – species and habitat conservation, restoration, protection and natural resource management.*”

Living shorelines

In low- to medium-energy coastal and estuarine environments and tidally influenced creeks, streams, and rivers, living shorelines can be effective alternatives to shore protection structures in efforts to restore, protect, and enhance the natural shoreline and its environment.¹⁴⁹⁸ Living shorelines use stabilization techniques that rely on vegetative plantings, other organic materials (e.g., biologs, matting), and sand fill or a hybrid approach combining vegetative planting with low rock sills or footers, living breakwaters (e.g., oysters), or other shore protection structures designed to keep sediment in place or reduce wave energy.¹⁴⁹⁹ There are a number of benefits to living shorelines.¹⁵⁰⁰ Specifically, they:

- Maintain natural shoreline dynamics and sand movement;
- Trap sand to rebuild eroded shorelines or maintain the current shoreline;
- Provide important shoreline habitat;
- Reduce wave energy and coastal erosion;
- Absorb storm surge and flood waters;

¹⁴⁹⁰ *U.S. EPA. (2009, p. 15)

¹⁴⁹¹ *U.S. EPA. (2009, p. 20)

¹⁴⁹² *U.S. EPA. (2009, p. 11)

¹⁴⁹³ *U.S. EPA. (2009, p. 11)

¹⁴⁹⁴ *Gregg et al. (2011, p. 64)

¹⁴⁹⁵ *Gregg et al. (2011, p. 64). The authors cite NRC (2002) for this information.

¹⁴⁹⁶ *Gregg et al. (2011, p. 64)

¹⁴⁹⁷ *Gregg et al. (2011, p. 65)

¹⁴⁹⁸ *NOAA. (2010, p. 80)

¹⁴⁹⁹ *NOAA. (2010, p. 80-81)

¹⁵⁰⁰ *NOAA. (2010, p. 81)

- Filter nutrients and pollutants from the water;
- Maintain beach and intertidal areas that offer public access;
- Are aesthetically pleasing;
- Allow for landward migration as sea levels rise;
- Absorb atmospheric carbon dioxide;
- Are less costly than shore protection structures¹⁵⁰¹

The techniques and materials used will depend on site-specific needs and characteristics.¹⁵⁰² Much of the site-specific information needed is similar to that for establishing coastal development setbacks, carrying out beach nourishment, and implementing other shoreline stabilization measures.¹⁵⁰³ Some design considerations and information needs include:

- Define the problem (episodic or chronic erosion) and scale of the shoreline region of concern.¹⁵⁰⁴ Analyze historical erosion rates, evaluate the condition of adjacent shorelines, and identify potential future problems related to sea level rise, storm frequency, and intensity.¹⁵⁰⁵
- Determine the (current and future) exposure of the shoreline from wind generated waves (referred to as fetch) as well as boat wakes, tidal ranges, and currents.¹⁵⁰⁶ This will help to verify that it is a low to medium energy environment.¹⁵⁰⁷
- Assess whether vegetation (upland, intertidal, subtidal) alone can address the problem, or if structural components (sand, stone) must be added in order to dampen wave energy and exposure to the shore.¹⁵⁰⁸
- Where feasible, employ an ecosystem approach—one that links subtidal, intertidal and upland protection and restoration initiatives.¹⁵⁰⁹ Consider the potential for landward transgression of vegetation with sea level rise.¹⁵¹⁰
- Some erosion-controlling vegetation have very slow growth rates.¹⁵¹¹ It may be necessary to take interim measures that involve the use of sand and stone or organic materials.¹⁵¹²

¹⁵⁰¹ *NOAA. (2010, p. 81)

¹⁵⁰² *NOAA. (2010, p. 81)

¹⁵⁰³ *U.S. AID. (2009, p. 103)

¹⁵⁰⁴ *U.S. AID. (2009, p. 103)

¹⁵⁰⁵ *U.S. AID. (2009, p. 103)

¹⁵⁰⁶ *U.S. AID. (2009, p. 103)

¹⁵⁰⁷ *U.S. AID. (2009, p. 103)

¹⁵⁰⁸ *U.S. AID. (2009, p. 103)

¹⁵⁰⁹ *U.S. AID. (2009, p. 103)

¹⁵¹⁰ *U.S. AID. (2009, p. 103)

¹⁵¹¹ *U.S. AID. (2009, p. 103)

¹⁵¹² *U.S. AID. (2009, p. 103)

6. CLIMATE ADAPTATION ACTIONS – GOVERNANCE, POLICY, AND LAW

Local, regional, and national governments play important roles in many climate change policies and provide support to resource managers, conservation practitioners, and communities.¹⁵¹³ Many projected climate impacts will have transboundary effects and require multilateral adaptation efforts.¹⁵¹⁴ The sections below describe components of governance, policy, and law.

*Note: Governance is not distinguished clearly from policy and law, as evidenced by the incorporation of policy and/or law into wide-ranging definitions of governance.*¹⁵¹⁵

Managed retreat of built infrastructure, relocation of people/communities

Some communities in low-lying coastal areas will be disproportionately affected by sea level rise and erosion.¹⁵¹⁶ These effects may require managed retreat of built infrastructure and/or relocation of people and communities.¹⁵¹⁷ This approach requires identification of high risk areas and cost-benefit analyses to determine if retreat and relocation are less costly options than installing, improving, and maintaining shoreline armoring structures.¹⁵¹⁸

Develop a disaster preparedness plan

Coastal hazards, such as erosion, landslides, and extreme weather events, can harm people and property; climate change is projected to exacerbate these effects in both frequency and magnitude.¹⁵¹⁹ Disaster preparedness plans can help coastal communities identify risks and vulnerabilities and develop options for response and recovery.¹⁵²⁰

Maintain adequate financial resources for adaptation

Economic barriers are frequently cited by groups as reasons for not taking adaptation action.¹⁵²¹ If adaptation activities focus on building climate change into existing efforts or frameworks (e.g., incorporating climate projections into bridge designs or harvest limits), ensuring adequate financing for adaptation means simply ensuring that project budgets reflect any needed additional funding (e.g. more materials needed for a higher bridge, or downscaled climate models).¹⁵²² Climate adaptation actions undertaken as a new and distinct set of activities (e.g., scenario planning exercises) will require new and distinct funding.¹⁵²³ Some adaptation actions require up-front financial investment but more than pay for themselves in reduced long-term expenditures, meaning that grants or loans may be appropriate sources

¹⁵¹³ *Gregg et al. (2011, p. 67)

¹⁵¹⁴ *Gregg et al. (2011, p. 67)

¹⁵¹⁵ United Nations Economic and Social Council. Committee of Experts on Public Administration (Fifth Session). *Definition of basic concepts and terminologies in governance and public administration (pdf, website)*. (2006).

¹⁵¹⁶ *Gregg et al. (2011, p. 67)

¹⁵¹⁷ *Gregg et al. (2011, p. 67)

¹⁵¹⁸ *Gregg et al. (2011, p. 67)

¹⁵¹⁹ *Gregg et al. (2011, p. 68)

¹⁵²⁰ *Gregg et al. (2011, p. 68)

¹⁵²¹ *Gregg et al. (2011, p. 69)

¹⁵²² *Gregg et al. (2011, p. 69)

¹⁵²³ *Gregg et al. (2011, p. 69)

of financing.¹⁵²⁴ Grants can also provide short-term funds for strategy development and testing, but over the longer term it is important to diversify, for instance by building support for governmental adaptation funding, forging new partnerships, or reworking organizational budgets.¹⁵²⁵ Establishing endowments (e.g., the \$90 million provincial endowment that established the Pacific Institute for Climate Solutions in British Columbia) can provide more stable funding than year-by-year funding.¹⁵²⁶ Increased and sustainable funding sources can help organizations and governments overcome financial constraints and adapt to changing environmental conditions.¹⁵²⁷

Develop/implement adaptive management plans

Because of the uncertainty about climate change, its effects, and appropriate management responses, adaptive management policies and plans can play an important role in climate change adaptation (although adaptive management is not inherently linked to climate adaptation).¹⁵²⁸ Adaptive management involves testing hypotheses about system function and management efficacy and adjusting behavior and actions based on experience and actual changes.¹⁵²⁹ These decisions can be either active or passive; active adaptive management involves experimenting with multiple options in order to determine the best strategy, while passive adaptive management requires selecting and implementing one option and monitoring to determine if changes are needed.¹⁵³⁰

Review existing laws, regulations, and policies

This strategy would initiate a review of all applicable laws, regulations, and other public policies related to wildlife management, natural resource management, and biodiversity conservation.¹⁵³¹ Many of these laws and regulations are decades old, and most were developed before climate change became a significant concern.¹⁵³² Actually addressing the deficiencies that are identified through these reviews may be difficult without significant political will to overcome institutional inertia.¹⁵³³ There will likely be significant concern expressed from all sides about any sweeping revisions to existing laws and regulations.¹⁵³⁴

