6. Ocean and Coastlines

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Washington State has a unique array of coastal and estuarine environments along the Pacific Ocean and Puget Sound. Around 70 percent of Washington residents live in counties that border the coast.[96] Coastal tourism, marine industries, and Washington's robust commercial fishing industry provide important jobs that sustain coastal communities. Washington's coastal areas and marine waters are not only an important economic engine for the state but also are central to the quality of life we enjoy. They provide vital recreational, transportation, and cultural benefits to Washington residents and support a stunning array of wildlife.

Climate change imposes pressures on coastal environments already experiencing environmental stressors from human activities and population growth. Rising sea level, storm surge, ocean acidification, and other climate impacts will pose serious risks for coastal communities and wildlife.

Because Washington has more than 3,000 miles of marine shoreline and a growing coastal population, understanding and planning for the effects of climate change on these environments is of paramount importance. The following sections describe the scientific understanding of the impacts of climate change on Washington's coasts and outline key strategies to support state and local efforts to protect these areas and lower risks to our communities and ecosystems.

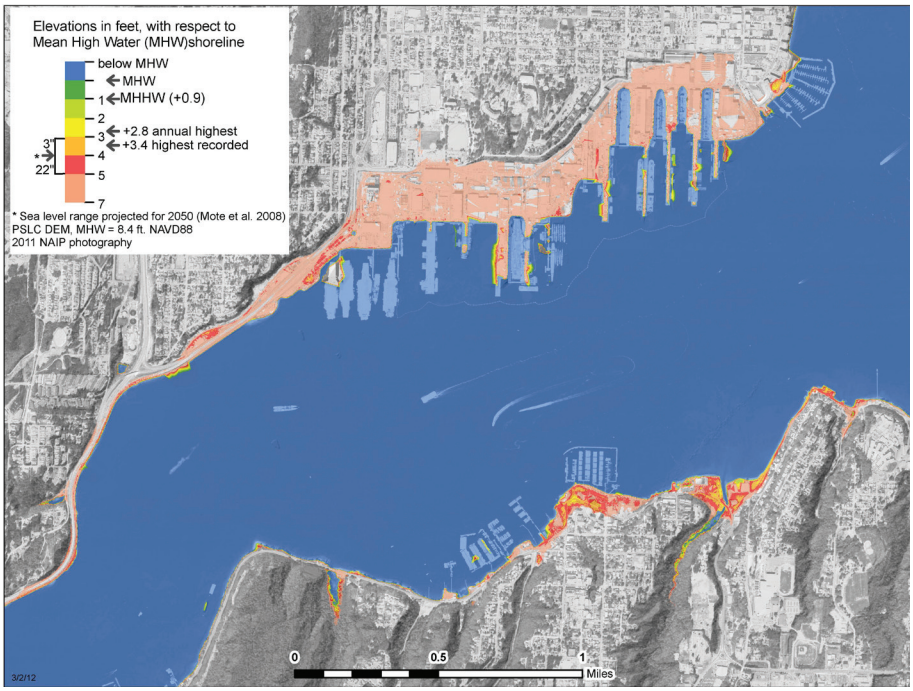
[96] U.S. Census Bureau (2010).

Impacts of Climate Change on Ocean and Coastlines

Climate change will affect coastal and marine environments in distinct ways:

- Sea level rise and storm surge will increase the frequency and severity of flooding, erosion, and seawater intrusion—thus increasing risks to vulnerable communities, infrastructure, and coastal ecosystems.
- Increased ocean acidity will affect marine ecosystems and Washington's commercial shellfish industry.[97]
- Warmer marine temperatures could alter the magnitude, frequency, and duration of harmful algal blooms and cause harmful effects to humans and animals.[98]
- Together, these impacts will have profound effects on Washington's coastal and marine areas and the resources they provide to our communities, wildlife, economy, and our way of life.

1 Sea level rise



Source: Washington State Department of Ecology

Global sea level is rising as a result of melting glaciers and ice caps and the expansion of warming ocean waters. Long-term tide gages and recent satellite measurements show that global sea levels rose approximately 8 inches from 1870-2008, an average of 0.06 inches per year. In the past decade, global sea level has risen at an accelerated rate of around 0.14 inches per year. Globally, sea level is expected to rise for several centuries due to current and projected greenhouse gas emissions and the oceans' delayed response to increasing global temperatures. [99] Current projections for global sea level rise by the end of this century are in the range of 3 to 4 feet or more, [100] well above the 7 and 23 inches that the Intergovernmental Panel on Climate Change projected in 2007.[101]

[97] Huppert *et al*. (2009); Feely *et al*. (2010).
[98] Huppert *et al*. (2009).
[99] IPCC (2007). Synthesis report
[100] Rahmstorf (2010).
[101] IPCC (2007a).

