



The State of Marine and Coastal Adaptation in North America: A Synthesis of Emerging Ideas

Final Report
January 2011



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Table of Contents

Executive Summary	9
I. Introduction	11
II. Summary of Marine and Coastal Climate Change Impacts.....	11
A. Rising Air and Sea Temperatures	12
B. Sea Level Rise.....	16
C. Precipitation Changes	19
D. Circulation Changes (currents, winds, upwelling)	22
E. Changes in Ocean Chemistry (pH and salinity)	25
III. Adapting to and Preparing for the Effects of Climate Change – Approaches and Projects	29
A. A Framework for Action.....	30
B. Five Tenets of Adaptation.....	30
1. Protect adequate and appropriate space for a changing world.....	31
2. Reduce non-climate stressors that interact negatively with climate change or its effects.....	31
3. Manage for uncertainty.....	32
4. Reduce local and regional climate change.....	32
5. Reduce greenhouse gas emissions.....	33
C. Adaptation Projects and Initiatives	33
1. Natural Resource Management and Conservation	35
2. Capacity Building	46
3. Infrastructure, Planning, and Development.....	61
4. Governance and Policy	67
IV. Trends and Opportunities	74
A. Assessments of vulnerability and risk to natural resources and coastal communities 74	
B. Scientific research on climate change with policy implications for adaptation.....	76
C. Integration of climate change concerns in the development and implementation of committees and plans.....	78

D.	Integration of climate change and its effects into programmatic and collaborative approaches to research, management, and planning	79
E.	Incorporation of information on the effects of climate change and approaches to adaptation into outreach and education efforts.....	82
F.	Restoration and protection of ecosystems to increase resilience and reduce vulnerability to climate change	83
G.	Climate change efforts in Mexico.....	85
V.	Conclusions.....	87
VI.	References.....	88
VII.	Appendices	96
A.	Glossary.....	97
B.	Methodology.....	98
C.	Partial list of reports that assess climate change impacts in geographic and sectoral detail from North America.....	100
D.	Partial list of reports that address climate change adaptation in North America.....	104
E.	Tools for Adaptation	107
F.	Inventory of adaptation projects by geographic region	110
G.	Adaptation projects by type of strategy.....	119
1.	Natural Resource Management and Conservation	119
2.	Capacity Building	126
3.	Infrastructure, Planning, and Development.....	138
4.	Governance and Policy	141

Tables

Table 1. Temperature changes (air and water).....	14
Table 2. Sea Level Rise (local and global).....	17
Table 3. Precipitation Changes (hydrological cycle)	20
Table 4. Circulation Changes (currents, winds, upwelling)	23
Table 5. Changes in Ocean Chemistry (pH, salinity)	27

Executive Summary

Climate change is now widely acknowledged as a global problem that threatens the success of marine and coastal conservation, management, and policy. Mitigation and adaptation are the two approaches commonly used to address actual and projected climate change impacts. *Mitigation* applies to efforts to decrease the rate and extent of climate change through the reduction of greenhouse gas emissions or the enhancement of carbon uptake and storage; *adaptation* deals with minimizing the negative effects or exploiting potential opportunities of climate change. Because the benefits of mitigation are not immediate and because we are already committed to a certain amount of climate change, adaptation has been increasingly viewed as an essential component of an effective climate change response strategy. The field of adaptation is developing rapidly but in an *ad hoc* fashion, and organizations and governments are often challenged to make sense of the dispersed information that is available.

The intent of this report is to provide a brief overview of key climate change impacts on the natural and built environments in marine and coastal North America and a review of adaptation options available to and in use by marine and coastal managers. This report presents the results of EcoAdapt's efforts to survey, inventory, and assess adaptation projects from different regions, jurisdictions, and scales throughout North America's marine and coastal environments.

First, we provide a summary of climate changes and impacts, including temperature changes, sea level rise, precipitation changes, air and water circulation changes, and changes in ocean chemistry, on the marine and coastal environments of the United States, Canada, and Mexico.

Second, we provide a summary of commonly used adaptation approaches and examples from our inventory of projects. We separate the examples, representing diverse activities, sectors, and targeted climate impacts, into four broad categories:

1. *Natural Resource Management and Conservation*

Strategies include incorporating future climate conditions and impacts into existing or future policies and plans, and changing management to enhance ecosystem connectivity, resilience, and monitoring and research efforts, among others.

2. *Capacity Building*

Strategies include acquiring or training staff, increasing organizational capacity, coordinating planning and management, investing in planning, training, and outreach efforts, collecting additional information, and conducting vulnerability assessments and studies, among others.

3. *Infrastructure, Planning, and Development*

Strategies include improving existing or designing new infrastructure to withstand the effects of climate change, creating or modifying shoreline development measures (i.e. removing shoreline hardening, restoring coastal vegetation to minimize erosion, encouraging low impact development along shorelines), and incorporating climate change concerns in community and shoreline planning, among others.

4. *Governance and Policy*

Strategies include maintaining or obtaining financial, public health, and technological resources, creating new or enhancing existing policies, and developing adaptation plans, among others.

Adaptation examples are presented and organized by the following geographic regions: **Arctic Canada** (Yukon, Northwest Territories, Nunavut), **Eastern Canada and Northeast USA** (New Brunswick, Newfoundland and Labrador, Nova Scotia, Ontario, Prince Edward Island, Quebec; Maine, Connecticut, Massachusetts, New Hampshire, Rhode Island), **Mid-Atlantic USA** (Delaware, Maryland, New Jersey, New York, Pennsylvania, District of Columbia, Virginia), **Southeast/Gulf USA** (North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Texas), **Gulf of Mexico and Yucatan Peninsula – Mexico** (Tamaulipas, Veracruz, Tabasco, Campeche, Yucatan, Quintana Roo), **Alaska and British Columbia, Pacific States USA** (Washington, Oregon, California, Hawaii), **Baja Peninsula and Pacific Coast – Mexico** (Baja California, Baja California Sur, Sonora, Sinaloa, Nayarit, Jalisco, Colima, Michoacan, Guerrero, Oaxaca, Chiapas), **Nationwide USA, Nationwide Canada**, and **Nationwide Mexico**.

Finally, the report concludes with a discussion of the common barriers and trends uncovered by the inventory of adaptation projects. Although real and perceived barriers can inhibit adaptation action, the projects discussed exemplify how to overcome these barriers by improving understanding of climate science, risks, and vulnerabilities; investing in capacity building, acquisition of resources, and outreach and education; and developing collaborative partnerships. We organize these approaches by the following characteristics:

- Assessments of vulnerability of and risk to natural resources and communities
- Scientific research on climate change with policy implications for adaptation
- Integration of climate change concerns in the development and implementation of committees and plans
- Integration of climate change and its effects into programmatic and collaborative approaches to research, management, and planning
- Incorporation of information on the effects of climate change and approaches to adaptation into outreach and education efforts
- Restoration and protection of ecosystems to increase resilience and reduce vulnerability to climate change

We acknowledge that climate adaptation is a rapidly changing field of study and that new science and approaches are being developed on a steady basis. Our survey is still underway and we have designed this report to be iterative so that it can be updated as new information and projects are inventoried or developed and implemented.

I. Introduction

Around the world, people are working to minimize climate change and its actual and projected impacts. Both mitigation and adaptation are approaches to managing the risks, vulnerabilities, and impacts of climate change, but with different foci. *Mitigation* applies to efforts to decrease the rate and extent of climate change through the reduction of greenhouse gas emissions or the enhancement of carbon uptake and storage; *adaptation* deals with minimizing the negative effects or exploiting potential opportunities of climate change (ADB 2005; IPCC 2007a; Bizikova et al. 2008). Because the benefits of mitigation are not immediate and because we are already committed to a certain amount of climate change, adaptation has been increasingly viewed as an essential component of an effective climate change response strategy.

II. Summary of Marine and Coastal Climate Change Impacts

Marine and coastal areas in North America already experience a multitude of climate change related impacts. These changes are beginning to affect ecological and socioeconomic aspects of marine and coastal systems. In this section, we provide a brief overview of the current and projected manifestations of climate change on marine and coastal systems. We have chosen to focus on five types of marine and coastal change: changes in air and water temperatures, sea level rise, changes in precipitation patterns, altered ocean and atmospheric circulation, and changes in water chemistry. We describe each type of change briefly and then provide place-based examples of its effects. This list is not intended to be comprehensive, but rather is designed to illustrate the variety and types of climate change effects throughout North America. Much as the same disease can elicit different symptoms depending upon the patient, climate change and its effects will vary based upon locale. For example, sea level rise in rural Washington State is causing land loss and saltwater inundation of aquatic lands,¹ while in the city of Olympia, Washington, sea level rise is projected to cause flooding in the city center as marine waters travel through existing stormwater systems into the interior of the city;² same phenomenon, different effects.

The supporting tables outline key climatic and physical factors causing each type of change, and describe potential consequences for natural and human systems. We also list some of the compounding physical and anthropogenic factors that may complicate the effects of climate change. This last category underscores the potential synergistic effects between global climate change and changes in local and regional processes in marine and coastal systems.

None of these changes occur in isolation; they operate in concert with each other, feeding back into one another and amplifying or dampening effects. For example, changes in sea level are a function of changes in atmospheric temperature, while changes in oceanic and

¹ [Preparing for Climate Change on State-Owned Aquatic Lands in Washington State](#)

² [Planning for Sea Level Rise in Olympia, Washington](#)

atmospheric circulation alter Earth's heat distribution and hence affect regional temperatures. The one common denominator amongst all of the climatic changes is greenhouse gas concentrations.

Predicting exact climatic changes and effects is difficult because how much and how soon change happens depends on future greenhouse gas emissions, the sensitivity of the system, and the level of preparedness and adaptation measures in place. This section does not provide predictions, but does provide a broad overview of current and projected manifestations and effects of climate change, and offers some place-specific examples where the effects of climate change are already being felt.

A. Rising Air and Sea Temperatures

Increasing atmospheric greenhouse gas concentrations are warming the lower atmosphere and changing the earth's radiative balance. Air temperatures in North America are projected to warm between 1.1 and 6.4°C by 2100 (IPCC 2007b). The annual average temperature for 2010 will likely be higher than any other year since 1880. In the past decade alone, global surface temperature has increased by 0.8°C relative to the beginning of the 20th century with two-thirds of the warming occurring since 1975 (Hansen et al. 2010).

Ocean temperature changes lag behind atmospheric temperatures because of the much greater mass of the ocean, relatively slower circulation patterns and rates, and the differing heat capacities of air and water. The Intergovernmental Panel on Climate Change (2007) has projected that ocean temperatures could increase between 1 and 3°C by 2100. Currently, some of the largest sea surface temperature excursions are occurring along the mid-Atlantic coasts of the United States where there has been a 1.2 and 1.6°C per century warming trend since 1900 (Deser et al. 2010).

Even if anthropogenic greenhouse gas emissions ceased today, the climate would still continue to warm until the thermal inertia of the ocean and atmosphere equilibrated (Soloman et al. 2009). Geographically diverse examples of temperature changes and other related impacts include:

- The Northern Hemisphere mid-latitudes (including in the **United States** and **Canada**) have had a substantial increase in average nighttime temperatures over the past 25 years (Alexander et al. 2006). Fewer nighttime frosts and cold snaps have been associated with the increases in some harmful insects (Bale and Hayward 2010).
- Decreased winter sea ice area and thickness in **Arctic Canada** and **Alaska** due to warmer air and water temperatures have enhanced coastal erosion rates as shorelines become more exposed to waves and storm surges as the ice retreats (ACIA 2005).
- Warmer waters may cause a northern shift of the Atlantic cod off the coast of **Eastern Canada** and **Northeast USA**, altering fishing activities in the North Sea (Portner et al. 2001).

- Permafrost is thawing in **Arctic Canada** and **Alaska**, damaging or destroying infrastructure as the land slumps and deforms as it warms (ACIA 2005).
- Increased water temperatures could stress some marine fish species, catalyzing the northern movement of fish stocks seeking thermal refugia in both the **Pacific and Atlantic oceans of North America** (USGCRP 2009).

Table 1. Temperature changes (air and water)		
Climatic factors	Sector	Effects
<p>Increased greenhouse gas concentrations alter the radiative balance on Earth and ultimately increase the amount of heat the atmosphere traps.</p> <ul style="list-style-type: none"> • Rising air temperature: According to the IPCC, North America is projected to warm between 1.1-6.4°C by 2100. • Rising sea temperature: Approximately 80% of the atmospheric heat will eventually be absorbed by the oceans. An increase in sea-surface temperature between 1-3°C is expected by 2100. 	Species	<ul style="list-style-type: none"> • Altered species' migration patterns • Range shifts: shifts in species distribution • Community shifts: changes in which species co-occur, and in interactions among species • Phenological shifts: changes in development, age of sexual maturity, timing of spawning, growth, and survival • Reduction in species resilience because of thermal stress, leading to increased disease outbreaks • Increased fitness for some species (e.g. many insects, both beneficial and harmful)
	Ecosystems/ habitats	<ul style="list-style-type: none"> • Altered oceanic current and circulation patterns and rates • Decreased regional upwelling could reduce nutrient availability, leading to lower productivity in surface waters • Increased risk of invasive species establishment • Increased algal blooms and dead zones • Loss of sea ice
	Economy/ infrastructure/health	<ul style="list-style-type: none"> • Loss of coastal protection by wetlands and coral reefs • Loss of coral reefs and supported fisheries and altered fisheries as fish migrate north • Increased damage from extreme weather events and storm surges
Compounding Factors:		

- ***Changes in land use and land cover:*** Deforestation, clearing vegetation, and burning release trapped carbon into the atmosphere, further increasing greenhouse gas concentration and temperatures. Also, deforestation significantly increases the rate and extent of local and regional heating and drying; conversion of vegetated areas to buildings or other infrastructure has a similar but smaller effect. Use of impermeable pavements can increase flood intensity and frequency as well as contribute to overall drying and warming. For these and other reasons, cities become/act as urban “heat islands.”
- ***Natural climatic variations:*** Air and water temperature can also be affected by natural climate patterns, such as the El Niño-Southern Oscillation, the Pacific Decadal Oscillation, changes in the sun’s solar activity and volcanic eruptions.
- ***Reduced ice and albedo:*** Snow and ice reflect solar radiation back into space, minimizing heat absorption. Loss of snow and ice increases regional heat absorption when darker surfaces, such as the ocean or land, are exposed beneath.
- ***Permafrost thawing:*** As temperatures rise, permafrost in the northern latitudes will thaw. As the soil warms, long sequestered carbon, such as methane, may be released into the atmosphere, increasing greenhouse gas concentrations and subsequently, air temperature. This has compounding effects for the high latitude ecosystems where plant and animal species have adapted to a stable permafrost regime.
- ***Aerosols:*** Aerosols are fine particles suspended in the atmosphere (e.g., smog, smoke, etc.). Depending upon their composition, they can either have a net cooling or warming effect on the climate.

B. Sea Level Rise

Increases in atmospheric greenhouse gas concentrations are causing global air, and subsequently, water temperatures to rise. Climate change-related sea level rise is attributed to two phenomena: 1) thermal expansion and 2) increases in freshwater input. As the ocean absorbs heat and warms up, water expands, causing global sea level to increase. Warmer air temperatures are also increasing the rate of melting and freshwater input from glaciers and terrestrial ice caps to the ocean.

Assessing the rate and total amount of sea level rise is difficult due to a shortage of historic instrumental records. However, it is estimated that sea level increased by 19.5 cm from the year 1870 to 2004. Throughout the 20th century, the rate of sea level rise has increased and was recently estimated to be roughly 0.2 cm per year (Church and White 2006). At this rate, global sea level could be 19–59 cm higher in 2100 than it was in 1990 (IPCC 2007b).