Create new or enhance existing policy

Legislation, regulations, agreements, and enforcement policies at local, regional, national, and international levels can be created or enhanced to support climate adaptation action.¹⁵³⁵ New legislative tools or regulations may be necessary to address specific climate change impacts.¹⁵³⁶ For example, given

¹⁵²⁴ *Gregg et al. (2011, p. 69)

¹⁵²⁵ *Gregg et al. (2011, p. 69)

¹⁵²⁶ *Gregg et al. (2011, p. 69)

¹⁵²⁷ *Gregg et al. (2011, p. 69)

¹⁵²⁸ *Gregg et al. (2011, p. 71)

¹⁵²⁹ *Gregg et al. (2011, p. 71)

¹⁵³⁰ *Gregg et al. (2011, p. 71)

¹⁵³¹ *Heinz Center. (2008, p. 33)

¹⁵³² *Heinz Center. (2008, p. 33)

¹⁵³³ *Heinz Center. (2008, p. 33)

¹⁵³⁴ *Heinz Center. (2008, p. 33)

¹⁵³⁵ *Gregg et al. (2011, p. 72)

¹⁵³⁶ *Heinz Center. (2008, p. 34)

that existing wildlife and biodiversity legislation is often decades old, new legislative or regulatory approaches may very well be needed to address specific effects or challenges associated with climate change.¹⁵³⁷ There are also opportunities to use existing regulatory frameworks to support conservation and management efforts to decrease the vulnerability of natural and human systems,¹⁵³⁸ provided that the program managers are given the flexibility needed to directly address climate threats.¹⁵³⁹

Create permitting rules that constrain locations for landfills, hazardous waste dumps, mine tailings, and toxic chemical facilities

Zoning regulations may allow zoning to protect estuaries and coastal zones, but can be difficult to enact.¹⁵⁴⁰

Setbacks

A coastal development setback may be defined as a prescribed distance to a coastal feature, such as the line of permanent vegetation, within which all or certain types of development are prohibited.¹⁵⁴¹ Setbacks create a buffer between shoreline development and the sea that provides some protection against the destructive effects of erosion or land loss resulting from accelerated sea level rise or increased storm activity.¹⁵⁴² Setbacks are designed to minimize damage from erosion and increase public access to beaches.¹⁵⁴³ Often setbacks contain a buffer zone.¹⁵⁴⁴ They also help maintain natural shore dynamics and shorefront access—both of which are critical in changing shoreline conditions.¹⁵⁴⁵ One potential issue with the use of setbacks is that once the water level reaches the setback, there is, in essence, an implicit contract that landowners will be able to build seawalls to protect their homes.¹⁵⁴⁶ Setbacks require information that is similar in kind to living shorelines and non-structural shoreline protection:¹⁵⁴⁷

- Conduct an analysis of beach dynamics, shoreline ecology and historical erosion rates before establishing setbacks.¹⁵⁴⁸
- Set up basic beach profile monitoring transects to determine erosion rates—long term data sets will be more accurate to characterize shoreline dynamics.¹⁵⁴⁹
- When evaluating historical rates (from maps, beach profiles, traditional knowledge), determine if the rates of erosion have changed from one decade to the next.¹⁵⁵⁰ Also determine if changing trends are the result of climate change factors (changes in storm activity or sea level elevations)

¹⁵³⁷ *Heinz Center. (2008, p. 34)

¹⁵³⁸ *Gregg et al. (2011, p. 72)

¹⁵³⁹ *Heinz Center. (2008, p. 34)

¹⁵⁴⁰ *U.S. EPA. (2009, p. 10)

¹⁵⁴¹ *U.S. AID. (2009, p. 98). The authors cite UNESCO (1997) for this information.

¹⁵⁴² *U.S. AID. (2009, p. 98)

¹⁵⁴³ *U.S. AID. (2009, p. 98)

¹⁵⁴⁴ *U.S. AID. (2009, p. 98)

¹⁵⁴⁵ *U.S. AID. (2009, p. 98)

¹⁵⁴⁶ *Kling and Sanchirico. *An Adaptation Portfolio for the United States Coastal and Marine Environment*. (2009, p. 46). The authors cite Caldwell and Segall (2007) for this information.

¹⁵⁴⁷ *U.S. AID. (2009, p. 99)

¹⁵⁴⁸ *U.S. AID. (2009, p. 99)

¹⁵⁴⁹ *U.S. AID. (2009, p. 99)

¹⁵⁵⁰ *U.S. AID. (2009, p. 99)

or man-made causes (e.g. removal of wetlands, construction of shoreline erosion control structures or local land subsidence).¹⁵⁵¹

- Observe characteristics of the beach profile from seasonal changes and current climate variability (e.g. El Niño).¹⁵⁵² Consider the stability of landforms (barrier beaches, dunes, bluffs) and the potential changes that may result from accelerated sea level rise, increased storm activity and subsequent erosion.¹⁵⁵³

Rolling easements

Rolling easements are a more flexible approach than setbacks and are intended to induce property owners to yield to advancing shorelines or wetlands.¹⁵⁵⁴ They are a type of easement that prevent property owners from holding back the sea and moves or “rolls” with the rising seas.¹⁵⁵⁵ The advantages of a rolling easement are: (1) the lack of disturbance of sedimentation transport; (2) the potential for wetlands and other tidal habitat to migrate unimpeded; and (3) continued public access to the shore.¹⁵⁵⁶ A rolling easement can be implemented by statute, the permitting process, and eminent domain actions.¹⁵⁵⁷

¹⁵⁵¹ *U.S. AID. (2009, p. 99)

¹⁵⁵² *U.S. AID. (2009, p. 99)

¹⁵⁵³ *U.S. AID. (2009, p. 99)

¹⁵⁵⁴ *Kling and Sanchirico. (2009, p. 46)

¹⁵⁵⁵ *Kling and Sanchirico. (2009, p. 46)

¹⁵⁵⁶ *Kling and Sanchirico. (2009, p. 46). The authors cite Titus et al. (1991) for this information.

¹⁵⁵⁷ *Kling and Sanchirico. (2009, p. 46). The authors cite Titus (1998) and Caldwell and Segall (2007) for this information.

7. CLIMATE ADAPTATION ACTIONS – SPECIES AND HABITAT CONSERVATION, RESTORATION, PROTECTION AND NATURAL RESOURCE MANAGEMENT

Addressing adaptation in management and conservation is necessary to deal with the actual and potential effects of climate change on ecosystems and the functions and services they provide.¹⁵⁵⁸ Climate change may have negative *and* positive effects on wildlife and habitat.¹⁵⁵⁹ Climate change may also interfere with the ability of ecosystems to withstand change.¹⁵⁶⁰ Managers and conservation practitioners can decrease ecosystem vulnerability by directly addressing expected climate change effects in policies and plans or by reducing the stressors that can exacerbate climate impacts.¹⁵⁶¹ The sections below describe components of species and habitat conservation, restoration, protection, and natural resource management.

Maintain shorelines

Several options are available to help maintain shorelines in a changing climate:

- **Create dunes along backshore of beach:** In addition to serving as buffers against erosion and flooding, which they do by trapping windblown sand, storing excess beach sand, and protecting inland areas against wave runup and overwash, dunes also provide habitat for wildlife.¹⁵⁶² Dune restoration is relatively inexpensive and entails the use of dune grass and other types of native vegetation and sand fences to capture shifting and blowing sands and stabilize dunes.¹⁵⁶³ Dunes may be restored or created in conjunction with a beach nourishment project or may be managed as part of a separate effort.¹⁵⁶⁴ Since dunes and beaches are interdependent, dune management should be incorporated into a strategy that considers the broader coastal system.¹⁵⁶⁵ The use of vegetation and sand fences to build and stabilize dunes is not a quick fix, will only be effective under certain conditions, and may not be effective as a way of encouraging the growth of new dunes where dunes did not exist in the past.¹⁵⁶⁶
- **Install natural or artificial breakwaters:** Along energetic estuarine shorelines, oyster beds and other natural breakwaters, rock sills, artificial reefs, and other artificial breakwaters protect shorelines and marshes and inhibit erosion inshore of the reef.¹⁵⁶⁷ They also induce sediment deposition.¹⁵⁶⁸ Artificial reefs, for example, are constructed of a wide variety of man-made materials and placed underwater to restore, create, or enhance ecosystems, typically as a fisheries management tool.¹⁵⁶⁹ The use of artificial reefs is a complex issue that requires planning, long-

¹⁵⁵⁸ *Gregg et al. (2011, p. 35)

¹⁵⁵⁹ *Gregg et al. (2011, p. 35)

¹⁵⁶⁰ *Gregg et al. (2011, p. 35)

¹⁵⁶¹ *Gregg et al. (2011, p. 35)

¹⁵⁶² *NOAA. (2010, p. 82)

¹⁵⁶³ *NOAA. (2010, p. 82-83)

¹⁵⁶⁴ *NOAA. (2010, p. 82)

¹⁵⁶⁵ *NOAA. (2010, p. 82)

¹⁵⁶⁶ *NOAA. (2010, p. 83)