Sea level rise is expected to vary across regions of Washington State depending on several factors, such as changes in local land levels caused by tectonic movement, sedimentation patterns, and changes in wind patterns. Projections of sea level rise in Washington developed by Ecology and the University of Washington's Climate Impacts Group (see Table 1) indicate that Puget Sound and the central and southern outer coast (on the Pacific Ocean) are likely to experience more sea level rise than the northwest Olympia Peninsula. Through movement of the earth's crust, the northwest Olympic Peninsula is rising at a rate that is likely to offset rising sea levels in that region for most of the 21st century.[102]

Year	Puget Sound	Northwest Olympic Peninsula	Central and Southern Outer Coast
2050	+3 to +22 inches	-5 to +14 inches	+1 to +18 inches
2100	+6 to +50 inches	-9 to +35 inches	+2 to +43 inches

Table 1. Projected sea level rise estimates for Washington
Source: Mote et al. (2008).

Washington, Oregon, and California are jointly funding a National Academy of Sciences study to evaluate sea level rise on the West Coast for the years 2030, 2050, and 2100. The study will provide updated projections of sea level rise for Washington. The final report will be published in summer 2012 and will cover both global and local sea level rise factors and estimates.

2 Flooding and damage to coastal communities

Rising sea levels will increase the frequency and severity of coastal flooding, increase erosion, and result in greater levels of storm damage along developed shorelines. The hazards associated with coastal areas will grow, and the demand for protection and reconstruction will increase. Coastal defenses may become necessary in places where they do not yet exist. Existing defenses—including seawalls, and dikes—may become more vulnerable and need to be repaired or expanded.

At the same time, pressure for people to retreat from vulnerable areas and maintain natural coastal ecosystems will increase. Communities will face increasingly complicated decisions about balancing demands for stabilizing the shorelines with calls for protecting habitats and publicly accessible shorelines.

Hardened or armored shorelines

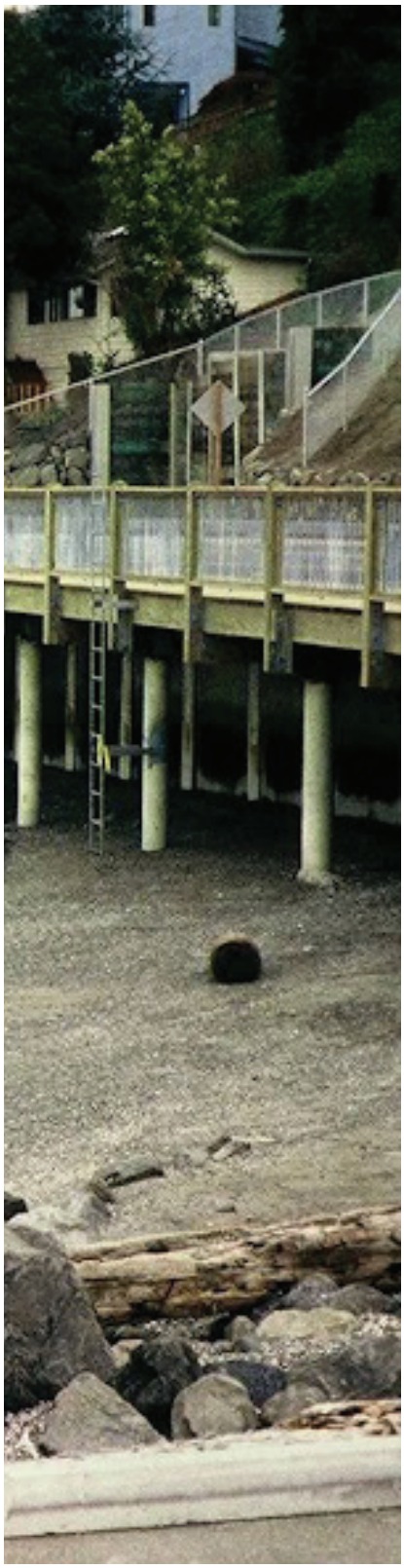
Many shorelines have been hardened with concrete, steel, gabions, or armor stone to prevent erosion. Such reinforcement usually results in the elimination of shoreline vegetation and cover that is important to fish and other wildlife.