Storm surges during hurricanes and tropical storms foreshadow the potential long-term effects of sea level rise on coastal systems. Low-lying coastal lands are acutely vulnerable to saltwater inundation as the sea level rises. On gradually sloped or low-lying shorelines a small increase in sea level can equate to a relatively large loss of land. Land subsidence and erosion may exacerbate the effects of sea level rise locally or regionally. Areas where extensive population centers exist in low-lying watersheds and along river and estuarine boundaries will also be vulnerable to sea level rise.

Local rates and impacts of sea level rise will vary depending on regional topography, sediment sources, tectonic action, and barometric pressure. Some specific geographic examples of sea level rise and related impacts include:

- Coastal freshwater forests in the **Southeast USA** and in the **Gulf of Mexico** are undergoing dieback from increasing saltwater intrusion as sea level rises and regional lands subside; in some areas, mangroves are expanding landward (Doyle et al. 2010).
- In the **mid-Atlantic USA** from New York to North Carolina, natural land subsidence has accelerated relative sea level rise rates to 0.25–0.44 cm per year as compared to the global average of .02 cm per year, causing wetland migration inland and coastal land losses (CCSP 2009).
- Forced migration of entire coastal communities, such as Shishmaref, Kivalina, Shaktoolik, and Newtok on the west coast of **Alaska**, because of increased erosion as a result of declining sea ice cover and its buffering effects against storms and high-energy waves (ACIA 2005).

Table 2. Sea Level Rise (local and global)		
Climatic factors	Sector	Effects
<p>Global sea level is projected to increase by 19-59 cm in 2100 as the oceans absorb excess atmospheric heat and freshwater input from terrestrial glaciers and ice caps increases.</p> <ul style="list-style-type: none"> • Thermal expansion: Water expands as it warms and takes up more space. Over the next 100 years, thermal expansion is projected to be the largest component of global sea-level rise. • Melting glaciers and terrestrial ice caps: Rising atmospheric temperatures are melting terrestrial snow and ice leading to increased amounts of freshwater in the oceans. • Regional changes in air pressure: Sea level changes in response to episodic hemispheric climate patterns such as the El Niño-Southern Oscillation or the Pacific Decadal Oscillation. Global air pressure patterns may be altered as the atmosphere and ocean warm. 	Species	<ul style="list-style-type: none"> • Saltwater inundation will stress coastal freshwater species • Shifts in species distribution and interactions among species • Loss or change in location and distribution of coastal breeding grounds and habitat
	Ecosystems/ habitats	<ul style="list-style-type: none"> • Altered oceanic current patterns and rates • Inundation of coastal ecosystems including wetlands and barrier islands • Changes (both loss and gain) in habitat availability and types (e.g. marsh migration)
	Economy/ infrastructure/health	<ul style="list-style-type: none"> • Loss of property and infrastructure due to flooding or erosion • Salinization of water supplies • Inundation of stormwater systems
<p>Compounding Factors:</p> <ul style="list-style-type: none"> • Changes in sediment input: Activities that reduce sediment input to coastal areas diminish coastal land accretion rates. When coastal shorelines are starved of sediment, local sea level rise is exacerbated. Relevant compounding activities include damming and bulkheading 		

anywhere along a river and other shoreline hardening such as seawalls, riprap, and jetties.

- ***Loss of coastal wetlands and vegetation:*** Healthy coastal vegetation and wetlands can reduce the relative rate of local sea level rise by trapping sediment and otherwise contributing to the build-up of coastal land.
- ***Withdrawal from aquifers and oil deposits:*** When significant volumes of oil, water, or other materials are removed from underground deposits in coastal areas, the land can subside, increasing the relative rate of local sea level rise.
- ***Tectonic forces:*** Land can move up or down rapidly in response to earthquakes, more slowly as a result of land deformation from tectonic plate movement, or over the course of centuries in response to isostatic rebound or plate deformation and reformation from the weight of glaciers.
- ***Atmospheric and oceanic circulation:*** Shifts in barometric pressure can rapidly alter relative sea level. Similarly, oceanic gyres and currents can cause water to build up in certain locations.

C. Precipitation Changes

Changes in regional and global temperature regimes and atmospheric water vapor content as well as terrestrial drying, will all influence precipitation intensity, distribution, timing, and form in North America. Warmer temperatures increase evaporation rates and also increase the amount of water vapor the atmosphere can hold. In general, it is likely that the southwest and west coast of the United States will become more arid while the East Coast will experience more frequent, intense precipitation events (CCSP 2008a).

While regional precipitation changes will vary, more intense, longer droughts and heat waves and more intense precipitation events have been observed globally and are projected to increase in frequency. Warming and drying trends will increase ocean and estuarine evaporation rates, thus increasing local or regional salinity; in contrast, increasingly intense precipitation and terrestrial runoff can decrease salinity locally and regionally.

Changes in evaporation rates and atmospheric moisture are already altering precipitation patterns. Geographically diverse examples of precipitation changes and other related impacts include:

- From 1950–1999, more mountain precipitation is falling as rain rather than snow in the **Pacific USA**. Using climate models, researchers were able to show that human effects accounted for 60% of this change (Barnett et al. 2008).
- Severe droughts may occur in the **Southwest United States** and **Baja Mexico** due to decreased precipitation and increased water demands as population levels grow (CCSP 2008b).
- The spring freshets that juvenile salmonids use to migrate to the ocean from streams may occur earlier and become more intense in the **Pacific USA**; an earlier freshet may decouple this historic relationship (Mote et al. 2004).
- Decreased precipitation and higher air temperatures have increased wildfire frequency, duration, and the wildfire season in **Pacific USA** (Westerling et al. 2006); similar impacts are expected to occur in **Canada** and **Alaska**. Such fires can provide a pulse of nutrients to downwind marine waters and affect nutrient and sediment runoff into coastal waters.
- Increased flooding and coastal erosion from more frequent storms and higher storm surges in the **Northeast United States** and **Eastern Canada** (USGCRP 2009).
- More frequent and intense storms will increase runoff in the **Mid-Atlantic** and **Southeast United States** and the **Gulf of Mexico**. The “dead zone” in the Gulf may expand in size due to increased nutrient and pollutant loads being carried in the Mississippi River (USGCRP 2009).

Table 3. Precipitation Changes (hydrological cycle)		
Climatic factors	Sector	Effects
<p>In the Northern Hemisphere mid and high latitudes, total precipitation is projected to increase, while in low latitudes total precipitation is projected to decrease. Precipitation is expected to become less frequent but more intense and droughts are expected to be more severe.</p> <ul style="list-style-type: none"> • Increased evaporation: As average temperatures increase, land and oceanic evaporation rates will also increase. The low latitudes are generally becoming more saline while the high latitudes are becoming less saline as water vapor is transported from the equator to the poles. • Moisture capacity: Higher atmospheric moisture capacity can lead to more intense precipitation events even when the total annual precipitation decreases. 	Species	<ul style="list-style-type: none"> • Shifts in species composition and distribution attributable to salinity changes in coastal marine and terrestrial habitats • Altered reproductive timing and success of salmon and other anadromous and marine species associated with changes in timing and intensity of seasonal flooding • Increased coastal dead zones from increased nutrient-rich runoff
	Ecosystems/ habitats	<ul style="list-style-type: none"> • Increased coastal erosion • Altered water quality from salinity changes and pollution loading from non-point sources • Increased wildfire frequency and intensity in the near- to medium-term, leading to increased nutrient and sediment loads in coastal areas downwind or down-river of fires
	Economy/ infrastructure/health	<ul style="list-style-type: none"> • Increase in waterborne diseases • Decreased water supply in drought-prone or snowmelt-dependent areas • Increased floods and droughts in some areas • Damage to coastal property and infrastructure

Compounding Factors:

- ***Natural climate cycles:*** Annual or decadal climate cycles such as the El Niño-Southern Oscillation or the Pacific Decadal Oscillation can cause dramatic shifts in precipitation patterns.
- ***Changes in land use and land cover:*** Increased urbanization increases water runoff, therefore decreasing groundwater recharge and increasing flooding intensity and frequency. Increased urbanization also decreases natural water filtration processes, degrading water quality. Deforestation significantly increases the rate and extent of local and regional heating and drying; conversion of vegetated areas to buildings or other infrastructure has a similar but smaller effect.

D. Circulation Changes (currents, winds, upwelling)

Multiple factors drive ocean circulation patterns on global and regional scales. On the global scale, ocean circulation is generally driven by a thermohaline “pump” whereby cold, highly saline (dense) water sinks in the Northern latitudes and is replaced by warmer, less dense water from the equator, essentially generating a pump that moves water throughout the ocean basins. This circulation pattern transports heat away from the tropics and releases it in the North Atlantic Ocean (CCSP 2008b). On a regional scale, consistent wind patterns can create coastal upwelling of nutrient-rich deep-ocean water that supports rich marine and terrestrial communities, the former through the delivery of deep, nutrient-rich waters to the surface and the latter through the creation of consistent fog when cold water meets the relatively warm atmosphere, allowing dense forests to thrive in otherwise drier environments. Mixing of deep and surface waters also occurs away from coasts as a result of winds, currents, and changes in density gradients.

Patterns of water movement such as currents, upwelling, and stratification (the degree of vertical mixing of the water) play a large role in determining local and regional climate, ocean productivity, and species dispersal patterns. Long standing circulation patterns may be altered as the atmosphere and ocean heat differentially, freshwater input increases, precipitation patterns change, and winds shift. Geographically diverse examples of circulation changes and related impacts include:

- The strength of the Atlantic Meridional Overturning Circulation (AMOC) along the **North Atlantic** coast is projected to decrease in response to increased greenhouse gas concentrations and influxes of freshwater from Greenland’s ice cap (Schmittner et al. 2005; CCSP 2008b).
- Changes in seasonal wind patterns along coasts have delayed and/or decreased upwelling events along the **Pacific USA**, decoupling trophic interactions and productivity (Barth et al. 2007).
- The occurrence of hypoxic waters (waters depleted in oxygen) may increase in coastal systems worldwide if upwelling is reduced and the water column is thermally stratified. This would increase the residence times of deep waters, further depleting them of oxygen, causing widespread fish kills when the hypoxic waters emerge onto the surface (Rabalais et al. 2010).

Table 4. Circulation Changes (currents, winds, upwelling)

Climatic factors	Sector	Effects
<p>Global circulation patterns are derived from a complex integration of land and ocean heat transfer, winds, water density gradients, and episodic, atmospheric pressure cells. Climate change has the capacity to alter all of these factors.</p> <ul style="list-style-type: none"> • Thermohaline circulation: Some global climate models project that thermohaline circulation may slow or even stop because of changes in water densities in the high latitudes. • Mixing: Warmer sea surface temperatures could increase water column stability due to enhanced stratification. Increased water column stability could decrease mixing and hence, the delivery of nutrients from deeper water to the surface. • Coastal upwelling: Altered wind patterns may decrease the strength and reliability of wind-driven upwelling. 	Species	<ul style="list-style-type: none"> • Altered species distribution and migration patterns • Shifts in species composition • Population declines from decreased food availability and habitat loss
	Ecosystems/ habitats	<ul style="list-style-type: none"> • Geographic shifts in water salinity • Decreased productivity in coastal upwelling areas • Loss of fog-dependent coastal forests
	Economy/ infrastructure/health	<ul style="list-style-type: none"> • Loss of fisheries productivity • Extreme weather-related damage to property and coastal areas
<p>Compounding factors</p> <ul style="list-style-type: none"> • Changes in freshwater input: Large dams and over-allocation of river water can diminish or even (in the case of the Colorado River) virtually eliminate the flow of freshwater into coastal environments. This affects mixing and currents in multiple ways, and also affects the delivery of nutrients to coastal waters. • Increased air and ocean temperature: Atmospheric and oceanic circulation varies with air and ocean temperatures. Changes to atmospheric and oceanic patterns could affect the intensity, duration, timing, track and location of extreme weather events and normal storm patterns. 		

- ***Stratosphere circulation:*** Increased greenhouse gases affect the circulation of stratospheric air masses from the tropics to the poles, altering atmospheric patterns.
- ***El Niño-Southern Oscillation:*** The periodic change in the atmosphere and ocean of the tropical Pacific region influences circulation and weather patterns.
- ***Evaporation and precipitation:*** Ocean circulation may be affected by changes in evaporation and precipitation rates and locations because they alter the densities of water masses.

E. Changes in Ocean Chemistry (pH and salinity)

Globally, the ocean absorbs roughly 30% of the annual worldwide emissions of CO₂ (Sabine et al. 2004). As the oceans take up CO₂, pH drops and seawater chemical speciation changes in ways that make the calcium carbonate ion less available for marine organisms to form. Changes in pH affect biological processes as basic as respiration and fertilization in organisms as diverse as fish, squid, algae, and sea urchins. Calcium carbonate is used by many shell-forming marine organisms, including plankton, mollusks, echinoderms, and corals. As carbonate ion concentrations decline, it is more difficult and energetically costly to produce calcium carbonate-based exoskeletons. Many marine species exhibit retarded shell formation and growth when exposed to high levels of CO₂ (Doney et al. 2009). Changes in pH also affect fundamental biological processes as basic as respiration and fertilization and can elicit effects in such diverse organisms as fish, squid, algae, and sea urchins.

Since the preindustrial revolution, the average ocean surface water pH has dropped from approximately 8.21–8.10 (Royal Society 2005). The pH scale is a logarithmic scale; as such, a drop of one pH unit indicates a tenfold increase in hydrogen ions. If greenhouse gas concentrations continue to increase unabated, it is estimated that ocean surface water pH may decrease 0.3–0.4 pH units, equivalent to a 150% increase in hydrogen ions and a 50% decrease in carbonate concentrations (Orr et al. 2005).

A decrease in the pH of surface waters will cause a shoaling (or shallowing) of the calcium carbonate saturation depth, serving to decrease the area in the water column where it is energetically favorable to form calcium carbonate structures. Currently, surface waters above ocean depths ranging from 1000–4500 m in the Pacific Ocean are considered to be saturated with the carbonate ion (Feely et al. 2004). At depths below the calcium carbonate saturation horizon, oceanic currents and the remineralization of organic carbon concentrate CO₂ into the ocean's deep-water reservoirs. As more CO₂ is absorbed into the ocean from the atmosphere, there will be a concurrent shoaling of the calcium carbonate saturation depth. In 2006, the calcium carbonate saturation depth in the Arctic Ocean was calculated to be at 3500 m (Jutterstrom and Anderson 2006) but researchers are expecting the saturation depth to migrate towards the surface as the oceans continue to absorb more CO₂ (Feely et al. 2004; Orr et al. 2005). When the calcium carbonate saturation depth reaches the surface, it may be energetically impossible for calcifying animals to form exoskeletons that rely upon calcium carbonate as a fundamental building block.

The North Pacific calcium carbonate saturation horizon has already shoaled by 30–200 m from the preindustrial period to the present (Feely et al. 2002). In fact, researchers recently found corrosive waters upwelling off the coast of Washington at mid-shelf depths of 40–120 m (Feely et al. 2008). It is projected that the North Pacific could be one of the first areas where surface waters are under saturated with the calcium carbonate ion because of the long residence times of the deep, cold, upwelling waters allow CO₂ to become concentrated and periodic storms enhance water mixing.

Locally, changes in salinity will also be affected by changes in precipitation, temperature, and runoff as described previously.

Some specific geographic examples of changes in ocean chemistry and other related impacts include:

- Changes in estuary and ocean salinity from a higher input of freshwater from melting ice and increased precipitation in **Alaska** and **Western Canada** (IPCC 2007a).
- Decreased coral growth and recruitment in the **Gulf of Mexico** and **Florida**. Experiments show that atmospheric CO₂ concentrations of 560 ppm can reduce coral calcification rates and growth by 40% (Hoegh-Goldberg et al. 2007).
- Increased regional ocean acidification in the **North Pacific** due to seasonal upwelling of deep, CO₂ rich waters, impacting the region's fisheries and shellfish industry (Feely et al. 2002).