¹⁵⁶⁷ *U.S. EPA. (2009, p. 13)

¹⁵⁶⁸ *U.S. EPA. (2009, p. 13)

¹⁵⁶⁹ *NOAA. (2010, p. 91)

term monitoring, and evaluation to ensure the anticipated benefits are derived.¹⁵⁷⁰ There is still considerable debate on how artificial reefs impact the natural aquatic community into which they are introduced.¹⁵⁷¹ Further, artificial breakwaters may not be sustainable in the long-term, because breakwaters are not likely to provide reliable protection against erosion in major storms.¹⁵⁷² They may require encroachment bayward or riverward, usually beyond the property limit, complicating the process for obtaining permits for construction.¹⁵⁷³

- **Remove shoreline hardening structures:** Shoreline modifications, such as bulkheads or seawalls, tend to harm habitat through the conversion of tidelands to uplands.¹⁵⁷⁴ Modification also indirectly affects habitat by altering nearshore processes.¹⁵⁷⁵ Removing hard structures such as bulkheads, dikes, and other engineered structures allows for shoreline migration, but may be costly for, and destructive to, shoreline property.¹⁵⁷⁶
- **Plant submerged aquatic vegetation:** Submerged aquatic vegetation such as seagrass beds dampen wave energy, stabilize sediments, improve water quality, and provide food and shelter for marine organisms.¹⁵⁷⁷ When used in conjunction with other living shoreline components such as marsh grasses, a natural shoreline buffer is created that reduces coastal erosion and stabilizes sediments via root growth.¹⁵⁷⁸ However, seagrasses may diminish in winter months, when wave activity is often more severe because of storms.¹⁵⁷⁹ Light availability is essential.¹⁵⁸⁰
- **Create marsh:** Planting the appropriate species – typically grasses, sedges, or rushes – in the existing substrate provides a protective barrier, and maintains and often increases habitat.¹⁵⁸¹ For example, marsh grasses dissipate wave energy, filter upland runoff, and improve habitat for fish and wildlife.¹⁵⁸² Native grasses are planted in the water and at the mean high tide mark in the intertidal zone.¹⁵⁸³ Marsh grasses may be more successful if they are planted in the spring in areas where there is evidence of existing marsh, where there is less than three miles of open water, and where the prevailing winds will not cause destruction of the newly planted grasses.¹⁵⁸⁴ Conditions must be right for the marsh to survive (e.g. sunlight for grasses, calm water) and the marsh may be affected by seasonal changes.¹⁵⁸⁵

¹⁵⁷⁰ *NOAA. (2010, p. 91)

¹⁵⁷¹ *NOAA. (2010, p. 91)

¹⁵⁷² *U.S. EPA. (2009, p. 13)

¹⁵⁷³ *U.S. EPA. (2009, p. 13)

¹⁵⁷⁴ *U.S. EPA. *National Estuary Program Coastal Condition Report. Chapter 6: West Coast National Estuary Program Coastal Condition (Puget Sound Action Team)*. (2007, p. 332)

¹⁵⁷⁵ *U.S. EPA. (2007, p. 332)

¹⁵⁷⁶ *U.S. EPA. (2009, p. 12)

¹⁵⁷⁷ *NOAA. *Living Shoreline Planning and Implementation (website)*. (2011)

¹⁵⁷⁸ *NOAA. *Living Shoreline Planning and Implementation (website)*. (2011)

¹⁵⁷⁹ *U.S. EPA. (2009, p. 12)

¹⁵⁸⁰ *U.S. EPA. (2009, p. 12)

¹⁵⁸¹ *U.S. EPA. (2009, p. 13)

¹⁵⁸² *NOAA. *Living Shoreline Planning and Implementation (website)*. (2011)

¹⁵⁸³ *NOAA. *Living Shoreline Planning and Implementation (website)*. (2011)

¹⁵⁸⁴ *NOAA. *Living Shoreline Planning and Implementation (website)*. (2011)

¹⁵⁸⁵ *U.S. EPA. (2009, p. 13)

- **Land exchange and acquisition:** Land exchange and acquisition programs allow for coastal land to be freed up for preservation uses.¹⁵⁸⁶ For example, a land acquisition program could purchase coastal land that is damaged or prone to damage and use it for conservation.¹⁵⁸⁷ Benefits of land acquisition include providing a buffer to inland areas and preventing development on the land.¹⁵⁸⁸ Constraints include costs and the availability of land to purchase.¹⁵⁸⁹ A land exchange program, such as a conservation easement, typically transfers some development and management options – such as the right to subdivide or to cut trees – from the landowner to a nonprofit or governmental organization that holds those rights.¹⁵⁹⁰ The landowner reserves certain rights, such as the right to build additional homes or add roads and also continues to own the property and manage it within the bounds set by the easement.¹⁵⁹¹ The easement holder is responsible for monitoring and enforcing easement specifications.¹⁵⁹² Benefits of land exchange programs include the preservation of open space and making more land available to protect estuaries.¹⁵⁹³ One constraint is that if an easement requirement cannot be readily monitored, it likely cannot be enforced.¹⁵⁹⁴

Maintain sediment transport

Sediment management is an important aspect of shoreline management and supports some of the other measures discussed in this category and the previous.¹⁵⁹⁵ It requires an understanding of sedimentation processes in the management area, recognizes the importance of sand and other sediments in protecting, maintaining, and restoring the shoreline and its associated waters and ecosystems, and incorporates activities affecting the erosion, transport, deposition, and removal of sediment.¹⁵⁹⁶ These activities include dredging and placing sediment, building shore protection structures and other structures that trap or divert sediment, and mining.¹⁵⁹⁷

- **Trap or add sand through beach nourishment:** Beach nourishment is the addition of sand to a shoreline to enhance or create a beach area, which creates protective beach for inland areas and replenishes sand lost to erosion.¹⁵⁹⁸ To maintain beaches, nourishment activities must be done repeatedly, as they treat only the symptoms and not the causes of the erosion.¹⁵⁹⁹ There are also high costs associated with importing beach material.¹⁶⁰⁰ However, even though beach nourishment efforts are typically costly and of uncertain value as a long-run solution to rising

¹⁵⁸⁶ *U.S. EPA. (2009, p. 16)

¹⁵⁸⁷ *U.S. EPA. (2009, p. 17)

¹⁵⁸⁸ *U.S. EPA. (2009, p. 17)

¹⁵⁸⁹ *U.S. EPA. (2009, p. 17)

¹⁵⁹⁰ *Merenlender et al. *Land trusts and conservation easements: Who is conserving what for whom?* (2004, p. 67)

¹⁵⁹¹ *Merenlender et al. (2004, p. 67)

¹⁵⁹² *Merenlender et al. (2004, p. 67)

¹⁵⁹³ *U.S. EPA. (2009, p. 16)

¹⁵⁹⁴ *Merenlender et al. (2004, p. 67)

¹⁵⁹⁵ *NOAA. (2010, p. 83)

¹⁵⁹⁶ *NOAA. (2010, p. 83)

¹⁵⁹⁷ *NOAA. (2010, p. 83)

¹⁵⁹⁸ *U.S. EPA. (2009, p. 14)

¹⁵⁹⁹ *Kling and Sanchirico. (2009, p. 43)

¹⁶⁰⁰ *U.S. EPA. (2009, p. 14)

seas, they are among the only tools available to protect certain coastal wetlands and pre-existing communities.¹⁶⁰¹

- **Trap sand through construction of groins:** Groins are a barrier-type structure that traps sand by interrupting longshore transport.¹⁶⁰² This creates a more natural shore face than bulkheads or revetments and is a quick fix.¹⁶⁰³ However, it can trigger or accelerate erosion on the downdrift side and loss of beach habitat.¹⁶⁰⁴
- **Reduce the diversion of water into channels and other stream diversions:** This permits adequate sedimentation flows to build up coastal wetlands.¹⁶⁰⁵ Policies to increase sedimentation flows are weighed against the possibility that they may contradict policies meant to reduce the increased variability of precipitation on agricultural and drinking water supplies.¹⁶⁰⁶
- **Promote wetland accretion by introducing sediment:** Promoting wetland accretion by introducing sediment helps maintain sediment transport to wetlands, which helps protect coastal land from storms.¹⁶⁰⁷ However, it requires continual management and can be very costly.¹⁶⁰⁸

Maintain water quality

Two options to help maintain water quality in a changing climate are:

- **Plug drainage canals:** Plugging drainage canals prevents subsidence-inducing saltwater intrusion and protects land subject to flooding.¹⁶⁰⁹ However, it may eliminate transportation routes.¹⁶¹⁰
- **Prevent or limit groundwater extraction from shallow aquifers:** Preventing or limiting groundwater extraction reduces relative sea level rise by preventing subsidence and reducing saltwater intrusion into freshwater aquifers.¹⁶¹¹ However, an alternative water source may need to be found.¹⁶¹²

Preserve habitat for vulnerable species

Several options are available to help preserve habitat for vulnerable species in a changing climate.