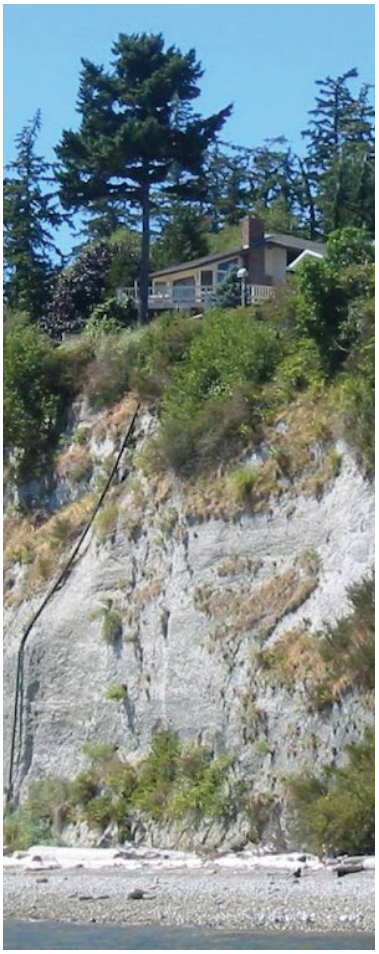
[102] Mote *et al*. (2008).

With increased vulnerability to coastal hazards, many communities will need to increase their attention to emergency management, hazard mitigation, and the costs of preparing for and recovering from natural disasters.

Levels of risk vary by location, and many specific impacts, such as the following, are possible:

- Coastal roads will be subject to more frequent closures and more frequent repairs.
- Shoreline parks will be subject to increased damages and closures. Access to the water and to natural shorelines will become more difficult as water levels rise and people construct hardened shorelines in response.
- Intrusion of seawater could damage equipment and strain the capacity of wastewater and stormwater systems. Backflow of water through stormwater pipes could cause localized flooding in low-lying areas. Drainage of low-lying areas will become more difficult, and stormwater management may require installation of tide gates, control works, and pump systems.
- Higher water tables and increased flood events may increase corrosion of underground utilities.
- Contaminated sites within shoreline areas may be affected by changes to water tables and increased flooding, spreading contaminants to Puget Sound and coastal marine waters.
- Sea level rise may affect fuel storage facilities and pipelines. Large oil handling facilities constructed their tanks, containment areas, and pipeline conveyance systems based on current water levels. Changes to the water level could alter the stability of the ground or the flow of groundwater, increasing the chance of a spill reaching Washington waters.
- Increasing storm severity off the Pacific Northwest coast could increase the risk of vessel incidents and oil spills.
- Puget Sound river deltas will be more vulnerable to longer-duration flooding, high water tables, and increased salinity, which could affect coastal agriculture and restoration projects.





3 Increase in erosion

Rising sea level is expected to increase shoreline erosion and the vulnerability of low-lying coastal areas to storms and flooding. On bluffs, which compose much of Puget Sound's shoreline, rapid erosion rates may put upland structures at risk and increase the likelihood of landslides. On spits and barrier beaches, erosion is likely to accelerate, and the potential for flooding and storm damage to low-lying areas will increase. Residential communities built on spits are common both in Puget Sound and on Washington's ocean coast. High-tide storms and chronic erosion already pose significant threats to many of these communities, and these threats will increase in the future. Extreme high tides can damage structures and utilities, contaminate water supplies, and cut off emergency access.

Rising sea level, erosion, and changes in surface water runoff patterns will alter coastal sediment transport systems from current trends that are in relative equilibrium. These changes could result in the delivery of a large volume of eroded sediment to new areas, or to existing areas in newly increased quantities, disrupting both ecosystem services and human infrastructure. Examples include ports that will require more frequent dredging and aquaculture areas and other nearshore habitats (like eelgrass beds) that are impaired by additional sediment.

In addition, small bays that now have inlets with sheltered salt marsh habitats could close from sediment buildup, with significant impacts to the associated salt marsh and coastal ecosystem. These changes will cause additional loss of those habitats, along with others inundated by rising sea levels.

4 Disruptions and damages to ports and harbors

The ports of Seattle and Tacoma are important gateways for international trade, and are the third largest load center for containers in North America. Other major ports in Washington include the Ports of Everett, Bellingham, Olympia, Grays Harbor, Vancouver, Longview, and Port Angeles. Rising sea levels could affect port operations, damage seawalls and structures, and flood low-lying port land and surrounding transportation networks. The severity of impacts will depend on the local rate of sea level rise, the proximity to rivers subject to flooding, and the dependence of the port on vulnerable transportation links.

Marinas and waterfront recreation facilities could also require more frequent repairs and modifications. Changes in the water level and coastal erosion could submerge or undermine fuel tanks for marinas and other facilities, which often locate their tanks close to their operations.

5 Loss of coastal habitats

Beaches and nearshore areas provide critical habitat for innumerable species of fish and wildlife.