Table 5. Changes in Ocean Chemistry (pH, salinity)		
Climatic factors	Sector	Effects
<p>The ocean pH is being reduced and salinity changed due to increased greenhouse gas emissions.</p> <ul style="list-style-type: none"> • Increased greenhouse gases: Ocean absorption of the atmospheric CO₂ increases the acidity of ocean waters, influencing the natural carbonate buffering system. As the ocean becomes more acidic, there is less available calcium carbonate. Reducing the carbonate ion concentration of the seawater will make calcification harder for corals and other marine calcifiers including; crabs, marine snails, and bivalves. • Altered freshwater input: Altered precipitation patterns are likely to result in more episodic river input, as well as direct effects of rainfall on marine waters. • Altered evaporation: Warmer air and water temperatures will result in more rapid evaporation of surface water, potentially increasing salinity. 	Species	<ul style="list-style-type: none"> • Decreased reproductive and recruitment success • Shifts in species composition and distribution • Changes in development, age of sexual maturity, timing of spawning, growth, and survival • Altered prey availability (plankton) • Physiological impairment • Changes in shell or skeleton growth rates and morphology
	Ecosystems/ habitats	<ul style="list-style-type: none"> • Cascading trophic shifts • Increased risk of invasive species establishment • Reduced habitat complexity (increased erosion / decreased growth/ recruitment) • Increased algal blooms • Increased dead zones
	Economy/ infrastructure/health	<ul style="list-style-type: none"> • Loss of ecosystem services • Loss of coral reefs and supported fisheries.
<p>Compounding factors</p> <ul style="list-style-type: none"> • Pollution: Certain types of pollution, including excess nutrients, SO_x and NO_x can contribute significantly to acidification in coastal waters 		

with low mixing.

- **Decreased freshwater input:** Large dams and over-allocation of river water can diminish or even (in the case of the Colorado River) virtually eliminate the flow of freshwater into coastal environments, leading to large increases in salinity.
- **Increased ocean temperature:** Some marine animals, such as corals, are prone to thermal stress; this coupled with acidification could have an additive, damaging effect, making it harder for coral reefs to recover.
- **Habitat degradation:** Coastal development, dredging, and boat groundings contribute to the continued loss of coral habitat. Ocean acidification will slow coral growth and make recovery more difficult.
- **Uncertainty:** One of the greatest difficulties with ocean acidification is that we are only beginning to understand the effects of more acidic waters.

More exhaustive discussions of the actual and projected impacts of climate change in North America can be found elsewhere, such as in the reports listed in Appendix B.

III. Adapting to and Preparing for the Effects of Climate Change – Approaches and Projects

Climate change is now widely acknowledged as a global problem that threatens marine and coastal conservation, management, and policy. Adaptation has emerged as a necessary response to and preparation for the unavoidable impacts of global climate change. In this report, we define adaptation as “adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities” (IPCC 2007a). Adaptation is in its infancy and the field is developing in a rapid but *ad hoc* fashion. Actions are undertaken to either avoid or take advantage of actual and projected climate change impacts either by decreasing a system’s vulnerability or increasing its resilience (ADB 2005; Levin and Lubchenco 2008; Lawler 2009; Pew Center 2009). Some characteristics on which adaptation strategies can be evaluated include importance, urgency, feasibility, speed of implementation, cost, economic efficiency, equity, flexibility, and performance under uncertainty (Titus 1990; ADB 2005; Bizikova et al. 2008; de Bruin et al. 2009; Lawler 2009) (see Box 1 taken from Hansen and Hoffman 2010).

Box 1. Evaluating adaptation options

The following considerations will help in the design, evaluation, and selection of adaptation options (adapted from Titus 1990 and de Bruin et al. 2009).

1. *Importance*: What is at stake if nothing is done? Are there unique or critical resources whose vulnerability will be reduced?
2. *Urgency*: What are the costs of delaying action, both in terms of what you might lose and in terms of what it would cost to implement later rather than now?
3. *No regrets and co-benefits*: Do the benefits (including non-climate-related benefits) exceed the cost of implementation? Will there be significant beneficial outcomes even if the adaptation benefits do not pan out as expected?
4. *Economic efficiency*: What are the expected benefits of this strategy relative to using the same resources elsewhere?
5. *Cost*: How costly will the strategy be in terms of time, money, or other resources?
6. *Effect on climate change*: Will the suggested action increase the emission of greenhouse gases, or lead to undesirable changes in the local or regional climate?
7. *Performance under uncertainty*: What is the strategy’s likely performance across the range of plausible changes in climate for your region?
8. *Equity*: Does the strategy benefit some people, places, or interests at the expense of others? Will this strategy have strong negative effects on any people, places, or interest?
9. *Institutional feasibility*: Is the proposed strategy possible given existing institutions, laws, and regulations? To what degree is the public likely to accept the strategy?
10. *Technical feasibility*: Is the suggestion strategy technically possible to implement? Do we have or can we access the necessary tools and other resources?
11. *Consistency*: Is the proposed strategy consistent with existing national, state, community, or private values, goals, and policies?

A. A Framework for Action

Adaptation strategies are meant to reduce the vulnerability of human and natural systems to climate change and its effects. Approaches include supporting resistance, resilience, or response of those systems in the face of change. Actions geared toward reducing the amount of local or regional change or increasing the ability of a system to withstand change falls into the category of *resistance*, while improving the ability of systems to recover from change supports *resilience*. The *response* approach focuses on helping systems accommodate changes that do occur (Millar et al. 2007).

General approaches to and principles of adaptation action in both human and natural systems have been addressed in past reports (ADB 2005; USAID 2007; IPCC 2007b; Lawler 2009; Glick et al. 2009; Glick and Stein 2010). They are typically consolidated into four broad steps:

1. Assess vulnerability to climate change. The assessment may focus on a species, place, program, community, or anything else of concern to those doing the assessment, and should include exposure (how much change may happen), sensitivity (plausible effects of climate change on the system in question), 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. In all cases, the assessment should begin with the overall goal of those carrying it out (e.g., sustainable fisheries management, coastal habitat protection).
2. Identify, design, and implement management, planning, or regulatory actions and policies that reduce the vulnerabilities identified in step 1. These may range from adjustments in existing regulations to wholesale changes in management approaches, and should be evaluated for robustness across a range of future scenarios.
3. Design and enact monitoring programs that assess changes in those climate and environmental parameters most important to the system in question as well as in the effectiveness of management or policy actions.
4. Create an iterative process by which activities can be reevaluated and redesigned, if necessary.

More exhaustive discussions of the guiding principles of adaptation theory can be found elsewhere, such as in the reports listed in Appendix C.

B. Five Tenets of Adaptation

When it comes to actually adapting work to climate change, no single element or component of adaptation is a solution on its own, and there is no universally best set of solutions. 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. The following tenets, designed and used by Hansen and Hoffman (2010), comprise a conceptual framework for developing adaptation plans.

They are best employed to improve existing work plans, rather than to design stand-alone responses to climate change.

1. Protect adequate and appropriate space for a changing world.

The existing paradigm for protected areas – establishing them in fixed locations to protect a particular species, community, or natural system – is highly vulnerable to climate change, but protected area design and management can be adjusted to address climate change and its effects in a number of ways, including:

- *Prioritize protection of climate refugia (places that are likely to maintain more stable climatic conditions).* Potential refugia may be identified using historic data to look for locations or types of locations (e.g., areas with high topographic variability) that have been changing more slowly either over the past century or during previous periods of climate change.
- *Support connectivity and corridors along climatic gradients.* Individual animals may track favorable climate conditions, and many species will experience range shifts towards higher latitude, higher elevation, or greater depth. Connectivity also supports genetic exchange among populations, potentially assisting the mixing of warmer-adapted genotypes into cooler-adapted populations. The risk of connectivity is that it also supports the movement of pests, diseases, and non-native species, as well as limiting adaptation to local conditions.
- *Protect areas or features that contribute to local or regional climate stability.* This is discussed further under tenet 4.
- *Protect resistant or resilient populations.* This may increase the likelihood that the species of which these populations are a part will survive, as well as key ecosystem services are maintained.
- *Protect heterogeneity of habitat, communities, and species.* Areas with many microclimates (e.g., caves, ravines, slopes facing different directions) may provide refugia to which individuals or populations can retreat, as well as potentially hosting populations with a greater diversity of climatic tolerances.

Of course spatial planning is not limited to protected areas; it is also integral to physical and infrastructure development and natural resource management plans. In all cases, ensuring the right space is managed properly is crucial for long-term success.

2. Reduce non-climate stressors that interact negatively with climate change or its effects.

Climate change may exacerbate the adverse effects of other stressors, or other stressors may worsen some negative effects of climate change. In a handful of cases, it may be that non-climate stressors and climate change can ameliorate each other's negative impacts. Already stressed ecosystems may be more vulnerable to climate change and its effects. Examples of such stressors include:

- *Pollution.* Changes in temperature or chemistry of soil and water can lower the tolerance of plants and animals to pollutants, or increase the toxicity of pollutants. Conversely, some pollutants lower the tolerance of plants and animals for changes or extremes of temperature, salinity, or other

environmental factors likely to be affected by climate change. The interactive effects of climate change and pollutants will also pose new challenges for maintaining municipal drinking water quality and sewage treatment efforts.

- *Pests, diseases, non-native species (“nuisance species”).* Higher temperatures allow some nuisance species to expand into new regions or dramatically increase their population growth rates, and plants and animals stressed by changing climatic conditions may become less able to compete with pests or non-native species. This is as much an issue for public health as it is for ecosystem health.
- *Overharvest or overexploitation (of forests, fishes, water, etc.).* Overharvest reduces the sheer numbers and genetic diversity that helps populations cope with changing environmental conditions both in the here and now and on an evolutionary level. Loss of keystone species or ecosystem engineers may reduce resilience. Overharvest of water or forests often increases the rate of local or regional change (see Tenet 4).

3. Manage for uncertainty.

Aside from uncertainty in climate models, we will never be able to predict future greenhouse gas emissions, or how human communities will respond to climate change or its effects. Uncertainty is a fact of life, and climate change simply adds another layer of uncertainty. We acted despite not knowing the future with certainty before we were aware of climate change, and there is no reason to wait for a firm map of the future now that climate change is part of reality.

Approaches to managing in the face of uncertainty include scenario planning, adaptive management, and robust decision-making. Scenario planning allows planners and managers to explore the effectiveness of various strategies across a range of plausible futures. Adaptive management 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. Robust decisions are those that leave open a range of positive future options across a range of plausible futures rather than simply targeting a single best outcome under a single presumed future.

4. Reduce local and regional climate change.

Even as the world changes, it is possible, in some cases, to reduce change in the local or regional climate. Reducing deforestation or planting trees locally can create cooler, moister conditions, as well as reduce the severity of flooding and erosion. In some cases, maintaining forest cover at somewhat distant locations can play a major role in maintaining stable water supplies (e.g., tropical lowland forests support montane cloud forests; upriver forest cover supports downriver water supply). Replanting vegetation along coasts, rivers, and streams can have impressive effects not only in terms of direct shading and cooling, but more generalized cooling effects, perhaps attributable to increased water retention in the system. For example, healthy beaver populations or appropriate levels of grazing can decrease the vulnerability of wetlands to



drought. Limiting the input of certain types of pollutants (NO_x, SO_x, nutrients) into coastal waters may reduce the rate of acidification.

5. Reduce greenhouse gas emissions.

In the world of climate change policy, reducing greenhouse gas emissions falls into the category of mitigation rather than adaptation. We include it to emphasize that the more we limit the rate and extent of global climate change, the greater our adaptation options.

C. Adaptation Projects and Initiatives

This section presents examples from our inventory of marine and coastal adaptation projects throughout North America with the goal of illustrating how a range of approaches plays out in practice. The full list of adaptation projects can be found in Appendices E and F, grouped by geographic region and strategy, respectively. In addition, case study summaries of these projects are available in a case study compendium and on the [Climate Adaptation Knowledge Exchange](#) (CAKE).

There are a number of ways to parse climate adaptation activities (Hansen, Biringer, and Hoffman 2003; Inkley et al. 2004; Fischlin et al. 2007; Julius, West, and Blake 2008; Heinz Center 2008). For the purposes of this report, we have delineated four broad categories for our inventory,³ including *Natural Resource Management and Conservation*; *Capacity Building*; *Infrastructure, Planning, and Development*; and *Governance and Policy*. Each category is then broken down into specific adaptation strategies. These include:

1. Natural Resource Management and Conservation

- a) Incorporate climate change into existing policies, plans, and regulations
- b) Enhance connectivity and areas under protection
- c) Design protected areas to allow for inland, altitudinal, or latitudinal movement
- d) Monitor climate change impacts and adaptation efficacy
- e) Reduce local climate or related change
- f) Reduce non-climate stressors likely to interact with climate change
- g) Initiate targeted research program(s)

2. Capacity Building

- a) Create new institutions (training staff, establishing committees)
- b) Enhance existing institutions – Increase organizational capacity
- c) Enhance existing institutions – Coordinate planning and management across institutional boundaries
- d) Invest in/enhance emergency services planning and training

³ Within the database on the Climate Adaptation Knowledge Exchange (CAKE), users can search and cross-reference different adaptation strategies in North America in a variety of ways, including by adaptation strategy type, primary motivation, taxonomic/habitat/sectoral focus, funding source(s), targeted impacts, and more.

- e) Increase/improve public awareness, education, and outreach efforts
- f) Conduct/gather additional research, data, and products
- g) Conduct vulnerability assessments and studies
- h) Provide new job training for people whose livelihoods are threatened by climate change
- i) Create/host adaptation training and planning workshops
- j) Create stakeholder engagement processes
- k) Conduct scenario planning exercises

3. Infrastructure, Planning, and Development

- a) Make infrastructure resistant or resilient to climate change
- b) Community planning
- c) Protect water supply systems from saltwater contamination
- d) Create or modify shoreline management measures

4. Governance and Policy

- a) Managed retreat of built infrastructure, relocation of people/communities
- b) Develop a disaster preparedness plan
- c) Maintain adequate financial resources for adaptation
- d) Create/enhance technological resources
- e) Develop/implement adaptation or adaptive management plans
- f) Create new or enhance existing policy

The examples below represent diverse activities, sectors, and targeted climate impacts in the following geographic regions:

- *Arctic Canada*
 - Yukon, Northwest Territories, Nunavut
- *Eastern Canada and Northeast USA*
 - New Brunswick, Newfoundland and Labrador, Nova Scotia, Ontario, Prince Edward Island, Quebec
 - Maine, Connecticut, Massachusetts, New Hampshire, Rhode Island
- *Mid-Atlantic USA*
 - Delaware, Maryland, New Jersey, New York, Pennsylvania, District of Columbia, Virginia
- *Southeast/Gulf USA*
 - North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Texas
- *Gulf of Mexico and Yucatan Peninsula – Mexico*
 - Tamaulipas, Veracruz, Tabasco, Campeche, Yucatan, Quintana Roo
- *Alaska and British Columbia*
- *Pacific States USA*
 - Washington, Oregon, California, Hawaii
- *Baja Peninsula and Pacific Coast – Mexico*

- Baja California, Baja California Sur, Sonora, Sinaloa, Nayarit, Jalisco, Colima, Michoacan, Guerrero, Oaxaca, Chiapas
- *Nationwide USA*
- *Nationwide Canada*
- *Nationwide Mexico*

1. Natural Resource Management and Conservation

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. Climate change may have negative *and* positive effects on wildlife and habitat. For example, decreased primary productivity rates, phenological changes, and poleward expansions or shifts in species' ranges may cause ecological disruptions in one area but allow for new opportunities in another. Climate change may also interfere with the ability of ecosystems to withstand change. For example, healthy and intact wetlands and salt marshes can reduce the effects of flooding and sea level rise; degraded habitats may be overwhelmed by extreme coastal storm events and be unable to buffer coastal areas from erosion. 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. A range of options exists, such as improving monitoring and research efforts to assess environmental change, restoring degraded habitats and ecosystem function to increase resilience, managing systems with an adaptive approach, and incorporating flexibility into plans to allow for uncertainty.

a) *Incorporate climate change into existing policies, plans, and regulations*

Managers and conservation practitioners can adapt to climate change by incorporating a range of plausible future climate scenarios and impacts (both biophysical and sociopolitical) into policies and plans, including restoration plans, development plans, harvest policies, critical habitat rules, species recovery plans, threatened or endangered species designations, or environmental impact statement (EIS) requirements.