Establish, expand, and/or connect protected areas and refugia

A number of studies provide evidence of elevated biodiversity within protected areas, with the greatest benefit accruing to nonmigratory species.¹⁶¹³ For example, effectively managed Marine Protected Areas

¹⁶⁰¹ *Kling and Sanchirico. (2009, p. 43)

¹⁶⁰² *U.S. EPA. (2009, p. 14)

¹⁶⁰³ *U.S. EPA. (2009, p. 14)

¹⁶⁰⁴ *U.S. EPA. (2009, p. 14)

¹⁶⁰⁵ *Kling and Sanchirico. (2009, p. 43)

¹⁶⁰⁶ *Kling and Sanchirico. (2009, p. 43)

¹⁶⁰⁷ *U.S. EPA. (2009, p. 12)

¹⁶⁰⁸ *U.S. EPA. (2009, p. 12)

¹⁶⁰⁹ *U.S. EPA. (2009, p. 19)

¹⁶¹⁰ *U.S. EPA. (2009, p. 19)

¹⁶¹¹ *U.S. EPA. (2009, p. 19)

¹⁶¹² *U.S. EPA. (2009, p. 19)

¹⁶¹³ *Kling and Sanchirico. (2009, p. 40). The authors cite Halpern (2003) for this information.

(MPAs) can be used to strategically target habitats and geographic areas that are critical to maintaining ecosystem goods (such as fisheries) and services (such as coastal protection, tourism and recreational use).¹⁶¹⁴ MPAs are defined by the World Conservation Union (IUCN) as any area of intertidal or subtidal terrain, together with its overlaying waters, and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part, or all, of the enclosed environment.¹⁶¹⁵ MPAs can be embedded within larger management and zoning efforts - such as coastal zone management, seascapes or networks of MPAs - or used as a stand-alone measure.¹⁶¹⁶ Ideally, MPAs should be part of a larger management effort, but the lack of resources and capacity often necessitate a more limited and targeted approach.¹⁶¹⁷ Regardless of their size or configuration, most MPAs use zoning schemes to designate certain areas for particular human uses or for ecological reserves.¹⁶¹⁸ Most MPAs include at least one core area within which all extractive and direct impact activities such as fishing and boat anchoring are prohibited.¹⁶¹⁹ To design MPAs, the following information may be gathered or incorporated:

- Compile or develop resource maps that depict key habitat, species location, and population and migration patterns.¹⁶²⁰ For example:
 - Map habitat types including location, area covered, structural elements (sand, kelp forests, seagrass beds, boulders, etc.), and functional elements (e.g. spawning grounds for particular species, nursery grounds, etc.).¹⁶²¹
 - Identify key biotic and abiotic variables controlling species distribution in the region, and how they will be affected by climate change.¹⁶²²
 - Identify the areas that may be more resilient to sea surface temperature change, or can help mitigate against sea level rise or increased frequency of storms.¹⁶²³
 - Account for the likelihood that species ranges—at least the ranges of mid-latitude species—will move toward the poles as the oceans warm.¹⁶²⁴
- Identify nearshore currents and source and sink areas for seeds/larvae to replenish species in the MPA.¹⁶²⁵
- Determine if there are areas with reduced water circulation, upwelling and high sea surface temperatures, which might be increasingly vulnerable to climate change.¹⁶²⁶
- Design reserves to provide temperature refugia.¹⁶²⁷ While shifting habitats to greater depth and higher latitudes is one way of finding cooler temperatures, most regions have identifiable “hot spots” and “cold spots” due to factors such as upwelling, shade, subhabitats, timing of

¹⁶¹⁴ *U.S. AID. (2009, p. 83)

¹⁶¹⁵ *U.S. AID. (2009, p. 83)

¹⁶¹⁶ *U.S. AID. (2009, p. 83)

¹⁶¹⁷ *U.S. AID. (2009, p. 83)

¹⁶¹⁸ *U.S. AID. (2009, p. 83)

¹⁶¹⁹ *U.S. AID. (2009, p. 83)

¹⁶²⁰ *U.S. AID. (2009, p. 84)

¹⁶²¹ *Hoffman. *Designing reserves to sustain temperate marine ecosystems in the face of global climate change*. (2003, p. 146)

¹⁶²² *Hoffman. (2003, p. 146)

¹⁶²³ *U.S. AID. (2009, p. 84)

¹⁶²⁴ *Kling and Sanchirico. (2009, p. 40)

¹⁶²⁵ *U.S. AID. (2009, p. 84)

¹⁶²⁶ *U.S. AID. (2009, p. 84)

¹⁶²⁷ *Hoffman. (2003, p. 140)

- tides, and freshwater input.¹⁶²⁸ Designing reserves to include “cold spots” may reduce thermal stress from climate change.¹⁶²⁹
- Establish reserves in transitional zones between biogeographic regions as well as in core areas and add an “insurance factor” to reserve size calculations.¹⁶³⁰ As climate changes, the “best” area for a species may shift away from what had been the core of its range.¹⁶³¹ An insurance factor is extra area added to the reserve, and assures that a reserve’s function goals are met despite catastrophes.¹⁶³² Such an approach could also be effective in buffering against possible effects of climate change, and would work well in conjunction with other hedging approaches.¹⁶³³ This approach may be ineffective in protecting many spatially restricted habitats and ecosystems.¹⁶³⁴
 - Design reserves based on features of the environment unlikely to change (e.g. physiographic features such as topography) and that show resistance and resilience to climate change.¹⁶³⁵
 - Determine the types and intensities of resource uses and identify stakeholder dependency on fishing, tourism, and mining in the area.¹⁶³⁶ Identify existing community resident perceptions of resource access and use rights.¹⁶³⁷
 - Identify the larger watersheds and river systems affecting the MPA, nearby human settlements and up-current sources of pollutants.¹⁶³⁸
 - Determine which species and habitats are most vulnerable currently and in the future.¹⁶³⁹ Determine representative and replicate sites as insurance against future impacts.¹⁶⁴⁰

Design estuaries with dynamic boundaries and buffers

Buffers are land use regulations designed to reduce the impacts of land uses (e.g., development) on natural resources by providing a transition zone between a resource and human activities.¹⁶⁴¹ Ecological buffer zones (buffers) are similar to setbacks (and may be included within setbacks), but are typically designed to protect the natural, rather than the built, environment.¹⁶⁴² By protecting natural resources, buffers protect the natural and beneficial functions those resources provide.¹⁶⁴³ Protective services include providing habitat and connectivity; minimizing erosion and flooding by stabilizing soil, providing flood storage, and reducing flood velocities; and improving water quality through filtration of harmful

¹⁶²⁸ *Hoffman. (2003, p. 140). The author cites Helmuth et al. (2002) for information on hot and cold spots.

¹⁶²⁹ *Hoffman. (2003, p. 140)

¹⁶³⁰ *Hoffman. (2003, p. 140-141)

¹⁶³¹ *Hoffman. (2003, p. 140)

¹⁶³² *Hoffman. (2003, p. 141)

¹⁶³³ *Hoffman. (2003, p. 141)

¹⁶³⁴ *Hoffman. (2003, p. 141)

¹⁶³⁵ *Hoffman. (2003, p. 142)

¹⁶³⁶ *U.S. AID. (2009, p. 84)

¹⁶³⁷ *U.S. AID. (2009, p. 84)

¹⁶³⁸ *U.S. AID. (2009, p. 84)

¹⁶³⁹ *U.S. AID. (2009, p. 84)

¹⁶⁴⁰ *U.S. AID. (2009, p. 84)

¹⁶⁴¹ *NOAA. (2010, p. 85)

¹⁶⁴² *NOAA. (2010, p. 85)

¹⁶⁴³ *NOAA. (2010, p. 85)

sediment, pollutants, and nutrients.¹⁶⁴⁴ Buffers also protect breeding and foraging habits of highly migratory species.¹⁶⁴⁵

Typically, buffers are maintained in their natural vegetative state and activities such as vegetation removal, soil disturbance, and construction are restricted or prohibited.¹⁶⁴⁶ As climate changes, buffers

Case Study 3. Federal, Tribal, and non-profit partners restore and study the Nisqually Delta (WA) to promote the recovery and resiliency of a treasured ecosystem in light of climate change and other stressors.