In their natural state, beaches and bluffs are fairly resilient to modest increases in sea level rise. Erosion may increase, but beaches can shift landward, preserving their associated habitats. In addition, increased erosion provides sediment to nearby beaches that makes them more resilient to rising water levels. On developed and armored shorelines, however, erosion is prevented, and higher sea levels will squeeze out beaches and nearshore habitats.

One of the challenges of rising sea level is that it will increase the pressure to harden the shoreline. Armoring of shorelines to protect upland development prevents the natural migration of sediment that maintains beaches and coastal marshes, resulting in more rapid beach erosion; loss of critical habitat for young fish, shorebirds, shellfish, and other species; and ultimately decreased resilience of coastal environments.

Rising sea levels may diminish and even destroy coastal marshes and wetlands. Some coastal wetlands may be able to migrate landward as sea level rises, but where dikes or natural topography prevent this movement, wetlands may be lost. In addition, salt marshes may be able to expand vertically as water levels rise but only if natural sources of sediment are maintained.

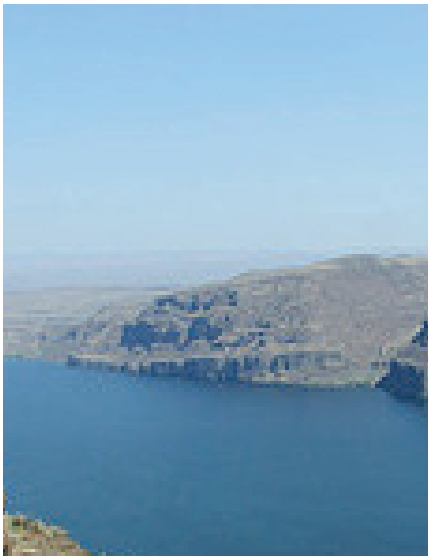
Nearshore environments along the Pacific coast and Puget Sound will likely face dramatic shifts in the extent and diversity of marshes, swamps, beaches, and other habitats.[103] With 27 inches of sea level rise, impacts to coastal ecosystems could include:

- Loss of two-thirds of the low tidal areas in Grays Harbor and Willapa Bay.
- Loss of 11 to 56 percent of freshwater tidal marsh in Grays Harbor, Willapa Bay, and Puget Sound.
- Loss of 40 percent of freshwater tidal areas in Whatcom, Skagit Bay, and Snohomish.[104]

[103] Glick *et al*. (2007).
[104] Ducks Unlimited (2010a, 2010b, 2010c, and 2010d).

6 Saltwater intrusion into coastal aquifers and rivers

Sea level rise could cause an increase in saltwater intrusion in coastal aquifers known to be hydraulically connected to saltwater bodies. The San Juan Islands and several coastal areas are susceptible to seawater intrusion. Groundwater is the main source of freshwater supplies for the Islands. The small amount of yearly precipitation keeps the islands' groundwater system in a fragile balance between the recharge rates and the groundwater pumping. Increased pumping rates may upset this balance and result in seawater intrusion into nearshore aquifers. Expert opinion suggests that sea level rise will have only a minor effect on coastal aquifers, however, and the amount of freshwater available is not expected to change for coastal areas. [105]



7 Increasing ocean acidity

The world's oceans absorb carbon dioxide (CO_2) from the atmosphere. As the oceans soak up excess carbon emissions, the chemistry of the seawater changes—both locally and globally. This absorption alters the ocean's natural acid-base balance. This move toward a lower pH value is called ocean acidification.

Washington State is particularly vulnerable to ocean acidification. Washington's coastal waters experience seasonal upwelling where waters that are naturally low in oxygen and rich in CO_2 rise to the surface. Coastal waters also receive excess nitrogen from human activities that can stimulate algae blooms. As these blooms die and sink, bacteria decompose them, depleting oxygen from the surrounding water. The combined effects of upwelling, nitrogen inputs, and low oxygen zones mean that Washington is likely to see the impacts of ocean acidification on marine organisms earlier than other coastal areas.

Ocean acidification and climate change

Ocean acidification is related to but distinct from climate change, though they share a common cause—increasing carbon dioxide in the atmosphere. Climate change encompasses the effects associated with changes in the Earth's temperature, which cause global warming and changes in weather patterns.

Ocean acidification refers to the lowering of ocean pH resulting from its increased absorption of carbon dioxide from the atmosphere. Ocean acidification does not include the warming of the ocean.

[105] Huppert *et al*. (2009).

Many animals and plants rely on calcium carbonate to form their skeletons or shells. The trend toward more acidic conditions can reduce the calcification in shellfish species including oysters, clams, scallops, mussels and other species. Acidified waters are suspected of contributing to a recent crisis in larval supplies in the Northwest's shellfish industry. The effects of ocean acidification are serious and real, putting at risk Washington's:

- Shellfish aquaculture.
- Commercial and tribal harvesting of wild shellfish resource.
- Important fish species that use marine plankton as a vital food source.