Examples

Alaska and British Columbia

Polar bears were listed under the Endangered Species Act in the United States because of climate change effects on critical habitat. Declines in sea ice, the bears' primary habitat, prompted the U.S. Fish and Wildlife Service and U.S. Geological Survey to recommend a "threatened" listing, which the Secretary of the Interior approved in 2008. Sea ice provides breeding, hunting, and feeding grounds and travel corridors for the bears; documented sea ice melt from increased air temperatures and changes in ocean circulation patterns in the Arctic have threatened the reliability of this habitat for polar bears. Polar bears are also listed as a "species of concern" in Canada and Russia and have been under the protection of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) since 1973. In addition, the U.S. Fish and Wildlife Service is working to formulate an agreement between indigenous hunters in Canada and

Alaska to limit overharvesting.⁴

Nationwide USA

The National Marine Fisheries Service is currently petitioning to list 82 species of stony coral under the Endangered Species Act. The petition lists greenhouse gas emissions as the primary cause of increased water temperatures, ocean acidification, increased frequency and intensity of coastal storms, and sea level rise, all of which combine to threaten corals.⁵ Two corals were listed as threatened for related reasons in 2006 – elkhorn (*Acropora palmata*) and staghorn (*Acropora cervicornis*).

Eastern Canada and Northeast USA

The Wellfleet Bay Wildlife Sanctuary, one of Massachusetts Audubon's protected areas in Cape Cod, has initiated an oyster reef habitat restoration project on the intertidal flats of Lieutenant Island. This project was initiated to boost local populations of the native American oyster (*Crassostrea virginica*) and restore oyster reef habitat and the ecological services it provides. Oyster reefs are disappearing globally; a May 2009 report by The Nature Conservancy on the state of shellfish estimated that 85% of oyster reefs have been lost. This habitat has essentially disappeared from Wellfleet Bay, primarily as a result of pollution, overfishing, and disease. The Sanctuary is seeking to restore these reefs because they serve as natural coastal buffers that help to protect shorelines and keep coastal marshes intact by helping to break down wave energy before it reaches the shoreline. This last piece is an important factor in protecting communities against increased storm surges and sea level rise expected with climate change in Massachusetts.⁶

Pacific States USA

The Papahānaumokuākea Marine National Monument (PMNM) is situated in the northwestern portion of the Hawaiian Archipelago and is one of the world's largest marine protected areas. Management of the Monument is the responsibility of three co-trustees: the State of Hawaii Department of Land and Natural Resources, the U.S. Fish and Wildlife Service, and the National Oceanic and Atmospheric Administration. In 2008, the co-trustees developed the PMNM Management Plan to ensure coordinated management of the natural, cultural, and historic resources of the Monument. The PMNM Management Plan provides a framework for the comprehensive understanding of climate change impacts and management is poised to develop adaptation strategies to these impacts.⁷

Pacific States USA

Salt production has occurred in San Francisco Bay since the 1800s and a large percentage of wetland loss in the south bay was due to tidal lands levied for salt ponds. Since 2003, there have been significant efforts to develop a restoration plan to restore and enhance the wetlands to historic tidal marsh conditions, and provide wildlife habitat, recreational opportunities, flood protection, and water quality improvement. The

⁴ [Polar Bear Designation Under the U.S. Endangered Species Act](#)

⁵ [Proposed Listing of Coral Reef Species Under U.S. Endangered Species Act](#)

⁶ [Wellfleet Bay Oyster Reef Habitat Restoration Project](#)

⁷ [Incorporating Climate Change Adaptation into the Papahānaumokuākea Marine National Monument Management Plan](#)

South Bay Salt Pond Restoration Project is the largest tidal restoration project on the West Coast and will transform 15,100 acres to a mosaic of tidal wetlands and managed pond habitats. In addition, the restored tidal wetland system will provide a critical natural buffer against the effects of climate change such as sea level rise, coastal flooding, and erosion.⁸

b) Enhance connectivity and areas under protection

This strategy includes improving the management of existing protected areas and refugia; increasing the amount of protected space through land acquisition, easements, and legislation (Heinz Center 2008; Glick et al. 2009); and ensuring that connectivity routes are intact by protecting adequate and appropriate space (Hansen, Biringer, and Hoffman 2003). Connectivity measures include maintaining migration corridors or softening the matrix, that is, managing non-protected or mixed-use space between protected areas to support individual movement or shifts in species ranges. These efforts are linked to creating new protected areas and increasing the size and number of protected areas. Some reports discuss the need to improve representation and replication of protected areas; *representation* to protect a suite of ecosystem types within a region, country, or other managed area, and *replication* to protect multiple forms of each ecosystem type (Heinz Center 2008).⁹

Examples

Pacific States USA

The Washington Wildlife Habitat Connectivity Working Group is developing a plan to identify the best places to invest in habitat connectivity enhancement efforts, for example, in areas situated between important core habitats, in order to help protect wildlife populations. The climate change subgroup is developing methodologies for integrating climate change into this plan. GIS analysis, which may incorporate down-scaled climate models and climate envelope models, will be used to identify connectivity investments most likely to continue to provide connectivity in future climates and facilitate climate-driven shifts in species ranges.¹⁰

Pacific States USA

Two dams in the Drakes Estero Estuary, constructed in the 1950s, have altered freshwater flows, created fish passage barriers, and restricted connectivity between freshwater and saltwater habitats in the area. This estuary supports federally threatened steelhead trout (*Oncorhynchus mykiss*) and the California red-legged frog (*Rana aurora draytonii*), and could support the federally endangered coho salmon (*Oncorhynchus kisutch*) if natural processes and connectivity are restored to support anadromous passage. In 2008, the

⁸ [South Bay Salt Pond Restoration Project](#)

⁹ "Protected areas" here refers to areas where there are some limitations on activities, but not necessarily complete restriction.

¹⁰ [Incorporating Climate Change Into Landscape Connectivity Plans](#)

National Park Service removed the two dams to restore natural ecological processes and functions to over 15 acres of tidal marsh. This has resulted in the restoration of natural transition zones between freshwater and saltwater habitats, which will enhance the ability of anadromous fish (e.g. steelhead trout, coho salmon) to survive. By restoring the natural ecological processes and reestablishing connectivity, project leaders believe that the area will be more resilient to climate change.¹¹

Alaska and British Columbia

The British Columbia Ministry of Environment has categorized the region's watersheds into vulnerability and disturbance classes to assess landscape connectivity using GIS. The resulting maps highlight relatively pristine, resilient areas that could be reconnected to provide migration corridors for plants and animals.¹²

Gulf of Mexico and Yucatan Peninsula – Mexico

Mexico's National Strategy on Climate Change (Intersecretarial Commission on Climate Change 2007) called for establishing biological corridors between protected areas to "improve the adaptive capacities of ecosystems and species." One effort to fulfill this goal was the incorporation of five ecosystems in southeast Mexico into the Mesoamerican Biological Corridor project, sponsored by the World Bank's Global Environment Facility. The corridors include regions of high biodiversity, including dry and moist forests in Tehuantepec and Yucatan, cloud forests in Chiapas, savannas in Tabasco, and wetlands in Quintana Roo. These ecosystems are connected to one another and to the larger Mesoamerican Biological Corridor, spanning Guatemala, Belize, Honduras, El Salvador, Nicaragua, Costa Rica, and Panama.¹³

Nationwide USA

The National Marine Protected Areas Center (MPA Center) is preparing for climate change by building a national system of MPAs. This national system is meant to be geographically and ecologically diverse and represent local, state, regional, and national interests. These protected areas can foster resilience to climate change impacts while conserving natural and cultural marine resources of national importance. The MPA Center is also leading the development of the North American Marine Protected Areas Network, an initiative to create a network of MPAs between Canada, Mexico, and the United States.¹⁴

c) Design protected areas to allow for inland, altitudinal, or latitudinal movement

Sea level rise is expected to inundate low-lying coastal areas, beaches, barrier islands, estuaries, and wetlands, leading to increased coastal erosion, flooding, and saltwater intrusion. Managers have a few options to facilitate the migration of protected areas, coastal wetlands, and other ecosystems as sea level rise, including establishing setbacks for shoreline development, acquiring upland habitat, and creating rolling

¹¹ [Estero de Limantour Coastal Watershed Restoration Project](#)

¹² [Vulnerability of British Columbia Landscapes](#)

¹³ [Mesoamerican Biological Corridor Project](#)

¹⁴ [Climate Change and the National Marine Protected Areas Center](#)

easements. Designing protected areas to include inland, altitudinal, or latitudinal gradients will have the added benefit of facilitating species movement.

Examples

Pacific States USA

Kayak Point is a park located in Snohomish County, Washington. Infrastructure and ecosystems at Kayak Point have been damaged by recent winter storms and managers are concerned that sea level rise could alter existing ecosystems. Shoreline hardening has occurred along roughly 39% of the 9.6 mile beach which has reduced sediment input from adjacent beach bluffs thereby hindering accretion on down-drift beaches. Sea level rise is expected to increase relative erosion rates within the park further displacing ecosystems and damaging infrastructure. Snohomish County is in the process of selecting one of three restoration plans for the park with varying degrees of bulkhead removal, habitat restoration, and infrastructure movement.¹⁵

Mid-Atlantic USA

The State of Maryland has more than 3,000 miles of coastline, the majority of which is experiencing naturally occurring subsidence. These low-lying coastal areas make Maryland particularly vulnerable to the effects of sea level rise. The state pioneered a mapping tool called “GreenPrint” to assess the relative ecological importance of every land parcel in the state and to help managers prioritize land acquisition and restoration plans. GreenPrint uses GIS software to create color-coded maps that combine information layers such as vegetation type and urbanization and aerial photographic surveys to produce maps that highlight ecologically valuable lands for conservation prioritization. In 2008, the Maryland Climate Action Plan recommended that a new layer of information be added to the GreenPrint tool that indicated climate change vulnerability. The Department of Natural Resources is developing criteria that systematically evaluate a system’s vulnerability to climate change. Once complete, the updated tool will allow managers to identify areas of forest, wetland, and shoreline that are suitable for long-term climate adaptation.¹⁶

Baja Peninsula and Pacific Coast – Mexico

San Quintín Bay in Baja California is recognized for its biodiversity and for being the largest coastal lagoon in the South Coast ecoregion that has not been significantly affected by human activity. A coalition was formed to enhance, protect, and conserve the biodiversity in the Bay from all stressors including climate change. A strategic plan was developed that identified climate change and impact sources (urban and tourism development, recreational activities, agriculture, etc.) and strategies to abate or mitigate their effects on conservation targets. As a result of these efforts, it is expected that the bay and surrounding habitats will be declared as a natural protected area.¹⁷

Gulf of Mexico and Yucatan Peninsula – Mexico

¹⁵ [Kayak Point Restoration Feasibility and Design Technical Memorandum: Sea Level Rise Projections](#)

¹⁶ [Integrating Climate Change Adaptation Strategies into Maryland’s Coastal Land Conservation Targeting](#)

¹⁷ [Vulnerable Mediterranean climate coastal habitats in Bahía de San Quintín, Baja California, México](#)

The MesoAmerican Reef (MAR), the largest reef system in the Western Hemisphere, extends along the Caribbean coasts of Mexico, Guatemala, Belize, and Honduras. The MAR Program has completed a threat analysis and developed a series of adaptation measures to increase the reef's resilience to potential and actual impacts of climate change. As a result, resilient reefs have been identified that can act as climate refugia and will be targeted for further protection.¹⁸

d) Monitor climate change impacts and adaptation efficacy

Creating or improving monitoring plans for natural resources, ecosystems, and coastal communities is important in order to track changes and to determine how management strategies may need to be modified based on these changes (Fischlin et al. 2007; Heinz Center 2008; Peterson et al. 2008). Monitoring can be designed to provide further information on climatic changes and linked environmental changes; to assess ongoing effects on the resources of concern; to provide early warning when critical ecological thresholds are nearing to allow for intervention; and to evaluate the effectiveness of management actions or other adaptation efforts.

Examples

Alaska and British Columbia

Cook Inletkeepers in Alaska has established a regional salmon stream monitoring network to assess the range and extent of water temperature throughout the watershed. Data will be collected in 48 streams from 2008–2012 and then overlaid on a georeferenced map with landscape characteristics. The stream temperature data combined with a landscape analysis will allow researchers to identify attributes that make a stream acutely vulnerable to experiencing high temperatures. This information will allow land managers to prioritize restoration and protection efforts to strategically reduce the vulnerability of salmon streams to high water temperatures in the future.¹⁹

Northeast, Mid-Atlantic, and Pacific States (USA)

National Estuarine Research Reserves in Rhode Island, Maine, Virginia, North Carolina, and Oregon have established salt marsh habitats as sentinel sites to monitor climate change impacts, including sea level rise, saltwater intrusion, and erosion. Salt marshes provide valuable habitat for fish, crabs, and other wildlife, and important ecosystem services by filtering water and protecting shorelines during strong coastal storms. Human alteration (e.g., dredging, filling, development) has resulted in restricted flow, increased sedimentation, and habitat degradation. Reserve personnel are monitoring salt marsh characteristics such as salinity, vegetation cover, flow patterns, and peat soils at natural marsh reference sites and recently restored marsh sites every year to track water levels and marsh height in order to determine if and how salt marshes can respond to sea level rise and other climate impacts.^{20,21,22,23,24}

¹⁸ [MesoAmerican Reef \(MAR\)](#)

¹⁹ [Stream Temperature Monitoring Network for Cook Inlet Salmon Streams](#)

²⁰ [Sentinel Monitoring of Salt Marshes in the North Carolina National Estuarine Research Reserve](#)

Pacific States USA

The San Francisco Estuary Invasive *Spartina* Project aims to limit or eliminate non-native cordgrasses from the Bay's tidal and salt marshes through targeted outreach, mapping, and monitoring throughout the Bay. The eradication of *Spartina* from the San Francisco Estuary may prevent large scale losses of native marshes and mudflats that can withstand the effects of sea level rise and coastal flooding. A region-wide monitoring has been established to map the extent and rate of invasive *Spartina* spread and to monitor the effectiveness of the project's efforts.²⁵

Nationwide Mexico

In Mexico, the Nature Conservancy is working to protect biodiversity and ecosystems from climate change in the country's natural and protected areas. Currently a pilot program is working in four protected areas in southeast Mexico to serve as a framework to develop climate adaptation strategies for all of Mexico's protected areas. The climate adaptation priorities are targeted at preserving ecosystem functionality, biodiversity, and ecosystem services to benefit people and natural resources and once identified will be integrated into current management. The adaptation strategies were ranked through a cost-benefit analysis and implementation feasibility. Once implemented, a monitoring and evaluation plan will analyze the project's success and determine if these adaptation plans can be implemented throughout Mexico's protected areas.²⁶

e) Reduce local climate or related change

Reducing local change in climate or related factors can help to limit ecosystem vulnerability to global climate change. Relative local sea level rise can be slowed by reducing water, oil, and gas withdrawals or enhancing accretionary processes. The latter may include restoring natural sedimentary processes that have been disrupted by dam construction, shoreline hardening, deforestation, and removal of vegetation, or restoration of soil-building habitats such as mangrove forests and coastal wetlands. Maintaining or enhancing sediment transport can support wetland and salt marsh accretion; these habitats help to protect coastal areas and communities from sea level rise, flooding, and erosion.