Climate stressors addressed: Increased frequency and severity of storms; SLR

Tidal wetlands restored by the Nisqually Indian Tribe and the Nisqually National Wildlife Refuge represent the largest estuarine restoration project in the Pacific Northwest, furthering the recovery of Puget Sound salmon and wildlife populations. Over the past decade, the Refuge and Tribe have restored 900 acres of estuarine habitat in the Nisqually Delta. With close partners, including Ducks Unlimited, more than 21 miles of historic tidal sloughs and historical floodplains have been reconnected to Puget Sound, increasing potential salt marsh habitat in the southern reach of Puget Sound by approximately 55%. The U.S. Geological Survey (USGS), in partnership with the Tribe and Refuge, is evaluating habitat development and changes in ecosystem functions associated with large-scale restoration, by conducting elevation, hydrology, geomorphology, vegetation, birds, fish, and invertebrate prey surveys. A sediment budget is being developed for the Delta to assess whether sufficient sedimentation will occur and enable the marsh and delta to accrete given present and projected rates of sea level rise and historic subsidence. Elevation and sedimentation data using surface elevation tables (SETs), feldspar marker horizons, and short cores will be compared to measured sediment fluxes through restored channels to quantify sediment transport and delivery. Vegetation development and habitat availability for birds will be evaluated using inundation (calculated from elevation and hydrology datasets) and salinity parameters. As the restoration progresses, the Tribe, USGS, and partners are also assessing the capacity and functioning of the restoring habitat to support salmonids, such as juvenile Chinook (*Oncorhynchus tshawytscha*). The monitoring and applied research forms the basis of models assessing near- and long-term restoration trajectories associated with climate and land-use change. These model scenarios can ultimately provide information to help land owners and land managers make decisions about future restorations and management in light of climate change and other stressors. Furthermore, estuary restoration is coupled with expansion of the Refuge boundary by 3,479 acres, providing future opportunities for protection, land acquisition, and upland migration of diverse habitats in response to climate change. In conclusion, the Nisqually Delta restorations helps promote system resiliency to loss of habitats and biodiversity, climate change effects such as increased winter storms, rainfall, and flooding, and rise in sea levels resulting in loss of shoreline areas.

Produced in collaboration with John Y. Takekawa, Isa Woo & Kelley Turner (USGS Western Ecological Research Center); Eric Grossman (USGS Pacific Coastal & Marine Science Center and Western Fisheries Research Center); Jean E. Takekawa & Jesse Barham (U.S. Fish and Wildlife Service Nisqually National Wildlife Refuge); and, Christopher Ellings (Nisqually Indian Tribe Salmon Recovery Program).

Sources: www.nisquallydeltarestoration.org; [Tide Returns to Nisqually Estuary](#) (press release); [Nisqually NWR CCP](#); unstructured interviews (December 2010 & April, July, & August 2011). All websites accessed 8.23.2011.

¹⁶⁴⁴ *NOAA. (2010, p. 85)

¹⁶⁴⁵ *U.S. EPA. (2009, p. 18)

¹⁶⁴⁶ *NOAA. (2010, p. 85-86)

will also be able to support inland wetland migration as well as carbon sequestration.¹⁶⁴⁷ The effectiveness of any buffer will depend on several factors, including size, elevation, vegetation, slope, soil, permitted activities, adjacent land uses, stormwater flow, and erosion rate.¹⁶⁴⁸ In addition, effectiveness will also be dependent on property owner compliance and the monitoring and enforcement of buffer regulations.¹⁶⁴⁹ In highly developed areas, boundaries may already be unmovable.¹⁶⁵⁰

Connect landscapes with corridors to enable migrations

The highly fragmented nature of today's landscapes has led many conservation biologists to promote increasing connectivity among protected areas to enhance movement in a changing climate (e.g., connecting protected lands along a coastline).¹⁶⁵¹ Corridors allow for species migration with climate change and sustain wildlife biodiversity across the landscape.¹⁶⁵² The ability to move through a corridor depends on species-specific behavior and habitat affinities.¹⁶⁵³ Given that many species, with diverse habitat requirements and dispersal abilities, will need to move in response to climate change, species-based corridor approaches may not be adequate or feasible.¹⁶⁵⁴ Further, significant effort and resources may be required.¹⁶⁵⁵ Two additional approaches to increasing connectivity have been proposed. First, small stepping-stone reserves can be placed between larger preserves to facilitate movement.¹⁶⁵⁶ The second approach is to manage the lands or waters between protected areas in ways that allow the most species to move through these spaces.¹⁶⁵⁷ Such approaches have been referred to as softening or managing the matrix.¹⁶⁵⁸ Some combination of matrix management, stepping-stone reserves, and corridors will likely allow the most movement in response to climate change.¹⁶⁵⁹ *For further information on reserves, please see "Establish, expand, and/or connect protected areas and refugia."*

Prohibit or remove hard protection or other barriers to tidal and riverine flow

The prohibition or removal of barriers to tidal and riverine flow such as dikes may allow species and wetlands to migrate inland.¹⁶⁶⁰ Removal of barriers may be costly and destructive to shoreline property.¹⁶⁶¹

¹⁶⁴⁷ *NOAA. (2010, p. 86)

¹⁶⁴⁸ *NOAA. (2010, p. 86)

¹⁶⁴⁹ *NOAA. (2010, p. 86)

¹⁶⁵⁰ *U.S. EPA. (2009, p. 18)

¹⁶⁵¹ *Lawler. (2009, p. 83). The author cites Shafer (1999), Noss (2001), Hulme (2005), and Welch (2005) for this information.

¹⁶⁵² *U.S. EPA. (2009, p. 24)

¹⁶⁵³ *Lawler. (2009, p. 83)

¹⁶⁵⁴ *Lawler. (2009, p. 84). The author cites Hulme (2005) for this information.

¹⁶⁵⁵ *U.S. EPA. (2009, p. 24)

¹⁶⁵⁶ *Lawler. (2009, p. 84)

¹⁶⁵⁷ *Lawler. (2009, p. 84)

¹⁶⁵⁸ *Lawler. (2009, p. 84). The author cites Franklin et al. (1992) and Noss (2001) for this information.

¹⁶⁵⁹ *Lawler. (2009, p. 84)

¹⁶⁶⁰ *U.S. EPA. (2009, p. 12)

¹⁶⁶¹ *U.S. EPA. (2009, p. 12)

Preserve and restore the structural complexity and biodiversity of vegetation in tidal marshes, seagrass meadows, and mangroves

Vegetation protects against erosion, protects mainland shorelines from tidal energy, storm surge, and wave forces, filters pollutants, and absorbs atmospheric CO₂.¹⁶⁶² This helps maintain water quality as well as shorelines, and may aid invasive species management.¹⁶⁶³

Identify and protect ecologically significant (“critical”) areas

Protecting critical areas such as nursery grounds, spawning grounds, and areas of high species diversity will promote biodiversity and ecosystem services.¹⁶⁶⁴ For example, critical areas produce and add nutrients to coastal systems, and serve as refugia and nurseries for species.¹⁶⁶⁵ However, federal or state protection may be required.¹⁶⁶⁶

Additional actions

The following adaptation actions for preserving habitat for vulnerable species were found in the literature, but were not described in detail or are described elsewhere in this report:

- Retreat from, and abandonment of, coastal barriers: This may help protect estuaries, allowing them to return to their natural habitat, but may be politically unfavorable due to the high value of coastal property and infrastructure.¹⁶⁶⁷
- Purchase upland development rights or property rights: *Please see the section “Maintain shorelines” for an explanation of land acquisition.*
- Replicate coastal habitat types in multiple areas to spread risks associated with climate change: Biodiversity and critical areas are protected, but land may not be available to replicate habitats.¹⁶⁶⁸
- Expand land use planning horizons to incorporate longer climate predictions: Longer planning horizons could inhibit risky development and provide protection for estuarine habitats.¹⁶⁶⁹ However, land use plans rarely incorporate hard prohibitions against development close to sensitive habitats and have limited durability over time.¹⁶⁷⁰
- Adapt protections of important biogeochemical zones and critical habitats: As the locations of critical habitats and biogeochemical zones change with climate, adapting protections allows for migration of critical areas, but will require consistent monitoring efforts.¹⁶⁷¹

¹⁶⁶² *U.S. EPA. (2009, p. 13)

¹⁶⁶³ *U.S. EPA. (2009, p. 13)

¹⁶⁶⁴ *U.S. EPA. (2009, p. 13)

¹⁶⁶⁵ *U.S. EPA. (2009, p. 13)

¹⁶⁶⁶ *U.S. EPA. (2009, p. 13)

¹⁶⁶⁷ *U.S. EPA. (2009, p. 17)

¹⁶⁶⁸ *U.S. EPA. (2009, p. 18)

¹⁶⁶⁹ *U.S. EPA. (2009, p. 17)

¹⁶⁷⁰ *U.S. EPA. (2009, p. 17)

¹⁶⁷¹ *U.S. EPA. (2009, p. 18)

Case Study 4. Responding to Changes in Seawater Chemistry: The Oyster Emergency Project, WA.

Climate stressors addressed: Ocean acidification, upwelling

In 2005, shellfish growers began to encounter difficulties in rearing hatchery-produced oyster larvae and in successfully setting wild populations of oysters. Preliminary research indicated that increasingly acidic, nutrient replete, deep, upwelled waters could be the cause of the increase in oyster mortalities. In response to persistently low shellfish harvests from 2005-2008, the Pacific Coast Shellfish Growers Association (PCSGA) proposed the “Oyster Emergency Project,” a collaboration between regional shellfish growers, NOAA, Oregon State University and The Nature Conservancy. To help shellfish growers adapt, PCSGA initiated a targeted research project to identify environmental stressors of oyster populations and to isolate genetic stocks of oysters that offer enhanced resilience; four projects were proposed. As of December 2009, three of the four projects had been funded: monitoring sea water, the genetic study, and developing an assay to detect a harmful bacterium. PCSGA is continuing to look for funding for the final project, retrofitting hatcheries. Through the “Oyster Emergency Project” targeted research plan, PCSGA hopes to identify short-term solutions that can be implemented within months to help shellfish hatcheries adapt to changes in seawater chemistry. The long-term monitoring program will allow researchers to specify environmental parameters that retard oyster larval development.