A decline in the shellfish and marine food web could also have serious economic consequences. Washington leads the country in production of farmed clams, oysters and mussels with an annual value of over $107 million a year.[106] Washington shellfish growers directly and indirectly employ more than 3,200 people and provide an estimated total economic contribution of $270 million each year. In addition, tourists and residents purchase more than 300,000 licenses to harvest clams and oysters from Washington waters, providing more than $3.3 million per year in state revenue.

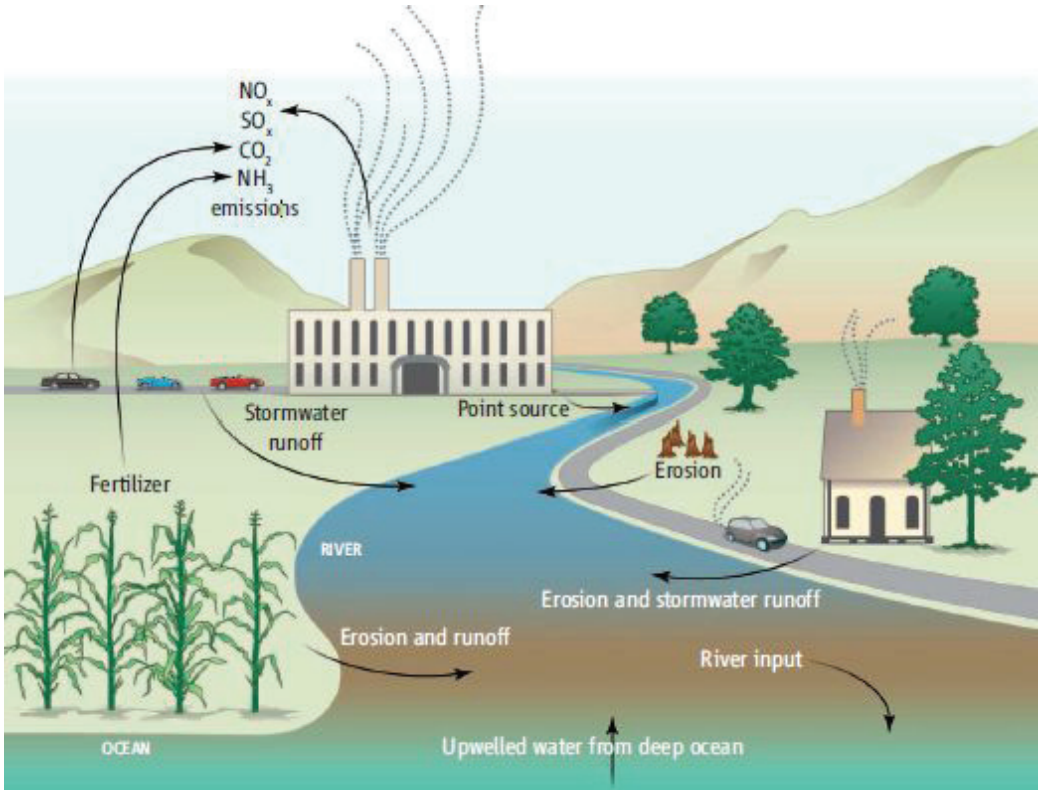


Figure 3. Contributors to ocean acidification[107]

[106] Northern Economics, Inc. (2010).
[107] Kelly *et al*. (2011).

8 Algae blooms and coastal hypoxia

Harmful algal blooms (HABs) are overgrowths of algae that can produce potent toxins. These toxins harm humans and other animals that eat contaminated fish or contact contaminated water. Warmer water and air temperatures promote algae blooms and may also promote earlier and longer-lasting blooms. Increase in nutrient rich runoff from rivers could also increase the frequency of algae blooms in coastal waters.[108]

Hypoxia: low oxygen concentration

More spring runoff and warmer coastal waters will worsen the seasonal reduction in oxygen resulting from excess nutrients. **Dead zones**—areas with low oxygen—are likely to increase in size and intensity as temperatures rise unless efforts to control runoff are strengthened.[109]

[108] Huppert *et al*. (2009).
[109] U.S. Global Change Research Program (2009).