Risk of and vulnerability to flood, drought, and temperature extremes can be reduced by maintaining vegetation cover or reducing deforestation. This also limits excessive sediment, pollutant, and freshwater runoff to sensitive coastal habitats. Sediment and vegetation (e.g., canopy, understory, shrubs) can reduce water flow and velocity (Evans et al. 1996) and provide stabilization; faster water flows can exacerbate

²¹ [Sentinel Monitoring of Salt Marshes in the Wells National Estuarine Research Reserve](#)

²² [Sentinel Monitoring of Salt Marshes in the Narragansett Bay National Estuarine Research Reserve](#)

²³ [Sentinel Monitoring of Salt Marshes in the Chesapeake Bay National Estuarine Research Reserve in Virginia](#)

²⁴ [Sentinel Monitoring of Salt Marshes in the South Slough National Estuarine Research Reserve](#)

²⁵ [San Francisco Estuary Invasive Spartina Project](#)

²⁶ [Climate Change Adaptation in Protected Areas in Mexico for the Conservation of Biodiversity, Ecosystems, and Ecosystem Services](#)

erosion, increase excessive sedimentation and turbidity, and lower water quality conditions in receiving waters (Everest and Reeves 2006).

Examples

Alaska and British Columbia

In 2007, Homer, Alaska was selected to pilot the ICLEI–Local Governments for Sustainability Climate Resilient Communities program, which works with local governments to catalog greenhouse gas emissions and develop mitigation and adaptation strategies. In December 2007, Homer released a Climate Action Plan. To initiate the plan, greenhouse gas emissions were inventoried using ICLEI’s Clean Air and Climate Protection software, and future emissions targets were set to reduce Homer’s carbon footprint by 20 percent of 2000 levels by 2020. Mitigation measures to reduce greenhouse gas emissions were also identified, ranging from increased dependence on renewable energy sources to altering human behavior.²⁷

Southeast/Gulf USA

The *Grasses in Classes* program piloted in Baldwin County, Alabama, trained students (with guidance from teachers and experts) to grow native plants for wetland and dune restoration projects in order to reduce erosion. Students planted bitter panic grass (*Panicum amarum*), sea oats (*Uniola paniculata*), and saltwater cordgrass (*Spartina patens*) at the Bon Secour Wildlife Refuge. They removed the invasive common reed (*Phragmites*) and replanted grasses black needle rush (*Juncus romerianus*) and smooth cordgrass (*Spartina alterniflora*) at the Weeks Bay National Estuarine Research Reserve. In addition, the students helped to maintain and monitor native plant nurseries and assisted scientists with monitoring at restoration sites when possible. This pilot project has also been instituted in classrooms in Tampa Bay (Florida) and Chesapeake Bay (Maryland).²⁸

Southeast/Gulf USA

The Gulf of Mexico Alliance, a partnership between Alabama, Florida, Louisiana, Mississippi, and Texas, is developing a Gulf Regional Sediment Management Master Plan. This plan will organize and facilitate sediment management policies for conservation and restoration of accretionary processes. The plan will provide steps for states to take to improve sediment management within individual regions and strengthen regional sedimentary processes.²⁹

Pacific States USA

Port Susan Bay, along the northwest coast of Washington State, has historically been subject to diking, levee installation, and other water diversions changing the sediments loads that enter the estuary, causing tidal marsh erosion. To prevent sea level rise and periodic flooding from altering the coastal habitats and causing further erosion, the Port Susan Large Wood Project was launched to reintroduce large logs to increase the

²⁷ [Homer, Alaska Climate Action Plan](#)

²⁸ [Alabama’s Baldwin County Grasses in Classes Program](#)

²⁹ [Gulf of Mexico Regional Sediment Management Master Plan](#)

estuary's structural complexity by creating scour pools, trapping sediment, stabilizing channels, and providing habitat for animals.³⁰

f) Reduce non-climate stressors likely to interact with climate change

The marine and coastal ecosystems of North America are stressed by a number of activities, including destructive fishing practices, overfishing, pollution, diseases, invasive species, and others, in addition to the actual and projected impacts of climate change. The cumulative effects of these stressors reduce overall ecosystem resilience and many of the stressors interact directly with climatic changes. Temperature, pH, and salinity all affect the toxicity of various chemicals and will all be affected by climate change. Increased water temperature can combine with nutrient pollution to further enhance plankton blooms and decomposition, making low oxygen zones larger, longer-lasting, and more severe, and climate change-related changes in hydrological regimes may further compound this problem. In the absence of specific vulnerability information or targeted adaptation options, supporting general resistance and resilience by reducing overall stress on a system is a reasonable approach, although likely less effective than the more climate-informed approach (Heinz Center 2008; Glick et al. 2009). It is also worth noting that exposure to stressful conditions over many generations may in some cases increase the resistance or resilience of affected populations as natural selection weeds out less robust individuals. Examples of reducing non-climate stressors likely to interact with climate change include reducing land-based pollution to limit coral bleaching; prohibiting or removing coastal infrastructure blocking the ability of coastal habitats to shift inland as sea level rises; incorporating climate change scenarios into fisheries management to adjust for shifts in species' ranges, reproduction, growth, and survival; and reducing activities that alter natural sediment fluxes to limit erosion.

Examples

Alaska and British Columbia

The North Pacific Fishery Management Council is authorized to manage fisheries within the Exclusive Economic Zone of the State of Alaska, which includes the Gulf of Alaska, Bering Sea and Aleutian Islands, and the Chukchi and Beaufort Seas. Because of observed northward shifts in the ranges of commercial species and uncertainty about ecosystem responses to climatic changes, the Council has adopted a precautionary approach to commercial fishing activities in the region, including prohibiting certain activities until better scientific information becomes available. The Council has established limits to minimize bycatch, seasonal restrictions, and gear requirements (e.g., bottom trawling prohibition) to diminish effects on mammals, birds, and habitat. The Council has also created some protected areas to protect sensitive habitats (e.g., deep sea corals) and areas where scientific information is limited (Chukchi and Beaufort Seas).³¹

Southeast/Gulf USA

³⁰ [Effects of Sea Level Rise in Port Susan Bay](#)

³¹ [Using a Precautionary Approach to Manage North Pacific Fisheries Under Uncertainty](#)

Coral reefs are extremely vulnerable to climate change impacts, especially when combined with existing stresses such as land-based sources of pollution, habitat degradation, and overfishing. The “Florida Climate Change Action Plan for the Florida Reef Tract 2010-2015” (Action Plan) was developed as a way forward for federal, state, and local government agencies to comprehensively act to maximize the resilience of Florida’s coral reefs. The Action Plan is based on implementation of actions that reduce non-climate stressors and increase resilience. The agencies responsible for managing the reefs themselves, other marine natural resources, and adjacent lands and watersheds, are tasked to restore and maintain the resilience of the ecosystem by increased protection of biodiversity, improved water quality, and sustainable fishing.³²

g) Initiate targeted research program(s)

Targeted research is needed to understand the intricacies of climate change effects on marine and coastal ecosystems. These research initiatives can provide baseline information from which to measure environmental changes and impacts on natural and human systems. Integrating climate change questions into research programs can provide information for practitioners and decision makers, inform risk assessments, and allow for cost-benefit analyses of action versus inaction. From an adaptation perspective, the key is to target research and monitoring to address specific uncertainties, unknowns, or ecosystem variables identified in the process of adaptation planning.

Examples

Eastern Canada and Northeast USA

Coastal communities in parts of Sept-Îles, Quebec, in the Gulf of Lawrence are witnessing shoreline erosion rates of up to 8 m per year. To evaluate the cause of the high erosion rates, the provincial government supported a targeted research program to analyze the current and historical erosion rates and to develop long-term management solutions. Results indicate that the current erosion rate exceeds historical norms. Researchers hypothesize the accelerated erosion rate is due to reduced wintertime sea ice, more intense storms, and heavier precipitation and storm frequency.³³

Pacific States USA

As carbon dioxide dissolves into the ocean, it reduces the pH of the water which can retard the development and growth of organisms reliant upon calcium carbonate. In response to persistently low shellfish seed survival, the Pacific Coast Shellfish Growers Association launched the “Emergency Plan to Save Oyster Production” research project to identify both short- and long-term solutions to enhance shellfish hatchery production, establish monitoring programs in key estuaries to better understand changes in the environment, identify resilient oyster genotypes, and identify better tools to detect disease-causing bacteria which may be enhanced by climate change. This will help to identify environmental stressors of oyster populations and isolate genetic stocks of oysters that offer enhanced resilience to climate change.³⁴

³² [A Climate Change Action Plan for the Florida Reef Tract \(2010-2015\)](#)

³³ [Causes and Adaptation Strategies to Shoreline Erosion in Sept-Îles](#)

³⁴ [Oyster Emergency Project](#)

Arctic Canada

The Igliniit Project in Nunavut, Canada is a collaboration between Inuit hunters and engineers in monitoring environmental conditions in the region. “Igliniits” are trails or roads that are routinely traveled on by members of an Inuit community. Over time, the location, use, and weather conditions change on Igliniits. This monitoring project integrates GPS devices attached to hunters’ snowmobiles that log locations and weather conditions. Collected data is transferred to community maps and, over time, will provide a more complete picture of the Inuit land-sea ice characteristics in the region.³⁵

Southeast/Gulf USA

The Florida Reef Resilience Program (FRRP) was initiated in 2004 to study the health of the Florida Reef Tract from the southeast Florida mainland to the Dry Tortugas and includes the Florida Keys. The FRRP seeks to increase the understanding of reef health to guide management actions that will improve the resilience of the Florida Reef tract to climate change impacts and enhance the reef-user industry.³⁶

³⁵ [The Igliniit Inuit Sea Ice Use and Occupancy Project](#)

³⁶ [Florida Reef Resilience Program](#)

2. Capacity Building

The following section discusses the various means that groups have taken to increase their capacity to adapt to the growing realities of climate change. Building capacity in organizations, managers, practitioners, decision makers, and the public can increase the ability to plan, develop, and implement adaptation strategies. 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. Strategies include acquiring or training staff; increasing organizational capacity; coordinating planning and management within and between governments; developing awareness to gain support for adaptation efforts, facilitating information sharing between adaptation players, and investing in or enhancing resources to support adaptation.

a) *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. Technical experts, scientists, and other staff can contribute important knowledge and recommendations to support governmental decision-making on climate adaptation.

Examples

Pacific States USA

In Washington State, Preparation and Adaptation Working Groups were formed to develop recommendations on climate change in the following sectors: Forestry, Agriculture, Human Health, Coastal/Infrastructure, and Water Resources and Quality. Based on recommendations from these groups, Governor Chris Gregoire signed legislation (E2SSB 5560) that included a directive to create a statewide climate change response strategy to help stakeholders prepare for and adapt to climate change. The 5560 Interagency Working Group, comprised of six state agencies (Ecology, Agriculture, Commerce, Fish and Wildlife, Natural Resources, and Transportation), has been tasked to develop an initial strategy by December 2011. The 5560 Interagency Working Group also created four topic advisory groups to identify preparation and adaptation strategies and additional research needs. The groups are:

Built Environment, Infrastructure, and Communities – to focus on strategies relevant to transportation, energy, water, waste, and information infrastructure.

Human Health and Security – to focus on strategies to address air quality, extreme weather events, public health, and emergency services and planning.

Ecosystems, Species, and Habitats – to focus on individual species and habitats, and whole ecosystems/ecological systems across the state.

Natural Resources – to address impacts related to the state's working lands and waters (e.g., forestry, agriculture, water quality, water resources).

These groups consist of representatives from federal, state, local, and tribal governments, non-governmental organizations, academic institutions, and the private sector.³⁷

Pacific States USA

In California, the Bay Area Ecosystems Climate Change Consortium (BAECCC), which is comprised of state and federal agencies and non-governmental organizations, plans to coordinate climate change activities for resources and communities in the San Francisco Bay Area. Specifically, the BAECCC collaborates on regional climate change impact assessments, research and monitoring, outreach and education, and adaptive management strategy development. The projected outcomes of this consortium include: testing and implementing science-based adaptive management approaches to support climate change responses, developing and implementing natural resource management plans, policies and protocols to support ecological resilience, and making San Francisco ecosystems and ecological services more resilient to climate change impacts.³⁸

Southeast/Gulf USA

The Miami-Dade Climate Change Advisory Task Force was created in 2006 by the Board of County Commissioners to create recommendations on reducing greenhouse gases and planning for adaptation. The Task Force consists of 25 members and seven committees: steering; built environment adaptation; economic, social, and health adaptation; greenhouse gas reduction; intergovernmental affairs; natural systems adaptation; and science. The Task Force reports to the Miami-Dade County Commissioners and provides annual reports and recommendations.³⁹

Arctic Canada

The Nunavut Climate Change Partnership is a collaborative effort between the Government of Nunavut, the Canadian Institute of Planners, Natural Resources Canada, and the Department of Indian Affairs and Northern Development focused on increasing provincial and local ability to adapt to climate change impacts. The partnership's effort, which is often called Atuliqtuq ('coming into force'), works toward increasing local and regional resilience through three initiatives: (1) building capacity; (2) increasing local scientific knowledge; and (3) developing adaptation support tools. The partnership is also developing local pilot adaptation projects in seven Nunavut communities, which will act as models for other communities to follow.⁴⁰

Nationwide USA

The U.S. Environmental Protection Agency's National Drinking Water Advisory Council created the Climate Ready Water Utilities (CRWU) Program to provide tools and resources for water utilities to prepare for the effects of climate change. A CRWU Working Group has also been created to provide recommendations on the

³⁷ [Developing a Washington State Climate Change Impacts Response Strategy](#)

³⁸ [Bay Area Ecosystems Climate Change Consortium](#)

³⁹ [Miami-Dade Climate Change Advisory Task Force](#)

⁴⁰ [Atuliqtuq: A Collaborative Approach in Support of the Nunavut Climate Change Adaptation Plan](#)

effectiveness of the CRWU Program, define characteristics of “climate ready” utilities, identify climate change-related tools and resources to assist water utilities’ planning efforts, and determine methods to facilitate adaptation and mitigation for the water sector throughout the United States. Currently, the CRWU Program offers three sets of tools for water utility owners and operators:

- (1) Climate Resilience Evaluation and Assessment Tool (CREAT) assists utilities in understanding and assessing risks from climate change impacts.
- (2) CRWU Toolbox provides resources ranging from climate science to mitigation to adaptation strategies.
- (3) Tabletop Exercise Tool for Water Systems: Emergency Preparedness, Response, and Climate Resiliency (TTX Tool) allows users to examine climate change impacts using fifteen different scenarios.⁴¹

b) Increase organizational capacity

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

Examples

Gulf of Mexico and Yucatan Peninsula – Mexico

The Mexican Institute of Ecology (INECOL) is working in the Gulf of Mexico to create an Environmental Strategic Plan for increasing organizational capacity to support public policies in the scenario of global climate patterns, freshwater discharge, floods, and sea level rise. INECOL is working on an ecosystem approach initiative that will produce a guide of tools required for implementing an Environmental Strategic Plan for the coastal zone in this region, towards public programs, strategic plans, public policies, and methods for evaluating and monitoring the results, coupled with the Government National Development Plan in Mexico. This initiative will influence both the National Development Plan and the States’ Development Plans in the Mexican coastal zone of the Gulf of Mexico.⁴²

Southeast/Gulf USA

Florida and Mississippi-Alabama Sea Grants and the National Oceanic and Atmospheric Administration Gulf of Mexico Regional Collaboration Team hosted a workshop in order to create a Community of Practice (CoP) of extension, outreach, and education professionals around climate change issues in the Gulf of Mexico. Workshop objectives included discussing attitudes and knowledge on climate change and sea level rise, learning from existing sea level rise preparation activities in the region, sharing and identifying needed information and resources to support sea level rise adaptation, and creating a regional approach to climate

⁴¹ [U.S. Environmental Program's Climate Ready Water Utilities Program](#)

⁴² [Impacts of Climate Change on the Coastal Zone of Mexico \(Gulf of Mexico\)](#)

change outreach and education. In addition, members of the CoP developed a sea level rise toolkit for extension, outreach, and education professionals.⁴³

Eastern Canada and Northeast USA

The Southern Maine Regional Planning Commission (SMRPC) is a council of governments that serves 39 municipalities and provides planning and technical assistance to communities, including assistance in response to local and regional issues such as sea level rise, coastal storms, and other hazards. In order to advance adaptation options in coastal zone land use planning with respect to climate change and sea level rise, the SMRPC partnered with the Maine Geological Survey to develop the Coastal Hazard Resiliency Tools Project. This project builds coastal resilience by providing information about sea level rise and coastal storms and hazards to local decision makers, coordinating regional responses to these hazards, and encouraging long-term thinking with regard to adaptation planning. In addition, a regional grant has been awarded to several Maine communities to establish a Sea Level Adaptation Working Group that will identify regional infrastructure vulnerabilities, facilitate coordinated responses, and obtain funding for adaptation projects.⁴⁴

c) 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. Because climatic variability is not confined by political or social boundaries, cross-jurisdictional coordination of planning and management can improve adaptation efforts. Increased cooperation may include information sharing, improved communication, and establishing formal partnerships to share resources, funds, and knowledge.