Source: Climate Action Knowledge Exchange, <http://www.cakex.org/case-studies/50> (accessed 12.14.2010)

Manage invasive species in a changing climate

In a 2008 report, the EPA’s National Center for Environmental Assessment recommended the following initial steps to incorporate climate change into aquatic invasive species management plans:

- Incorporate climate change considerations into leadership and coordination activities;
- Identify new aquatic invasive species threats as a result of climate change;
- Identify ecosystem vulnerabilities and improve methods to increase ecosystem resilience;
- Evaluate the effectiveness of control mechanisms under changing conditions; and,
- Manage information systems to include considerations of changing conditions¹⁶⁷²

An aquatic invasive species program that considers climate change would also include a comprehensive monitoring system that can detect new aquatic invasive species and changes in existing ones and how they affect the management area.¹⁶⁷³

Two additional options are available for managing invasive species in a changing climate:

- **Strengthen rules that prevent the introductions of invasive species:** Given the extreme difficulty and high cost of eradication of self-sustaining marine non-native invasive species populations, the most fruitful avenues for adapting to increased recruitment probability are regulations and incentive schemes targeting key introduction pathways, including ballast water, aquaculture, the exotic pet and aquarium trade, and the seafood trade.¹⁶⁷⁴ Practices that have proven effective in combating non-native invasive species introduction through ballast

¹⁶⁷² *NOAA. (2010, p. 92)

¹⁶⁷³ *NOAA. (2010, p. 93)

¹⁶⁷⁴ *Kling and Sanchirico. (2009, p. 41). The authors cite Ruiz et al. (2000b) and Williams and Grosholz (2008) for this information.

water range from low-tech options, such as ballast water exchange outside of less-saline estuaries, to biocide and the use of treatment facilities, such as those currently in place at California ports.¹⁶⁷⁵ No-discharge zones for ballast water are another option.¹⁶⁷⁶ Ballast water exchange is considered by some to be an inadequate response because it is ineffective against species capable of surviving more saline water or within drained ballasts.¹⁶⁷⁷ Current alternatives that would allow for the treatment of ballast water are costly; the cost of retrofitting a single commercial vessel to enable it to interface with existing port-based treatment facilities has been estimated at close to \$400,000.¹⁶⁷⁸

- **Remove invasive species and restore native species:** Local removals of invasives are viable to improve marsh characteristics that promote fish and wildlife.¹⁶⁷⁹ It may be difficult to implement on a larger scale.¹⁶⁸⁰

¹⁶⁷⁵ *Kling and Sanchirico. (2009, p. 41). The authors cite Buck (2006) for this information.

¹⁶⁷⁶ *U.S. EPA. (2009, p. 16)

¹⁶⁷⁷ *Kling and Sanchirico. (2009, p. 41)

¹⁶⁷⁸ *Kling and Sanchirico. (2009, p. 41). The authors cite Buck (2006) for this information.

¹⁶⁷⁹ *U.S. EPA. (2009, p. 16)

¹⁶⁸⁰ *U.S. EPA. (2009, p. 16)

8. STATUS OF ADAPTATION STRATEGIES AND PLANS IN THE STATES, PROVINCES, AND SELECTED TRIBAL NATIONS OF THE NPLCC

Alaska

To address the impacts of climate change on Alaska, Governor Sarah Palin signed Administrative Order 238 on September 14, 2007, which established and charged the Alaska Climate Change Sub-Cabinet to advise the Office of the Governor on the preparation and implementation of a comprehensive Alaska Climate Change Strategy (AO 238).¹⁶⁸¹ The Adaptation Advisory Group (AAG) was charged with evaluating and developing options to adapt to climate change.¹⁶⁸² The Final Report Submitted by the Adaptation Advisory Group to the Alaska Climate Change Sub-Cabinet was released in January 2010. The types of recommendations made by the AAG vary.¹⁶⁸³ The options cover four broad sectors (public infrastructure, health and culture, natural systems, and economic activities) and range from new systems approaches and institutional structures to adoption of new or revised policies, initiatives, and other actions.¹⁶⁸⁴ The Sub-Cabinet will consider these, as well as recommendations from the Immediate Action Work Group, the Mitigation Advisory Group, and the Research Needs Work Group in the context of other complementary efforts.¹⁶⁸⁵ A comprehensive Climate Change Strategy for Alaska will then be drafted for consideration by the Governor.¹⁶⁸⁶

Yukon Territory

Within the Yukon Territory (186,272 mi², 482,443 km²),¹⁶⁸⁷ the only land within the NPLCC region is that covered by the Kluane National Park and Preserve (8,487 miles², 21, 980 km²; ~4.6% of total area in Yukon Territory),¹⁶⁸⁸ located in the southwest corner of the Territory. Parks Canada lists impacts in its Pacific Coast parks largely consistent with those described in this report for the region: higher temperatures, a moderate increase in winter precipitation and drier summers, increased ocean surface temperatures, greater storm intensity, and altered ocean currents (please see relevant sections of this report for further information).¹⁶⁸⁹ Information on climate change adaptation planning for the Kluane National Park and Preserve was limited; however, information on adaptation planning by the Government of Yukon is described below.

The Government of Yukon Climate Change Strategy, released in 2006, sets out the government's role and key goals for its response to climate change.¹⁶⁹⁰ After its release, Environment Yukon began researching and collecting information needed to develop the Yukon Government Climate Change Action Plan, which was released February 2009.¹⁶⁹¹ The Climate Change Strategy includes broad goals targeted at enhancing

¹⁶⁸¹ *AK Department of Environmental Conservation. (2010, Ch 1, p. v-vi)

¹⁶⁸² *AK Department of Environmental Conservation. (2010, Ch 1, p. vi)

¹⁶⁸³ *AK Department of Environmental Conservation. (2010, Ch 1, p. vi)

¹⁶⁸⁴ *AK Department of Environmental Conservation. (2010, Ch 1, p. vi)

¹⁶⁸⁵ *AK Department of Environmental Conservation. (2010, Ch 1, p. vi)

¹⁶⁸⁶ *AK Department of Environmental Conservation. (2010, Ch 1, p. vi)

¹⁶⁸⁷ Government of Yukon. *Executive Council Office: General Facts: Land (website)*. (2011)

¹⁶⁸⁸ Parks Canada. *Kluane National Park and Preserve of Canada Management Plan*. (2010, p. 3)

¹⁶⁸⁹ *Parks Canada. *The Climate is Changing Our National Parks: Impacts on Pacific Parks (website)*. (2009)

¹⁶⁹⁰ *Yukon Government. *Government of Yukon Climate Change Strategy*. (July 2006, p. 1)

¹⁶⁹¹ *Yukon Government. *Yukon Government Climate Change Action Plan*. (February 2009, p. 9)

the awareness and understanding of climate change impacts, taking measures to reduce the levels of greenhouse gas emissions in Yukon, building environmental, social and economic systems that are able to adapt to climate change impacts and positioning Yukon as a northern leader for applied climate change research and innovation.¹⁶⁹² The Action Plan, providing clear direction and action, advances the goals of the Climate Change Strategy.¹⁶⁹³ The four goals outlined in the Action Plan are: (1) enhance knowledge and understanding of climate change; (2) adapt to climate change; (3) reduce greenhouse gas emissions; and, (4) lead Yukon action in response to climate change.¹⁶⁹⁴

Preparation of the Action Plan included discussions with a wide variety of government and non-government representatives, an interdepartmental workshop, working-group meetings and several external workshops.¹⁶⁹⁵ A draft of the Action Plan was circulated for public comment from May 12 to July 31, 2008 before its release in February 2009.¹⁶⁹⁶

The Yukon government will pursue the implementation of its Climate Change Strategy in partnership and collaboration with First Nation governments, municipalities, industry, the public, the other northern territories and the provinces, the federal government and other governments around the world.¹⁶⁹⁷ Implementation of the Action Plan will involve all departments and agencies of the Yukon government.¹⁶⁹⁸ The Yukon government will also work with partners to meet the challenges and opportunities of climate change in Yukon – other governments, non-governmental organizations, industry, and the academic community.¹⁶⁹⁹