Recommended Adaptation Strategies and Actions—Ocean and Coastlines

We already have some excellent tools and strategies for better managing our shorelines. The strategies and accompanying actions described below will help us better prepare for and adapt to climate change impacts on Washington's Pacific Coast, Puget Sound, and coastal communities by:

- Limiting new development in highly vulnerable areas.
- Protecting the shoreline from rising sea levels using green or "soft" alternatives to traditional "hard" shore armoring, seawalls, and dikes.
- Accommodating rising sea levels through engineering and construction practices or raising the height of piers or buildings.
- Managing retreat from highly vulnerable sites.
- Restoring and maintaining wetlands, preserving sediment transport processes, and preserving habitat for vulnerable species.
- Enhancing monitoring and research of ocean chemistry changes and effects on marine ecosystems.

Managed retreat:

Managed retreat is the deliberate process of altering barriers or other defenses to allow flooding of a presently defended area. Such efforts can reduce both coastal flooding and erosion. Managing this flooding process helps to reduce risk and negative impacts.

Strategy C-1. Lead by example by developing a state framework to guide decision-making and protect people, assets, and natural areas from coastal hazards.

Actions:

1. Evaluate and propose revisions of laws and rules that govern land use, shoreline management, and other programs to effectively address sea level rise and other climate change impacts.

2. Develop guidance and require state agencies to integrate current and anticipated coastal climate impacts into planning, policies, programs, and investment decisions related to:

   - *Land use.*
   - *Transportation.*
   - *Shoreline management.*
   - *Economic development.*
   - *Facility siting and design.*
   - *Conservation and restoration.*
   - *Emergency preparedness.*

3. Require all projects that the state funds, permits, or approves in vulnerable coastal areas to consider the effects of sea level rise and other coastal hazards. Evaluate alternatives to reduce vulnerability and protect communities and coastal ecosystems.

4. Identify essential public infrastructure at risk and develop a decision-making process to determine when to protect, retrofit, relocate, or manage retreat.

5. Revise oil spill response plans to consider climate change. The plan revisions should include geographic-specific response strategies based on risk assessments and considerations of changes in infrastructure and logistical support.

6. Recommend an institutional arrangement to align state agencies' coastal adaptation strategies and actions, help prioritize actions across state agencies, and enhance emergency preparedness and response to extreme weather events.

Strategy C-2. Avoid development in highly vulnerable areas and promote sustainable development in appropriate, less vulnerable areas.

Actions:

1. Provide guidance, updated maps, tools, and information to help local jurisdictions assess risk and vulnerability and incorporate best available information on sea level rise, climate impacts, and adaptation options into their planning, regulations, project siting, and permitting.

2. Identify incentives and regulatory tools to reduce exposure to risk and discourage new public development in coastal areas at high risk from erosion, landslides, flooding, and storm surges. The tools should include:
   - *Acquisitions and easements.*
   - *Transfers of development rights.*
   - *Setbacks.*
   - *Rebuilding restrictions.*
   - *Tax incentives and fees.*

3. Update various planning guidelines and provide incentives to local governments to consider impacts of climate change and adaptation actions when amending shoreline master programs, land use management plans, and other plans.

4. Develop policies and information to guide insurers in dealing with properties in vulnerable areas. Inform property purchasers and investors regarding sea level risks that may affect coastal property.

5. Assess damage costs and remove incentives that encourage rebuilding in at-risk areas.

6. If rebuilding is the only option, construction techniques and building code amendments should be adopted to increase resilience and reduce risk to development projects.

Swinomish Climate Change Initiative

In 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 recommended actions to adapt to projected impacts.

With expert assistance from scientists at the University of Washington Climate Impacts Group, in 2009 the Tribe issued the *Impact Assessment Technical Report*, an assessment of projected impacts. The report identified potential impacts from sea level rise and storm surge on infrastructure and tribal land. Detailed maps were developed highlighting coastal inundation risk zones on tribal lands and in neighboring areas.

In 2010, the Swinomish published the *Climate Adaptation Action Plan* outlining actions to help build a climate-resilient community that can meet the challenges of anticipated climate impacts in the years to come.

www.swinomish-nsn.gov/climate_change/climate_main.html

Strategy C-3. Accelerate efforts to protect and restore nearshore habitat and natural processes.

Actions:

1. Identify priority conservation and restoration areas that can increase natural resiliency and protect vulnerable communities. Identify regulatory and non-regulatory mechanisms that local jurisdictions can use to conserve and protect those areas.

2. Develop guidelines for state agencies, local governments, watershed groups, nongovernmental organizations, and others to address sea level rise in coastal habitat restoration and protection. Direct state agencies to use the guidelines to incorporate sea level rise into state-managed and supported coastal restoration and protection projects.