Examples

Southeast/Gulf USA

The Southeast Florida Regional Climate Change Compact was signed by Broward, Miami-Dade, Palm Beach, and Monroe counties in 2009 to coordinate mitigation and adaptation activities across county lines. This partnership will also result in a climate action plan.⁴⁵

Nationwide USA

The U.S. Department of the Interior, through a September 2009 Secretarial order, is creating a Department-wide strategy to address climate change in the United States. The order created a Climate Change Response Council to coordinate activities within the Department's agencies and bureaus to develop this strategy; the

⁴³ [Sea Level Rise in the Gulf of Mexico: Awareness and Action Tools for the Climate Outreach Community of Practice](#)

⁴⁴ [Municipal Adaptations to Create Resilient Beach Communities in Southern Maine: The Coastal Hazard Resiliency Tools Project](#)

⁴⁵ [Southeast Florida Regional Climate Change Compact](#)

Council also plans to coordinate its activities with other federal agencies and offices. The order also created eight regional Climate Change Response Centers in Alaska, the Northeast, the Southeast, the Southwest, the Midwest, the West, Northwest, and Pacific regions, and a network of Landscape Conservation Cooperatives, which will engage with the Department of the Interior and other federal, state, and local partners to create strategies for management under climate change.⁴⁶

Pacific States USA

The Indigenous People's Global Summit on Climate Change brought together over 400 indigenous people from 80 countries to share their knowledge and experiences with regard to climate change impacts, successful adaptation strategies currently in use, and recommendations for future action. The main outcome of the conference was the Anchorage Declaration, which represents the common position of all indigenous participants relating to climate change impacts and adaptation strategies.⁴⁷

d) Invest in/enhance emergency services planning and training

Climate change is expected to increase risks to public health and safety throughout North America. 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. Warmer temperatures and changes in precipitation patterns will likely increase incidences of wildfires and drought, pests and diseases, and intense heat waves. 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.

Examples

Alaska and British Columbia

The watershed in which Homer, Alaska, resides is forested. Increases in air temperature have caused massive outbreaks of Spruce Bark Beetle infestations, leading to the widespread die-off of trees. The large numbers of dead trees coupled with warmer air temperatures and projected decreases in precipitation will increase the fire risk within the area. To combat the increased fire risk, the Homer Climate Action Plan calls for increased fire fighting capabilities to protect the region.⁴⁸

Alaska and British Columbia

The village of Kivalina, Alaska is located at the tip of an eight-mile barrier reef near the Arctic Circle. The village has pursued relocation efforts for almost 20 years because of overcrowding and erosion problems, and continues to be at risk from severe coastal storms, thawing permafrost, and shoreline erosion. In 2006, the U.S. Army Corps of Engineers released the Kivalina Relocation Master Plan, which examines different alternatives for the village including do nothing, improve existing site, and move to a new site. Relocation

⁴⁶ [U.S. Department of the Interior Climate Change Strategy](#)

⁴⁷ [Indigenous People's Global Summit on Climate Change](#)

⁴⁸ [Homer, Alaska Climate Action Plan](#)

was identified as the preferred alternative; unfortunately, the relocation process is in a stalemate as the village seeks technical and financial assistance to support their efforts.⁴⁹

Alaska and British Columbia

Seabird Island is located in British Columbia, Canada and is at increased risk of flooding due to heavy precipitation and snowpack melt as a result of climate change. In response to these potential impacts, the community formed the Seabird Island Emergency Response Team, which developed an emergency preparedness plan that was distributed to community members through a door-to-door awareness and educational campaign.⁵⁰

Arctic Canada

The City of Iqaluit, Canada, is located on the south coast of Baffin Island. It has a typical Arctic climate with cold winters and short summers. Global climate models project that extreme weather will increase in the future, causing heavy precipitation and high winds. To prepare, the Iqaluit government is revising its disaster management and preparedness plan to include protocols to safeguard residents such as closing town operations during extreme weather events.⁵¹

Nationwide USA

The U.S. Army Corps of Engineers (ACE) is responsible for the design and management of public engineering and public works projects throughout the United States, including a number of activities at risk from the impacts of climate change such as flood control and protection, ecosystem restoration, and design and management of military facilities. ACE is actively working to address climate change by collaborating with other federal agencies on a number of projects that develop adaptation strategies and options for coping with the impacts of climate change. For example, ACE is part of the project *Incorporating Sea Level Rise into Planning and Siting Design Standards*, which develops guidelines on how to incorporate sea level rise into civil works projects in order to make infrastructure more resilient.⁵²

e) Increase/improve public awareness, education, and outreach efforts

This strategy relates to improving the links between science, management, decision making, and public awareness. These efforts may be in the form of presentations and workshops, print and internet media, steering and advisory committees, and traditional educational venues. 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. Enabling managers and decision makers to incorporate climate adaptation into practice requires that the appropriate science be available in useable forms when needed. 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-

⁴⁹ [Relocating the Village of Kivalina due to Coastal Erosion](#)

⁵⁰ [Emergency Preparedness on Seabird Island](#)

⁵¹ [Sustainable Development Initiatives in the Polar Town of Iqaluit, Canada](#)

⁵² [Planning for Climate Change in the U.S. Army Corps of Engineers](#)



being. Gaining public buy-in may increase political and social capital to support climate adaptation action at local, regional, national, and international levels.

Examples

Eastern Canada and Northeast USA

The Clean Nova Scotia Climate Change Centre was established in the spring of 2009 to inform community members and interested stakeholders about projected climate change impacts in Nova Scotia and to facilitate a community-wide discussion on adaptation options for coastal communities. An informational booklet was developed that includes trends, projections, impacts, adaptation options, and web addresses for additional information. This program will increase public awareness about the impacts of climate change and promote the development of adaptation plans.⁵³

Southeast/Gulf USA

The Tampa Bay Estuary and Coastal Bend Bays and Estuaries Programs in Florida and Texas, respectively, are developing a Gulf Coast Community Handbook that will act as a toolkit of options for the incorporation of climate change impacts into restoration efforts. It will provide specific adaptation strategies and recommendations to communities to help them make informed decisions regarding their restoration priorities.⁵⁴

Southeast/Gulf USA

Bald Head Island is a barrier island located off the coast of North Carolina and is vulnerable to sea level rise and other climate change impacts due to its low lying elevation and shifting sand dunes. The Bald Head Island Conservancy has developed a lecture series to educate community members about potential climate change impacts and ways that individuals can help reduce them. In addition, the Conservancy is collaborating with neighboring barrier island communities to develop a knowledge-sharing network (i.e., the Coastal Barrier Island Network), which will facilitate the transfer of knowledge and lessons learned as communities begin adapting to climate change impacts.⁵⁵

Pacific States USA

The State of Hawaii is still in the initial stages of planning for climate change impacts, which is thought to be due to a lack of accessible information on potential climate changes and what attributes are most at risk from these changes. In order to address this gap, Dr. Chip Fletcher at the University of Hawaii partnered with the Center for Island Climate Adaptation and Policy to produce Hawaii's Changing Climate Briefing Sheet, 2010. The purpose of the briefing sheet was to communicate scientific understanding of present and future climate change impacts in Hawaii, and was sent to every legislator (state and county) and agency in the State of Hawaii with the hopes of moving climate change-related legislation forward.⁵⁶

⁵³ [Community Consultations on Climate Change Adaptation](#)

⁵⁴ [Creating a Gulf Coast Community Handbook for Restoration and Adaptation](#)

⁵⁵ [Bald Head Island Conservancy Climate Change Adaptation: Using Outreach to Catalyze Small Changes](#)

⁵⁶ [Hawaii's Changing Climate: Legislative Briefing Sheet 2010](#)

Arctic Canada

The Many Strong Voices Programme launched the Portraits of Resilience photography project in 2009, which illustrates the impacts of climate change and the efforts people are making to adapt to it through the words and photographs of youth in Arctic and Small Island Developing States communities. The project is intended to bring personal stories about the effects of climate change on people's livelihoods and well-being to the attention of the public and policy makers. Portraits of Resilience is a traveling exhibit that was featured during the UN climate talks in Copenhagen, at the Vancouver Winter Olympics 2010, and is now open at the Field Museum of Natural History in Chicago.⁵⁷

f) 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. 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. For example, increased sea surface temperatures, Arctic ice melt, and sea level rise are happening more quickly than anticipated (Engelhaupt 2007). Incorporating the best available science, traditional ecological knowledge, and citizen science efforts may improve climate adaptation decisions.

Examples**Mid-Atlantic USA**

The Delaware Coastal Management Program has launched its regional Sea Level Rise Initiative. One critical component to the Initiative is to provide data and conduct research for vulnerability assessments. Studies are currently focused on sediment transport, elevations and accretion rates, developing a coastal monitoring network, gathering historical storm and tidal information, and developing coastal inundation maps.⁵⁸

Southeast/Gulf USA

The Florida Oceans and Coastal Council meets regularly to create an annual ocean and coastal research plan and priorities for the state. It was created by the Florida Legislature in 2005 to help coordinate public and private research for more effective coastal management.⁵⁹

Alaska and British Columbia

In Kotzebue, Alaska, the indigenous Qikiktagrugmiut residents developed a study to collect traditional ecological knowledge from tribal members regarding observed changes from the 1950s to 2002 when a final report was released entitled *Documenting Qikiktagrugmiut Knowledge of Environmental Change*. The results detail observed changes in weather, hunting patterns, and snow and ice characteristics; this report serves as

⁵⁷ [Portraits of Resilience](#)

⁵⁸ [Delaware Sea Level Rise Adaptation Initiative](#)

⁵⁹ [Florida Oceans and Coastal Council](#)

a reference point from which to measure further environmental changes and consequences of climate variability in the region.⁶⁰

Southeast/Gulf USA

The Mission-Aransas National Estuarine Research Reserve located near Corpus Christi, Texas, has created the Ecosystem Based Management Tools Project to increase understanding of the links between land use and impacts on coastal and marine ecosystems. Three decision support tools were used to evaluate ecological, social, and economic effects of different land use scenarios in order to encourage sustainable land use planning and management.⁶¹

Nationwide USA

The U.S. Global Change Research Program (USGCRP) coordinates scientific research within the federal government on global climate change and its implications for human and natural systems. In addition, the USGCRP provides assessment and educational materials for use by the public and private sectors such as the U.S. Climate Change Science Program's 21 Synthesis and Assessment Products, the *Climate Change, Wildlife, and Wildlands Toolkit for Formal and Informal Educators*, and the guide *Climate Literacy: The Essential Principles of Climate Science*.⁶²

g) 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. 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. 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.

Examples

Eastern Canada and Northeast USA

The Massachusetts Adaptation Project is a joint effort by the Manomet Center for Conservation Sciences and the Massachusetts Division of Fisheries and Wildlife. The project aims to ensure that climate change impacts and considerations are detailed within the conservation strategies outlined in the State Wildlife Action Plan (SWAP), the 2005 Comprehensive Wildlife Conservation Strategy (CWCS); a primary component of this project has been to conduct thorough vulnerability assessments of habitats in the state. An expert panel was convened to evaluate a number of habitats under climate change conditions, including forests (spruce/fir, pitch pine/scrub oak, etc.), wetlands (emergent marsh, boreal swamp, etc.), coastal (intertidal mudflats, salt marsh, brackish marsh), and aquatic (coldwater streams and lakes, etc.). The project aims to evaluate the

⁶⁰ [Documenting Traditional Ecological Knowledge in Northwest Alaska](#)

⁶¹ [Mission-Aransas National Estuarine Research Reserve's Ecosystem Based Management Tools Project](#)

⁶² [U.S. Global Change Research Program](#)

relative vulnerabilities of habitats, focal areas, and species under climate change in order to inform the Division of Fisheries and Wildlife's habitat acquisition priorities.⁶³

Pacific States USA

Forty of King County, Washington's 77 major wastewater facilities are located adjacent to tidally influenced water bodies. Sea level rise attributable to thermal expansion and melting glaciers coupled with storm surges may make the low-lying treatment facilities prone to flooding in the future. The County assessed the vulnerability of its wastewater treatment facilities using sea level rise projections, historical tidal data and site elevations. The report concludes that based upon current sea level rise projections, the probability of imminent damage to King County's wastewater treatment facilities is low.⁶⁴

Nationwide USA

The National Park Service (NPS) manages about 7,500 miles of coastline throughout the United States. Since 2001, the NPS Geologic Resources Division and the U.S. Geological Survey have partnered together to conduct sea level rise hazard assessments for NPS-managed shorelines. This project creates maps of vulnerable areas through a coastal vulnerability index (CVI), which allows scientists to quantify potential physical changes to the shoreline from sea level rise. The CVI assessments are being used to inform long-term management decisions and evaluate threats to natural and coastal resources.⁶⁵

Alaska and British Columbia

Graham Island is located off the North Pacific coast of British Columbia and is highly vulnerable to sea level rise, coastal erosion, and flooding. A team of researchers from the University of Victoria and the Geological Survey of Canada created a series of flood hazard maps based on future sea level changes in order to identify human and biophysical vulnerabilities to climate change impacts. This study laid the groundwork for developing evaluative tools and planning strategies that facilitate community decision making about priority actions.⁶⁶

h) 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. Increased water temperatures and ocean acidification will severely impact fisheries, aquaculture, and ecotourism and recreation based on natural resources.

Examples

⁶³ [Integrating Climate Change into the Massachusetts State Wildlife Action Plan Using an Expert Panel-Based Vulnerability Assessment](#)

⁶⁴ [Vulnerability of King County, Washington Wastewater Treatment Facilities to Sea Level Rise](#)

⁶⁵ [Assessing the Relative Coastal Vulnerability of National Park Units to Sea Level Rise](#)

⁶⁶ [Preparing for Sea Level Rise on Graham Island, British Columbia](#)

Southeast/Gulf USA

Storms, such as Hurricanes Ivan and Katrina, have degraded shoreline habitats along the Gulf Coast of the United States and caused major economic and job losses in coastal Alabama. The Nature Conservancy in Alabama received a two year grant through the American Recovery and Reinvestment Act to design and implement an oyster reef habitat restoration project in Mobile County. This project is designed to restore oyster habitat and its associated ecological services, stabilize and restore approximately 1500 m of shoreline, and create 30–40 fishery and restoration related jobs for south Mobile County.⁶⁷

i) 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. 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. Training and planning workshops can provide context, guidance, and practical examples of how adaptation is being addressed on-the-ground.