British Columbia

Building on a framework established in 2007, British Columbia released a Climate Action Plan in 2008.¹⁷⁰⁰ The section on adaptation outlines a range of coordinated actions to help B.C. adapt to climate change, including options for investing in new ideas and solutions, protecting forests, protecting water, and building carbon smart communities.¹⁷⁰¹ The Climate Change Adaptation Strategy addresses three main themes that provide a solid framework to address climate change impacts and adaptation: (1) build a strong foundation of knowledge and tools to help public and private decision-makers across B.C. prepare for a changing climate, (2) make adaptation a part of B.C. Government's business, ensuring that climate change impacts are considered in planning and decision-making across government, and (3) assessing risks and implementing priority adaptation actions in key climate sensitive sectors.¹⁷⁰²

¹⁶⁹² *Yukon Government. (July 2006, p. 1)

¹⁶⁹³ *Yukon Government. (February 2009, p. 5)

¹⁶⁹⁴ *Yukon Government. (February 2009, p. 7)

¹⁶⁹⁵ *Yukon Government. (February 2009, p. 9)

¹⁶⁹⁶ *Yukon Government. (February 2009, p. 9)

¹⁶⁹⁷ *Yukon Government. (July 2006, p. 1)

¹⁶⁹⁸ *Yukon Government. (February 2009, p. 5)

¹⁶⁹⁹ *Yukon Government. (February 2009, p. 5)

¹⁷⁰⁰ *Government of British Columbia. *Climate Action Plan*. (2008, p. 1)

¹⁷⁰¹ Government of British Columbia. *Climate Action Plan*. (2008, p. 66-69)

¹⁷⁰² *B.C. Ministry of Environment. *Climate Change Adaptation Strategy (website)*. (2011)

Washington

In the spring of 2009, Governor Gregoire signed legislation (E2SSB 5560) that included provisions for the formation of an “integrated climate change response strategy” that would “better enable state and local agencies, public and private businesses, nongovernmental organizations, and individuals to prepare for, address, and adapt to the impacts of climate change.”¹⁷⁰³ The legislation directs Ecology, in partnership with the departments of Agriculture, Commerce, Fish and Wildlife, Natural Resources, and Transportation to develop an initial state strategy by December of 2011.¹⁷⁰⁴

Four Topic Advisory Groups (TAGs) were formed to assist in developing a state strategy for how Washington can prepare for and adapt to the impacts of climate change.¹⁷⁰⁵ The TAGs are structured around four areas (built environment, infrastructure, and communities; human health and security; ecosystems, species, and habitats; natural resources) and will address a wide range of key issues that citizens, governments, and businesses will face in a changing climate.¹⁷⁰⁶ The Departments of Agriculture, Ecology, Fish and Wildlife, Health, Natural Resources, Transportation, and the University of Washington lead TAGs that examine climate change impacts and identify preparation and adaptation strategies as well as additional research needs.¹⁷⁰⁷ TAG members met regularly since their inception in early 2010 through January 2011, including three cross-cutting TAG meetings.¹⁷⁰⁸ The draft strategy will be completed in Spring 2011, followed by a period of public comment and outreach through Summer 2011.¹⁷⁰⁹ The final strategy will be submitted to the Legislature in December 2011.¹⁷¹⁰

Jamestown S’Klallam Tribe

In late 2009, Tribal Council approved a proposal by the Tribe’s Natural Resources Department to write a formal Jamestown S’Klallam Plan for Climate Change.¹⁷¹¹ The purpose of the plan is to prepare for a warming climate, and to help reduce the Tribe’s carbon footprint, to slow down the warming planet.¹⁷¹²

Swinomish Indian Tribal Community

In the fall of 2008 the Swinomish Indian Tribal Community started work on a landmark two-year Climate Change Initiative to study the impacts of climate change on the resources, assets, and community of the Swinomish Indian Reservation and to develop recommendations on actions to adapt to projected impacts.¹⁷¹³ This followed issuance of a Proclamation by the Tribal Senate in 2007 directing action to

¹⁷⁰³ *WA Department of Ecology. *Preparing for impacts: adapting to climate change (website)*. (2011)

¹⁷⁰⁴ *WA Department of Ecology. *Preparing for impacts: adapting to climate change (website)*. (2011)

¹⁷⁰⁵ *WA Department of Ecology. *Topic Advisory Groups (website)*. (2011)

¹⁷⁰⁶ *WA Department of Ecology. *Topic Advisory Groups (website)*. (2011)

¹⁷⁰⁷ *WA Department of Ecology. *Topic Advisory Groups (website)*. (2011)

¹⁷⁰⁸ *WA Department of Ecology. *Topic Advisory Groups (website)*. (2011)

¹⁷⁰⁹ WA Department of Ecology Topic Advisory Groups. *Integrated Climate Change Response Plan: Draft Topic Advisory Group Work Plan (unpublished internal document)*. (2009)

¹⁷¹⁰ WA Department of Ecology Topic Advisory Groups. (2009)

¹⁷¹¹ *Jamestown S’Klallam Tribe. *Newsletter (Vol 32, Issue 2) (pdf; website)*. (2011, p. 9)

¹⁷¹² *Jamestown S’Klallam Tribe. (2011, p. 9)

¹⁷¹³ *Swinomish Indian Tribal Community. *Swinomish Climate Change Initiative: Climate Adaptation Action Plan*. (2010, p. 1)

study and assess climate change impacts on the Reservation.¹⁷¹⁴ Under the guidance and coordination of the Swinomish Office of Planning & Community Development, the first year of the project was devoted to assessment of projected impacts, as presented in an Impact Assessment Technical Report issued in the fall of 2009.¹⁷¹⁵ The second year of the project was focused on evaluation of strategies and options for recommended actions to counter identified impacts, which resulted in preparation and release of the *Climate Adaptation Action Plan*.¹⁷¹⁶ The ultimate goal of the project was to help ensure an enduring and climate-resilient community that can meet the challenges of anticipated impacts in the years to come.¹⁷¹⁷

The Action Plan discusses climate change within the context of Swinomish cultural traditions, community health, and cultural resilience, and reviews the relationship between tribal traditions and effective adaptation planning. This information, along with the climate change impacts assessed in the Technical Report and strategic evaluation of many adaptation options, was used to derive the adaptation goals, action recommendations and priorities described in the Action Plan. These are organized into four focal areas (coastal resources, upland resources, physical health, and community infrastructure and services). Strategic evaluation included assessment of six key objectives (comprehensive, sustainable, dynamic response, fiscally feasible, non-regulatory, and meets community goals).¹⁷¹⁸ Strategies were then screened against a number of key considerations (evaluation objectives met, existing authority and capacity versus required authority and capacity, potential internal and external partners, and timeframe anticipated for potential implementation), as well as the vulnerability and estimated risk to the system in question.¹⁷¹⁹ At time of writing, the Swinomish are moving forward on a number of their priority actions. For example, they are seeking grants for their work, evaluating existing management plans and regulations, and assessing needed changes to building and zoning codes. A description of the Swinomish Tribe's Climate Adaptation Action Plan can be found at http://www.swinomish-nsn.gov/climate_change/Docs/SITC_CC_AdaptationActionPlan_complete.pdf (accessed 4.7. 2011).

Tulalip Tribe

The Tulalip Adaptation and Mitigation Policy Frameworks for Climate Change lists six criteria for incorporating policies and law in planning and management that allow the Tulalip Tribes to sustainably maintain healthy, resilient human communities in the face of change.¹⁷²⁰ These policies and law need, among other things, to be *integrated* (involve multiple independent sectors in the creation of holistic solutions that address a full range of natural and social factors), *cross-scale* (address problems at multiple scales, and devise scale-appropriate actions, working to ensure policies and actions do not defeat measures taken at any one scale), *adaptive* (monitor and respond to the effectiveness of efforts and advances in scientific and local knowledge, adapt objectives when necessary), *restorative* (use historical baselines for mitigation goals for processes that maintain healthy watersheds and communities), *participatory* (recognize stakeholder equity by including federal, state, tribal and local governments, businesses and citizens in the transparent development of baselines, objectives, and mitigation and

¹⁷¹⁴ *Swinomish Indian Tribal Community. (2010, p. 1)

¹⁷¹⁵ *Swinomish Indian Tribal Community. (2010, p. 1)

¹⁷¹⁶ *Swinomish Indian Tribal Community. (2010, p. 1)

¹⁷¹⁷ *Swinomish Indian Tribal Community. (2010, p. 1)

¹⁷¹⁸ Swinomish Indian Tribal Community. (2010, p. 38)

¹⁷¹⁹ Swinomish Indian Tribal Community. (2010, p. 40)

¹⁷²⁰ *Tulalip Tribes. *Climate Change Impacts on Tribal Resources (pdf; website)*. (2006, p. 2)

adaptation measures), and *sustainable* (design objectives and actions on a basis of ecological and cultural sustainability, and include mechanisms to ensure the sustained financial and administrative support for their implementation).¹⁷²¹

Oregon

In October 2009, Governor Kulongoski of Oregon asked the directors of several state agencies, universities, research institutions and extension services to develop a climate change adaptation plan.¹⁷²² Among other things, the plan provides a framework for state agencies to identify authorities, actions, research, and resources needed to increase Oregon's capacity to address the likely effects of a changing climate.¹⁷²³ *The Oregon Climate Change Adaptation Framework* was released in December 2010. The Framework lays out eleven expected climate-related risks, the basic adaptive capacity to deal with those risks, short-term priority actions for each risk, and several steps that will evolve into a long-term process to improve Oregon's capacity to adapt to variable and changing climate conditions.¹⁷²⁴