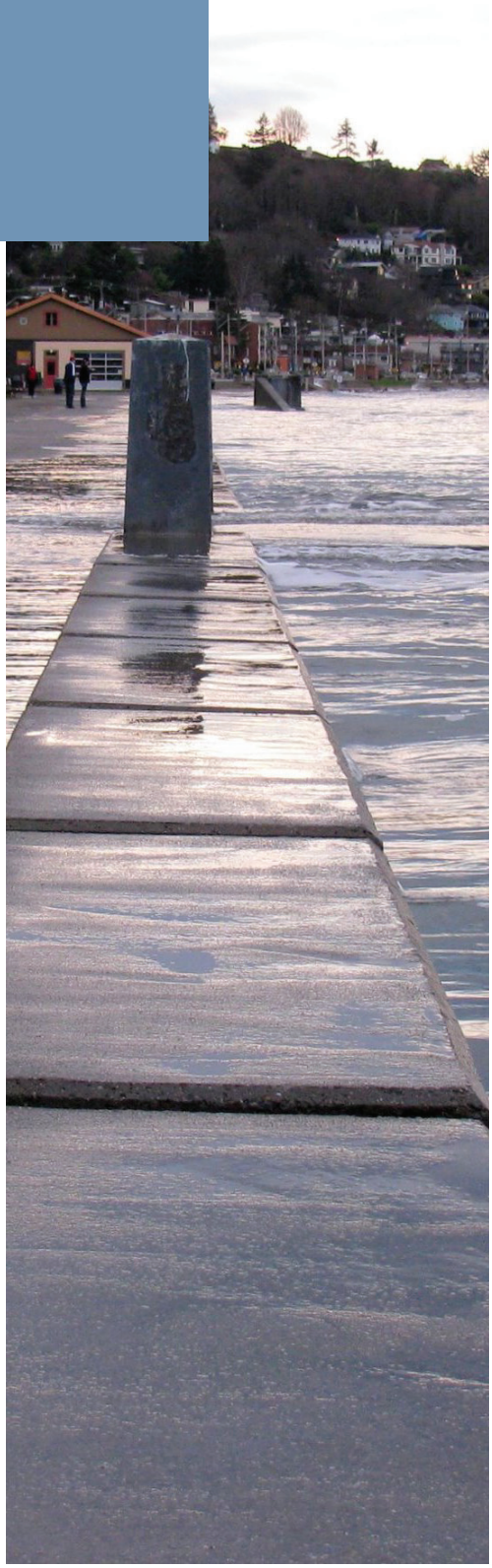
3. Identify feasible state level policy options to avoid or minimize shoreline hardening, especially in Puget Sound. Policy options should seek to streamline state and local permitting processes to provide incentives for green shoreline and soft armoring practices.

4. Develop a program to promote green shoreline programs for Puget Sound and some urbanized coastal areas. This program can be built on the lessons learned from pilot projects currently in progress in San Juan County and Lake Washington (City of Seattle), as well as the green shores initiative in British Columbia.[110] Develop and provide state and local jurisdictions with green shoreline design manuals for different types of shoreline along Puget Sound and the Pacific coast.

5. Incorporate future sea level rise in the prioritization, design, and post-project maintenance of toxic clean-up sites near the shoreline.

[110] For more information on green shores in Canada, visit www.greenshores.ca

Strategy C-4. Build local capacity to respond to coastal climate impacts by providing tools to assess vulnerability and advancing research, monitoring, and engagement efforts.



Actions:

1. Complete a coast-wide (including Puget Sound) sea level rise vulnerability assessment. Update periodically as new and improved scientific information becomes available.

2. Identify and provide local jurisdictions with information, web-based tools, training, case studies, locally effective adaptation policies and actions, and other resources needed to build resilient coastal communities. Case studies could address, for example, how communities are using the National Oceanic and Atmospheric Administration's (NOAA) Digital Coast, which provides data, tools, and training to help manage coastal resources.

3. Assist coastal planners with activities such as:
   - *Simulating potential impacts of long-term sea level rise on wetlands and shorelines.*
   - *Analyzing risks and potential losses from floods, sea level rise, and storm surges.*
   - *Mapping hazard areas.*
   - *Assessing and evaluating the risks from sea level rise and other climate change impacts in local jurisdictions.*
   - *Enhancing sustainable development in coastal areas.*
   - *Identifying community exposure to climate change—considering land cover, land use, zoning, structures, vacant lots, parcel values, and social disruption.*

4. Identify potential funding mechanisms and help local governments seek funding to incorporate climate adaptation into plans, policies, and projects.

Washington's Coastal Planning for Climate Change Training

The Coastal Training Program's Planning for Climate Change course is designed for planners to increase awareness about climate impacts to Pacific Northwest shorelines and specific action steps to prepare for climate change.