Examples***Arctic Canada***

The Centre for Indigenous Environmental Resources developed and hosted a climate change risk assessment workshop in 2009 to build capacity for First Nation communities. The workshop was designed to provide an overview of climate change impacts and opportunities and to engage participants in discussing adaptation options for local and regional climate change issues. The Centre plans to continue hosting these kinds of workshops.⁶⁸

Nationwide USA

In 2010, NOAA's Office for Habitat Conservation will host a series of meetings to create tools and strategies to help natural resource managers and decision makers prepare for changes in climate. These meetings will focus on selective habitat conservation as a tool for climate change adaptation.⁶⁹

Pacific States USA

The *Planning for Climate Change* workshop was developed and piloted in Washington State for use by the National Estuarine Research Reserve System, but is also available for other agencies. This workshop serves as an "Adaptation 101" for coastal resource managers and shoreline planners and provides information on impacts, current regulations addressing climate change, how to conduct vulnerability assessments, and

⁶⁷ [Oyster Reef Breakwater Restoration Project on Alabama's Gulf Coast](#)

⁶⁸ [Climate Change Risk Assessment Training Workshop for Nunavut Communities](#)

⁶⁹ [NOAA 2010 Workshop: Habitat Conservation in a Changing Climate- Tools and Strategies](#)

adaptation planning. The training offered by this workshop model provides tools, sources of data, strategies, and practical exercises to engage participants in methods to prepare for climate change.⁷⁰

Eastern Canada and Northeast USA

The Mi'kmaq Confederacy of Prince Edward Island and the Indigenous Cooperative on the Environment organized the Atlantic Aboriginal Climate Change Adaptation Workshop, which was held in order to create a toolbox for Aboriginal First Nations to cope with climate change impacts. A central focus of the workshop was capacity development and included emergency planning, impact evaluations, assessment of adaptation strategies, mapping, and risk identification.⁷¹

Nationwide Canada

In 2009, the Centre for Indigenous Environmental Resources hosted a climate change risk assessment workshop to build the capacity of First Nation communities in Canada. Workshop objectives included providing an overview of climate change impacts and issues, assessing adaptation efforts, reviewing energy efficiency options, and helping First Nation communities design community action plans for adaptation and mitigation of climate change impacts.⁷²

j) Create stakeholder engagement processes

As mentioned previously, gaining public buy-in for adaptation can be critical to ensuring the effectiveness of any strategy. Engaging stakeholders can occur in a variety of ways; for example, participating in meetings and workshops, one-on-one interactions, and websites, among others. Activities like interactive, participatory discussions, problem solving sessions, and role-playing exercises have been used to engage stakeholders in climate adaptation.

Examples

Mid-Atlantic USA

The New Jersey Office of Smart Growth reviews local land use policies and endorses successful plans through a “plan endorsement” process. To satisfy the requirements to get a land use plan endorsed, communities must complete a rigorous stakeholder outreach process. The local leadership must create a committee which includes non-elected community members to oversee the land use ordinance update process. At least three visioning meetings are held with outside facilitators in order to produce a product that incorporates the opinions of community members. The local land use ordinances create growth centers, provide environmental protections, and highlight areas for restoration; the state governs the placement of major infrastructure. The Office of Smart Growth has been working with communities to craft land use ordinances that include strategies to reduce vulnerabilities to flooding and extreme tidal flux. Specifically they are trying

⁷⁰ [The National Estuarine Research Reserve’s “Planning for Climate Change” Workshop](#)

⁷¹ [Atlantic Aboriginal Climate Change Adaptation Workshop](#)

⁷² [Climate Change Risk Assessment Training Workshop for Nunavut Communities](#)

to reduce the amount of impervious surface along the coasts, protect wetlands and wetland buffers, and restore coastal sand dunes. Land is targeted for protection or restoration through low-resolution shape file analysis and with local guidance and suggestions. Although these measures are not explicitly labeled as climate change adaptation, these strategies will reduce community vulnerability to sea level rise and stronger storms.⁷³

Mid-Atlantic USA

The Maryland Department of Natural Resources created the Coast Smart Communities Initiative and pioneered a role-playing simulation so that stakeholders can develop an understanding of the complexities associated with climate change adaptation. Participants engage in discussions about possible community responses to climate-related risks in coastal communities.⁷⁴

Alaska and British Columbia

The Nunat Climate Observations Database, created by the Alaska Inter-Tribal Council, provides a centralized location where Native Villages can exchange observations about climate, land, and subsistence changes. Existing, seasonal, and long-term climate observations are recorded and shared through stories, pictures, and video and audio files. The site allows Alaska Villages and their residents to document and exchange information and solutions related to impacts brought about by climate change that may affect their livelihoods and culture.⁷⁵

Eastern Canada and Northeast USA

Maine Sea Grant developed a project to increase understanding of climate change impacts and coastal community resilience by facilitating communication and cooperation between coastal property owners and municipal officials. The project helped determine the barriers faced by coastal property owners and municipal officials when preparing for climate change and coastal hazards and encouraged collaboration between stakeholders to create coordinated strategies for dealing with these impacts.⁷⁶

Southeast/Gulf USA

The National Oceanic and Atmospheric Administration's Center for Sponsored Coastal Ocean Research invited over 50 coastal zone managers and stakeholders from North Carolina to participate in a workshop to help plan for and mitigate the regional climate change impacts of future sea level rise and increased storm intensity. The purpose of the workshop was to use stakeholder input to help scientists design useful management products such as user-friendly mapping and modeling tools that will facilitate management planning for the effects of long-term climate changes and sea level rise.⁷⁷

⁷³ [New Jersey Climate Change Adaptation Using Community Plan Endorsements](#)

⁷⁴ [Implementation of Maryland's Climate Action Plan](#)

⁷⁵ [Nunat Climate Observations Database](#)

⁷⁶ [Coastal Community Resilience in Maine](#)

⁷⁷ [Planning for the Impacts of Sea Level Rise and Climate Change in North Carolina](#)

k) 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 (e.g., “In Scenario A, the water authority builds a dam that stops sediment flow to the coast, all the marshes are paved over thereby decreasing sediment accretion, and the global rate of sea level is X; all of this combines to give a local sea level rise rate of Y”). It also involves the use of those scenarios for evaluating policy/management options. Scenario planning allows participants to identify actions that work well across multiple scenarios, to discover options for dealing with uncertainty, and can improve adaptive management (Peterson 2003).

Examples

Pacific States USA

The National Park Service uses scenario planning to assist long-term decision-making regarding climate change and Park management. In 2007, the Service held a workshop to explore the use of scenario planning for management; Kaloko-Honokōhau National Historical Park in Hawaii was one of the first two case studies. Sea level rise and coastal storms were identified as the two primary climate impacts of concern to the park and the impacts with the highest levels of uncertainty surrounding them; the group designed and tested preliminary scenarios focused around managing the park under uncertainty associated with climate change.⁷⁸

Eastern Canada and Northeast USA

The Lamprey River Watershed in New Hampshire drains roughly 212 square miles into the Great Bay Estuary. From 2005-2007, major flooding events occurred within the watershed annually, causing damage to the towns residing within the watershed. Development and land use change coupled with climate change impacts can affect flood events in both magnitude and frequency. Scientists are assessing flood vulnerabilities under different land use, urbanization and climate change scenarios (greenhouse gas emissions, sea level rise, temperature, precipitation) to develop maps of future 100-year flood risk boundaries. These maps will aid decision makers and support land use decision making in coastal communities.⁷⁹

Eastern Canada and Northeast USA

The New York chapter of The Nature Conservancy launched the *Rising Waters* project to determine the vulnerability of Hudson River Valley communities to sea level rise and climate change. A series of scenario planning workshops were held to examine potential climate change impacts to these communities and explore the effectiveness of four different scenarios. The scenarios were then used to inform the development of recommendations for potential mitigation and adaptation strategies for local communities.⁸⁰

⁷⁸ [Scenario Planning Pilot Study for Kaloko-Honokōhau National Historical Park](#)

⁷⁹ [Assessing the Risk of 100-year Freshwater Floods in the Lamprey River Watershed of New Hampshire Resulting from Climate Change and Land Use](#)

⁸⁰ [Rising Waters: Helping Hudson River Communities Adapt to Climate Change](#)

Alaska and British Columbia

The University of British Columbia's Collaborative for Advanced Landscape Planning program created the Local Climate Change Visioning Project, which uses downscaled future climate scenarios to allow decision makers to visualize projected climate change impacts on local communities in British Columbia and identifies potential adaptation responses at the local level. Project leaders released a guidance manual on visioning which includes participatory scenario building, data and modeling, and a full visioning package that is presented to local communities. The purpose of the project is to provide a scenario-based lens through which decision makers can examine climate change impacts and create appropriate policy responses at the local level.⁸¹

⁸¹ [British Columbia's Local Climate Change Visioning Project](#)



3. Infrastructure, Planning, 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. Planners and developers need to identify and assess risks and develop strategies to protect infrastructure, public health and safety, and limit environmental damage. Adaptation options include incorporating climate change impacts into siting and planning for new infrastructure, retrofitting of existing infrastructure, shoreline development measures, and community and land use planning.

a) *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, sewage systems, transportation, water supply, or buildings. Melting permafrost, sea level rise, erosion, and flooding, among others, increase the risk of landslides and infrastructure damage.

Examples

Eastern Canada and Northeast USA

The historical town of Annapolis Royal, Nova Scotia, is located adjacent to the Bay of Fundy and was built upon reclaimed land using dykes and levees. Since its establishment in the 17th century, Annapolis Royal has experienced major flooding at least three times when oceanic waters breached the town's levees; projected sea level rise coupled with storm surge will make the town even more vulnerable to flooding in the future. To assess the impact sea level rise will have on the town's vulnerability, a team at the Geomatics Center at Nova Scotia Community College generated a flood-risk assessment using LIDAR data, water modeler software, and historical tidal and flood records. Based upon the model, the likelihood that extreme flooding occurs in Annapolis Royal increases from an average ranging from once every 43-121 years to once every 23-55 years due to climate change. A cost-benefit analysis was used to assess a variety of adaptation strategies; upgrading and rebuilding existing levees from 5 m above water to 5.4 m was deemed to be the most effective strategy.⁸²

Eastern Canada and Northeast USA

Communities in the Northwest Territories (NWT) of Canada are likely to experience climate change impacts such as melting permafrost and coastal erosion, which can negatively affect municipal water and wastewater systems. In response to these potential threats, Ecology North - a local non-profit - assessed the potential impacts of climate change on water and wastewater systems in NWT communities and recommended actions to help build adaptive capacity. Recommended strategies included implementing source-control measures and public education campaigns to control the release of hazardous materials and environmental contaminants; supporting education, training, and professional development opportunities for water and wastewater system operators; establishing more consistent and comprehensive monitoring programs for

⁸² [Annapolis Royal Tidal Surge Analysis](#)

source water, wastewater, and landfill leachate; and establishing a cost-sharing fund for adapting community infrastructure to climate change impacts.⁸³

Eastern Canada and Northeast USA

One of the Massachusetts Water Resources Authority (MWRA) primary wastewater treatment plants was built on Deer Island in Boston Harbor. The Deer Island plant's effluent is discharged through a gravity-fed pipe into Boston Harbor and it is projected that sea level rise may disrupt the pipe drainage system. Rather than trying to incorporate protective barriers in the future, the MWRA opted to build the plant 1.9 feet higher, which accommodates the predicted amount of sea level rise through 2050.⁸⁴

Pacific States USA

The city of Olympia, Washington was built on reclaimed land created with hydraulic fill within Budd Inlet and is on average 18-20 feet above sea level. During extremely high tides, the water's edge can be mere feet from downtown buildings and the city's infrastructure; when storms coincide with high tides, marine waters have traveled through the city's stormwater system and emerged inside the city, flooding streets and causing water damage. To assess the impacts sea level rise could have on downtown Olympia, the city invested in high resolution 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. Results indicate that sea level rise could compromise the city's stormwater system and further, could infiltrate the city's wastewater system during extreme tides. City planners are considering both short-term and long-term solutions to reduce their vulnerability, some of which are consolidating the number of stormwater outfalls, installing underground water pumps, raising the shoreline height, and altering the city's comprehensive plan to include the impacts of sea level rise.⁸⁵

b) Community planning

Local-level planning and involvement are key to achieving on-the-ground implementation of adaptation strategies. 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 and zoning. Building local capacity is especially important for dealing with disaster risk management and gaining stakeholder support for action.

Examples

Eastern Canada and Northeast USA

From 2003–2004, damage from extreme weather events in Halifax, Nova Scotia, resulted in massive,

⁸³ [Preparing Communities of the Northwest Territories for the Impacts of Climate Change on Municipal Water and Wastewater Systems](#)

⁸⁴ [Proactive incorporation of sea level rise: The case of Deer Island Wastewater Treatment Plant](#)

⁸⁵ [Planning for Sea Level Rise in Olympia, Washington](#)

unbudgeted spending by community members and the government. As a result, ClimAdapt, a local consortium of environmental consulting firms, launched the Climate SMART (Sustainable Mitigation & Adaptation Risk Toolkit) program to reduce local greenhouse gas emissions and help prepare the region for climate change impacts in the future. The toolkits help communities assess their risks, vulnerabilities, costs, environmental impacts and conduct public outreach. Halifax Harbor has utilized the resources in the Climate SMART to identify future flood risks and vulnerabilities to sea level rise.⁸⁶

Eastern Canada and Northeast USA

Nova Scotia is an Atlantic Canadian province almost entirely surrounded by water; as such, communities are expected to experience similar climate change impacts including increased coastal erosion, inundation of floodplains, and saltwater intrusions. To facilitate land use and community planning decisions with regard to climate change impacts, a consulting firm, Birch Hill GeoSolutions, created and/or modified tools to analyze potential climate change impacts as well as tools to implement adaptation actions. The resulting analysis and implementation toolkits were then tested in two case study sites to develop final recommendation strategies for land use planning.⁸⁷

Southeast/Gulf USA

The City of Satellite Beach, Florida, and the Indian River Lagoon National Estuary Program are working to incorporate sea level rise projections and policies into the city's Comprehensive Growth Management Plan. The three components of this project are a vulnerability assessment, public outreach, and planning and policy development. The city is planning to integrate these changes in 2010.⁸⁸

c) Protect water supply systems from saltwater contamination

Sea level rise and flooding will cause saltwater intrusion, increasing the salinity of surface and ground water. Increased salinity can also harm intolerant plant and animal species. 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.