Coquille Tribe

Building on the traditions and values of the Tribal community, the Coquille Indian Tribe is focused on developing a plan to adapt to the challenges presented by climate change and related threats to the tribe's well-being.¹⁷²⁵ Currently, the tribe is focused on building capacity within the Tribal government to understand the impacts of climate change, engaging the tribal community in climate change discourse, and strengthening collaboration and partnerships with non-tribal organizations within the region.¹⁷²⁶ The Tribe has committees in place to identify and investigate the issues, including the Climate Change Committee and the Emergency Preparedness and Disaster Mitigation Committee.¹⁷²⁷ The Climate Change Committee, for example, was established in 2008 and has been tasked by Tribal Council to: become familiar with the causes of climate change and consequences of climate change to the Tribe, tribal members, tribal enterprises and the outlying community; evaluate practices, policies operations and enterprises and make recommendations regarding opportunities, adaptations and mitigations regarding the climate change process as it affects the Tribe and its members; and, provide information to the Tribal membership regarding the causes, effects and prudent responses to climate change.¹⁷²⁸

In addition to continuing current efforts, the Tribe is preparing a *Climate Action Plan*, a more detailed and informed plan that incorporates insight and knowledge from Tribal members, the Tribe's natural resources and planning staff, information and data from climate scientists, research and other organizations dedicated to climate issues, and the assistance and resources available from local, state and federal government.¹⁷²⁹ The plan will help to further identify local risks to Coquille Tribal land and natural resources, infrastructure and transportation systems, and in turn, the Tribe's culture, economy,

¹⁷²¹ *Tulalip Tribes. (2006, p. 2)

¹⁷²² *State of Oregon. *The Oregon Climate Change Adaptation Framework*. (2010, p. i)

¹⁷²³ *State of Oregon. (2010, p. i)

¹⁷²⁴ State of Oregon. (2010, p. i)

¹⁷²⁵ *Institute for Tribal Environmental Professionals. *Climate Change and the Coquille Indian Tribe: Planning for the effects of climate change and reducing greenhouse gas emissions (pdf)*. (2011, p. 1)

¹⁷²⁶ *Institute for Tribal Environmental Professionals. (2011, p. 2)

¹⁷²⁷ *Institute for Tribal Environmental Professionals. (2011, p. 2)

¹⁷²⁸ *Institute for Tribal Environmental Professionals. (2011, p. 3)

¹⁷²⁹ *Institute for Tribal Environmental Professionals. (2011, p. 1)

health, and safety.¹⁷³⁰ Additionally, impacts to other regions of the northwest and the world that may also bring adverse local impacts will be investigated.¹⁷³¹ Further information on the Coquille Tribe's efforts around climate change can be found at http://tribalclimate.uoregon.edu/files/2010/11/tribes_Coquille_web2.pdf (accessed 4.7. 2011).

California

California strengthened its commitment to managing the impacts from sea level rise, increased temperatures, shifting precipitation and extreme weather events when Governor Arnold Schwarzenegger signed Executive Order (EO) S-13-08 on November 14, 2008.¹⁷³² The order called on state agencies to develop California's first strategy to identify and prepare for these expected climate impacts.¹⁷³³ The California Natural Resources Agency (CNRA) has taken the lead in developing this adaptation strategy, working through the Climate Action Team (CAT).¹⁷³⁴ Seven sector-specific working groups led by twelve state agencies, boards and commissions, and numerous stakeholders were convened for this effort.¹⁷³⁵ The strategy proposes a comprehensive set of recommendations designed to inform and guide California decision-makers as they begin to develop policies that will protect the state, its residents and its resources from a range of climate change impacts.¹⁷³⁶ Four comprehensive state adaptation planning strategies were identified by all climate adaptation sectors.¹⁷³⁷ These strategies were intended to be in place or completed by the end of 2010.¹⁷³⁸

Following a 45-day public comment period since its release as a Discussion Draft in August 2009, the CNRA and sector working groups have revised the strategy incorporating public stakeholder input.¹⁷³⁹ This document will be updated approximately every two years to incorporate progress in strategies and changing climate science.¹⁷⁴⁰ The current draft reviews projections for temperature, precipitation, sea level rise, and extreme events, then evaluates climate impacts by sector.¹⁷⁴¹

Yurok Tribe

In 2010, the Yurok Tribe received a grant from the U.S. Environmental Protection Agency for a Climate Change Impacts Assessment and Prioritization Project.¹⁷⁴² The final goal of the project is the preparation and completion of the Yurok Tribe Climate Change Prioritization Plan and an initial assessment of potential climate change impacts that will serve as a guide for future tribal climate change research and planning efforts.¹⁷⁴³ The project also aims to build tribal government and community capacity via

¹⁷³⁰ *Institute for Tribal Environmental Professionals. (2011, p. 1)

¹⁷³¹ *Institute for Tribal Environmental Professionals. (2011, p. 1)

¹⁷³² *CA Natural Resources Agency. (2009, p. 4)

¹⁷³³ *CA Natural Resources Agency. (2009, p. 4)

¹⁷³⁴ *CA Natural Resources Agency. (2009, p. 4)

¹⁷³⁵ *CA Natural Resources Agency. (2009, p. 4)

¹⁷³⁶ *CA Natural Resources Agency. (2009, p. 4)

¹⁷³⁷ CA Natural Resources Agency. (2009, p. 23)

¹⁷³⁸ CA Natural Resources Agency. (2009, p. 23)

¹⁷³⁹ *CA Natural Resources Agency. (2009, p. 4)

¹⁷⁴⁰ *CA Natural Resources Agency. (2009, p. 4)

¹⁷⁴¹ CA Natural Resources Agency. (2009, p. 4)

¹⁷⁴² U.S. EPA. *Environmental Justice Grant Recipients in the Pacific Southwest: Yurok Tribe Project (website)*. (2011)

¹⁷⁴³ *U.S. EPA. (2011)

technical training of the program staff and participation in national meetings.¹⁷⁴⁴ The project will engage the reservation community in potential localized changes through the production of educational materials, including a brochure outlining various opportunities to participate in local and regional climate change planning efforts.¹⁷⁴⁵

West Coast Governor's Agreement

On September 18, 2006 the Governors of California, Oregon and Washington announced the [West Coast Governors' Agreement on Ocean Health](#).¹⁷⁴⁶ The Agreement launched a new, proactive regional collaboration to protect and manage the ocean and coastal resources along the entire West Coast, as called for in the recommendations of the U.S. Commission on Ocean Policy and the Pew Oceans Commission.¹⁷⁴⁷ The [Executive Committee](#) established multiple workgroups, known as Action Coordination Teams (ACTs).¹⁷⁴⁸ At the present time, there are ten functioning ACTs: Climate Change, Integrated Ecosystem Assessment, Marine Debris, Ocean Awareness and Literacy, Polluted Runoff, Renewable Ocean Energy, Seafloor Mapping, Sediment Management, *Spartina* eradication, and Sustainable Ocean Communities.¹⁷⁴⁹ The primary objective of the Climate Change ACT is to create a framework and access to information that helps local governments wisely plan for the shoreline impacts resulting from climate change over the next several decades.¹⁷⁵⁰ The products from this ACT should assist state agencies in their various roles managing coastal lands, with an emphasis on those activities involving local land use and infrastructure planners as well as resource managers.¹⁷⁵¹ In addition, this group will provide recommendations to facilitate continuing coordination among the states and federal agencies by identifying the common regional issues and solutions.¹⁷⁵² Specifically, the Climate Change ACT seeks to provide access to tools and information that will allow the states to develop strategies necessary to address shoreline change, and for local governments to develop detailed vulnerability assessments.¹⁷⁵³

¹⁷⁴⁴ *U.S. EPA. (2011)

¹⁷⁴⁵ *U.S. EPA. (2011)

¹⁷⁴⁶ *West Coast Governor's Agreement on Ocean Health. *Homepage (website)*. (2011b)

¹⁷⁴⁷ *West Coast Governor's Agreement on Ocean Health. (2011b)

¹⁷⁴⁸ West Coast Governor's Agreement on Ocean Health. *Action Teams (website)*. (2011a)

¹⁷⁴⁹ West Coast Governor's Agreement on Ocean Health. (2011a)

¹⁷⁵⁰ *West Coast Governor's Agreement on Ocean Health. *Climate Change Action Coordination Team Work Plan (pdf)* (2010, p. 4)

¹⁷⁵¹ *West Coast Governor's Agreement on Ocean Health. (2010, p. 4)

¹⁷⁵² *West Coast Governor's Agreement on Ocean Health. (2010, p. 4)

¹⁷⁵³ *West Coast Governor's Agreement on Ocean Health. (2010, p. 4)