The Coastal Training Program provides practical, science-based training to professionals who make decisions about coastal management in Washington State. The program is administered through the Padilla Bay National Estuarine Research Reserve, which is part of the Department of Ecology and NOAA.

www.coastaltraining-wa.com

5. Assist local jurisdictions in raising awareness about the impacts of sea level rise and the need for adaptation actions by providing educational materials, participating in local events, and engaging the communities in efforts such as the King Tides, Washington Beach Program, and water quality monitoring programs.

6. Collaborate with local partners—including local governments, tribal governments, federal agencies, universities, nonprofits, NOAA Sea Grant, and National Estuarine Research Reserves—to monitor the effectiveness of climate adaptation tools and options and to identify changes that are needed.

7. Expand essential data collection and monitoring programs to improve our understanding of climate impacts, including:
   - *The impacts of sea level rise and storm surge on the shoreline.*
   - *Changes in erosion.*
   - *Unstable bluffs.*
   - *Saltwater intrusion and inundation of freshwater areas.*

8. Develop an inventory of dikes, levees, tide gates, clean-up sites, nearshore fuel storage facilities, and other facilities. Provide this information to local jurisdictions and others to plan for and adapt to rising sea levels and coastal hazards and to aid investment decisions in coastal areas. Ensure that the inventory products and maps are widely available to planners, agencies, tribes, and other users.

Strategy C-5. Enhance our understanding and monitoring of ocean acidification (pH) in Puget Sound and coastal waters as well as our ability to adapt to and mitigate effects of seawater acidity on shellfish, other marine organisms, and marine ecosystems.

Actions:

1. Support the work of the newly created Blue Ribbon Panel on Ocean Acidification, convened under the auspices of the Washington Shellfish Initiative. The Panel will focus on documenting the current state of scientific knowledge and ways to advance our scientific understanding of the effects of ocean acidification. The Panel will recommend actions to respond to increasing ocean acidification, reduce harmful effects on Washington's shellfish and other marine organisms, and adapt to the impacts of acidified waters. A report will be submitted to the Governor, NOAA's administrator, regional research groups, and other policymakers in October 2012.

2. Expand collaboration with NOAA Fisheries, other federal agencies, nonprofit organizations, academic groups, and the shellfish industry to enhance monitoring to track biological and chemistry changes in the Pacific Ocean, Puget Sound, and coastal areas of Washington, including key areas such as Hood Canal and Willapa Bay.

Washington Shellfish Initiative

In December 2011, Washington became the first state in the nation to have the Governor endorse an agreement among federal and state government, tribes, and the shellfish industry to respond and expand Washington's shellfish resources, promote clean-water commerce, and create family-wage jobs.

The agreement builds on the National Shellfish Initiative created by the National Oceanic and Atmospheric Administration (NOAA) to stimulate coastal economies and improve the health of ailing estuaries through increasing commercial shellfish production and native shellfish populations and habitats in our nation's waters.

As a part of the Washington Shellfish Initiative, and with strong support from the NOAA administrator and scientists, Governor Gregoire has convened a Blue Ribbon Panel on Ocean Acidification of leading tribal, local, state, and federal policymakers; scientific experts; public opinion leaders; and industry representatives.

For more information:

www.ecy.wa.gov/water/marine/oceanacidification.html

NANOOS: Creating customized ocean information and tools

The Northwest Association of Networked Ocean Observing Systems (NANOOS) is a partnership of federal and state agencies, local governments, tribes, nongovernmental organizations, industry, and educational institutions involved in a wide range of decisions about our oceans and estuaries.

NANOOS is the regional association of the national Integrated Ocean Observing System (IOOS) in the Pacific Northwest, primarily Washington and Oregon. The system operates several buoys in the Puget Sound monitoring hypoxia (low oxygen concentrations), algae blooms (indicated by chlorophyll), and climate effects (especially on temperature, salinity, and underwater sunlight penetration).

A pilot project between NANOOS and the National Estuarine Research Reserve System is providing real-time water quality data for shellfish growers in the Pacific Northwest, which can help oyster growers determine whether oysters have enough oxygen.

www.nanoos.org

3. Coordinate with state and federal agencies to improve monitoring by evaluating and adopting improved pH measurement protocols to support fine-scale data analysis and tracking of small changes in pH. Create a new baseline data set.

4. Continue to actively address problems of pollutants in marine waters (which add to acidity problems) by studying toxics and nutrients entering Puget Sound. Develop models to determine the effects of nitrogen discharges on dissolved oxygen levels in Puget Sound. Evaluate trends in water quality over time and detect emerging issues.

5. Continue to explore how Clean Water Act authorities can be used to prevent or reduce localized effects from ocean acidification and climate change.