Examples

Eastern Canada and Northeast USA

Narragansett Bay Research Reserve is located in Rhode Island and is part of the National Estuarine Research Reserve System. Roughly 50% of its historical salt marshes have been damaged or destroyed by human activities; sea level rise, warmer temperatures and coastal storms may further compromise them. The

⁸⁶ [Halifax Climate SMART: The Climate Sustainable Mitigation and Adaptation Risk Toolkit](#)

⁸⁷ [Climate Change Adaptations for Land Use Planners](#)

⁸⁸ [Indian River Lagoon and City of Satellite Beach, Florida Adaptation Project](#)

reserve is monitoring vegetation, flow patterns, and soils to track water levels and marsh heights. Nearby Prudence Island relies upon the intact salt marsh system to protect its freshwater supply in community wells. To assess saltwater intrusion, the community monitors the wells; the community is also conducting a public outreach campaign to increase water conservation.⁸⁹

Eastern Canada and Northeast USA

The Pereau Watershed is a rural watershed located in Annapolis Valley, Nova Scotia. Climate change impacts including sea level rise, increases in extreme weather events and storm surges, and changes in precipitation are likely to affect the valley and watershed through agricultural drought and saltwater intrusion. A consulting firm, Birch Hill GeoSolutions, incorporated climate change considerations into modeling and mapping tools to determine the impacts on watershed hydrogeology and recommended a adaptation strategies. The final mapping results show an increase in the area of saline environment in the dykeland and nearshore agricultural area, which is likely to affect water wells. An increase in the protection area of well buffers (from development) was the final recommended strategy.⁹⁰

Pacific States USA

The East Bay Municipal Utility District is the primary water supplier for approximately 1.3 million consumers in more than 20 San Francisco Bay area cities. Climate change impacts of concern to the water system include loss of snow pack, changes in freshwater flow patterns, changes in precipitation levels, increased temperatures, sea level rise, and saltwater intrusion. The District is working to stay up-to-date on the science and assessment of climate change effects in the nearby watersheds, and examining these impacts in terms of consequences for water supply and demand and potential vulnerabilities of the system's infrastructure. Vulnerability assessments have been conducted to investigate the reliability of infrastructure to deal with rising sea levels and water supply because the aqueducts running from the Mokelumne River cover about 90 miles of the Bay Delta, which is currently below sea level and protected by levees. Sea level rise increases the vulnerability of both the aqueducts and levees. The long-term solution is to bury the aqueducts under the Bay Delta for a 10 to 15 mile stretch; this construction would be very expensive (~\$500 million) but may be necessary.⁹¹

d) Create or modify shoreline management measures

Planners and developers often use shoreline hardening to address erosion and sea level rise issues. 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 (NRC 2002). 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). Studies show that natural coastal systems are "often more

⁸⁹ [Sentinel Monitoring of Salt Marshes in the Narragansett Bay National Estuarine Research Reserve](#)

⁹⁰ [Climate Change Adaptations for Land Use Planners](#)

⁹¹ [Preparing for Climate Change in California's East Bay Municipal Utility District](#)

effective (and reliable) at supporting important ecosystem services such as protecting coasts from erosion and flooding than engineered systems (e.g., dikes, levees, and seawalls)” (Glick et al. 2009). This strategy involves removing shoreline hardening structures, restoring coastal vegetation to minimize erosion, and encouraging low impact development along shorelines.

Examples

Mid-Atlantic USA

In 2006, Worcester County, Maryland updated its Comprehensive Development Plan, including efforts to address climate change. One goal outlined in the plan was to reduce flooding from storm surge, sea level rise and heavy precipitation events. To protect beaches and wetlands at low elevations, the plan recommended the removal of hardened shorelines to allow the inland migration of natural features as sea level rises. The plan further recommended that the county acquire properties in the 100-year floodplain and return them to their natural state and institute a 2-foot freeboard perimeter for properties vulnerable to sea level rise and flooding.⁹²

Eastern Canada and Northeast USA

Save the Bay in Providence, Rhode Island, has worked to improve the ability of salt marshes to absorb storm surges and rising sea levels by creating more vibrant, living shorelines that are adaptive by nature. They have worked on salt marsh restoration and educating shoreline landowners to create natural vegetative buffers. Save the Bay developed guidebooks for coastal property owners to encourage low impact development and management of shoreline property – *Backyards on the Bay: A Yard Care Guide for the Coastal Home Owner* and *Coastal Property and Landscape Management Guidebook*.⁹³

Pacific States USA

The Hayward shoreline is located along east San Francisco Bay and is susceptible to inundation from wave action and flooding. Sea level rise scenarios for the San Francisco Bay Area estimate a rise in sea level of 16 inches by 2050 and 55 inches by 2100, further threatening the Hayward shoreline. In response to these projected scenarios, an engineering consulting firm, Philip Williams and Associates, identified four adaptation strategies ranging from installing levees and seawalls to utilizing natural backshore wave-buffering processes. The Hayward Area Shoreline Planning Agency will most likely adopt a mix of approaches that allow portions of the shoreline and marshland to adapt naturally.⁹⁴

Pacific States USA

Despite the use of stabilizing structures, the City of Pacifica, California has battled chronic flooding and coastal erosion for decades. In the early 1990s, the city partnered with state and federal agencies, scientists, engineers, and non-profit organizations to work toward a managed retreat strategy for the beach and

⁹² [Planning for Sea Level Rise and Storm Surge in Worcester County, Maryland](#)

⁹³ [Increasing Coastal Resilience through Restoration and Education in Narragansett Bay, Rhode Island](#)

⁹⁴ [Adapting to Sea Level Rise in Hayward, California](#)



improve flood management of San Pedro Creek. Both strategies restored natural processes and habitats through methods such as soft stabilization techniques, removal of structures, expansion of tidally influenced wetlands, and restoration of eroding banks. The coincident projects achieved 100-year flood protection for Pacifica, enhanced steelhead habitat in San Pedro Creek, increased functioning wetland habitat, and expanded recreation opportunities.⁹⁵

⁹⁵ [Restoration and Managed Retreat of Pacifica State Beach](#)



4. Governance and Policy

Local, regional, and national governments play important roles in many climate change policies and provide support to resource managers, conservation practitioners, and communities. Many projected climate impacts will have transboundary effects and require multilateral adaptation efforts. The projects covered in this section use strategies such as maintaining or obtaining resources to support adaptation; taking legislative action; and developing strategic and action plans and frameworks.

a) *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. These effects may require managed retreat of built infrastructure and/or relocation of people and communities. 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.

Examples

Alaska and British Columbia

Native coastal communities in Alaska are actively planning to relocate because of ongoing extensive erosion from ice melt, coastal storms, and thawing permafrost. One community, Newtok, is currently building a new village (called Mertarvik) on higher ground nine miles away for its 350 residents. The high cost of relocation (about \$200 million) has caused the villagers to take on much of the building themselves with some support from the U.S. military, and has required multiple funding requests from local, state, and federal governments and non-governmental organizations. In 2006, the Newtok Planning Group was created to assist with many of the tasks and relocation is expected by 2011 or 2012.⁹⁶ Other villages, such as Kivalina and Shishmaref, have also been advised to relocate; however, lack of funding has delayed the process in both villages and the people and infrastructure remain at risk.^{97,98}

Pacific States USA

Erosion has been a consistent problem at Surfer's Point in Ventura, California, for over twenty years. Multiple options were explored by city and non-governmental groups, including the Surfrider Foundation. Surfrider played a critical role in the approval of a managed retreat strategy, which included relocation of a bike path and parking lot, removal of rip rap, beach renourishment, and habitat restoration.⁹⁹

Pacific States USA

⁹⁶ [Relocating the Village of Newtok, Alaska due to Coastal Erosion](#)

⁹⁷ [Relocating the Village of Kivalina due to Coastal Erosion](#)

⁹⁸ [Relocating the Native Village of Shishmaref, Alaska Due to Coastal Erosion](#)

⁹⁹ [Managed Retreat at Surfer's Point, California](#)

Flooding and coastal erosion at Pacifica State Beach in California has been a continual problem for decades despite the installation of shoreline stabilization structures. Since the 1990s, the City of Pacifica, along with federal and state agencies, scientists, engineers, and non-profit organizations, has worked toward a managed retreat strategy for Pacifica State Beach. The strategy (The Pacifica State Beach Master Plan) calls for the removal of vulnerable structures on the beach and the use of soft stabilization techniques to reduce flooding threats, preserve the beach, and improve steelhead habitat.¹⁰⁰

b) 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. Disaster preparedness plans can help coastal communities identify risks and vulnerabilities and develop options for response and recovery.

Examples

Eastern Canada and Northeast USA

A sustainable development initiative project in Iqaluit, Canada, funded by the Indian and Northern Affairs Canada, was created to identify risks to infrastructure and develop adaptation options. In particular, the city focused on the effects that changes in permafrost, extreme weather, precipitation, the coastal environment, and ultraviolet radiation could have on buildings, roads, water supply, and wastewater treatment facilities. Using scenarios and other scientific and local knowledge, the report identifies several adaptation options to increase the resilience of the coastal, polar community, including revising the city's existing disaster management plan to incorporate the consideration of future impacts.¹⁰¹

Eastern Canada and Northeast USA

The Cape Cod Commission developed disaster preparedness materials to assist local officials and residents prepare for natural coastal hazard risks. The Commission coordinates and helps local communities develop hazard mitigation plans. The 2010 Multi-Hazard Mitigation Plan (MHM) for Barnstable County was developed to update the 2004 Natural Hazards Pre-Disaster Mitigation Plan; the plan addresses the county's vulnerability to flooding, wind, snow and ice, drought, earthquakes, hurricanes, sea level rise, shoreline erosion, increased coastal storms, and increased precipitation. In order to reduce risks to public health and safety, infrastructure, and natural resources, the plan aims to increase coordination of planning, assist with local planning preparation, increase outreach and education efforts for local residents and visitors on hazards and climate change risks, implement risk assessment in planning, protect infrastructure and emergency facilities, protect economic viability of coastal businesses, include climate adaptation concerns in planning, and increase and build local capacity to prepare for and deal with coastal hazards, including

¹⁰⁰ [Restoration and Managed Retreat of Pacifica State Beach](#)

¹⁰¹ [Sustainable Development Initiatives in the Polar Town of Iqaluit, Canada](#)

developing adaptation plans. By assisting towns in developing local MHM Plans, the Commission can help towns qualify for FEMA pre- and post-disaster planning funds.¹⁰²

Pacific States USA

The Native Village of Shishmaref, Alaska has been working to relocate its entire community further inland since 2002. While the village continues to apply for state and federal funding to support capacity building and technical assistance to facilitate relocation, Shishmaref is also developing a series of emergency preparedness and response plans as called for by the Alaska Climate Change Sub-Cabinet's Immediate Action Workgroup in case funding cannot be found to support relocation.¹⁰³

c) Maintain adequate financial resources for adaptation

Planning, developing, and implementing adaptation strategies cannot be done without adequate financial resources and investment. Economic barriers are frequently cited by groups as reasons for not taking adaptation action. 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). Climate adaptation actions undertaken as a new and distinct set of activities (e.g., scenario planning exercises) will require new and distinct funding. 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 of financing. 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. 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. Increased and sustainable funding sources can help organizations and governments overcome financial constraints and adapt to changing environmental conditions.

Examples

Southeast/Gulf USA

The Florida Energy and Climate Commission created by Governor Charlie Crist and the Florida Legislature in 2008 is the primary organization for state energy and climate change programs and policies. The Commission holds a variety of responsibilities, including administering financial incentive programs.¹⁰⁴

Nationwide USA

¹⁰² [Disaster Preparedness and Response Planning in Barnstable County, Cape Cod](#)

¹⁰³ [Relocating the Native Village of Shishmaref, Alaska Due to Coastal Erosion](#)

¹⁰⁴ [Florida Energy and Climate Commission](#)

The StormSmart Coasts Network, a national program in the United States, provides users with links to funding and technical resources to assist coastal communities looking to prepare for and recover from storm events. These links include vetted federal and non-governmental sites.¹⁰⁵

d) Create/enhance technological resources

Technological resources can make adaptation action easier and more accessible. These resources include the tools that can support information exchange, modeling of vulnerability and risk, and decision making. 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.

Examples

Arctic Canada

The Igliniit Project in Nunavut, Canada, supports the use of a GPS device that can be mounted on indigenous Inuit hunters' snow machines to track routes, weather conditions like temperature and pressure, and observations like hazards, sea ice, and animals. The data provided in these devices are then used to create community maps that provide qualitative and quantitative information to inform status and trends in hunting patterns and land and sea ice characteristics, including the locations of hazardous conditions.¹⁰⁶

Eastern Canada and Northeast USA

There has been an ongoing effort to acquire regional LIDAR data (technology that documents topographic shoreline characteristics at fine scales) in the Northeast United States. The Rhode Island Coastal Resources Management Council is coordinating with the University of Rhode Island's Environmental Data Center and others in an effort to obtain seamless LIDAR coverage for the state (and at a minimum, coastal communities) so that the council can develop accurate fine-scale elevation data for mapping sea level rise scenarios. The acquisition of this level of information will help predict the landward migration of flood hazard zones along the coast as the sea level rises.¹⁰⁷

Alaska and British Columbia

To help survey and assess the vulnerability of lands in British Columbia to climate change, the British Columbia Ministry of Environment uses GIS technology to create sensitivity maps of the Province. These projects were done in collaboration with students at the Vancouver Island University in Nanaimo, BC, under the mentorship of Ministry of Environment staff.¹⁰⁸

¹⁰⁵ [The National StormSmart Coasts Network: Linking Coastal Decision Makers to Resources](#)

¹⁰⁶ [The Igliniit Inuit Sea Ice Use and Occupancy Project](#)

¹⁰⁷ [Planning for Sea Level Rise in Rhode Island's Coastal Management Program](#)

¹⁰⁸ [Vulnerability of British Columbia Landscapes](#)

Mid-Atlantic USA

The Nature Conservancy created the Coastal Resilience program to help planners, managers, and decision makers visualize future scenarios and identify favorable alternatives with respect to global climate change effects in Long Island Sound. The website provides an interactive mapping tool for decision makers to visualize different inundation and flooding scenarios; information to analyze the potential ecological, social, and economic impacts of each scenario; and recommendations for adaptation options that minimize losses to natural and human communities.¹⁰⁹

e) Develop/implement adaptation or 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). Adaptive management involves testing hypotheses about system function and management efficacy and adjusting behavior and actions based on experience and actual changes. 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.

Examples**Southeast/Gulf USA**

Coral reefs are extremely vulnerable to climate change impacts, especially when combined with stresses such as land-based sources of pollution, habitat degradation and overfishing. EcoAdapt has been working on a climate change adaptation action plan for Florida's reefs as result of the Reef Resilience conference recommendations in 2008. The *Florida Climate Change Action Plan for the Florida Reef System 2010-2015* recognizes the need to reduce local impacts to increase resilience and offers a framework of actions to be incorporated into reef management plans to address the complex factors associated with climate change.¹¹⁰

Southeast/Gulf USA

The Alligator River National Wildlife Refuge is located in Dare and Hyde Counties, North Carolina, in the Albemarle-Pamlico Estuary. A pilot project has been created with the support of a partnership between the North Carolina chapter of The Nature Conservancy and the U.S. Fish and Wildlife Service to evaluate the effects of different adaptation strategies on areas impacted (or likely to be impacted) by sea level rise. This is an adaptive management study to determine how to make the shoreline more resilient to rising sea levels. The strategies include constructing oyster reefs to buffer shorelines from waves and storm surges, restoring the natural hydrologic regime and associated wetland systems, and planting salt- and flood-tolerant

¹⁰⁹ [Coastal Resilience: Visualizing Climate Change Impacts and Coastal Hazards and Implementing Solutions in Long Island Sound](#)

¹¹⁰ [Florida Reef Resilience Program](#)

species.¹¹¹

Nationwide Mexico

The Nature Conservancy in Mexico has created a program to develop climate change adaptation options to conserve biodiversity, ecosystems, and ecosystem services in the country's protected areas. A pilot project in Southeast Mexico began in July 2010 to determine climate change impacts in the area and design adaptation strategies; these strategies will be monitored and evaluated as to their effectiveness and the most successful will be integrated into management plans for the area.¹¹²

f) 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. There are also opportunities to use existing regulatory frameworks to support conservation and management efforts to decrease the vulnerability of natural and human systems.

Examples

Mid-Atlantic USA

In 2007, the Governor of Maryland signed an Executive Order that created the Commission on Climate Change which was tasked to develop a comprehensive Climate Action Plan for the state. Within the Plan the Climate Change Commission's Adaptation and Response working group recommends that the Governor and General Assembly take legislative and policy actions, such as incorporating climate predictions into state and local policies and strengthening building codes, to promote avoidance and/or reduction of impacts to existing built environments as well as to future growth and development in vulnerable coastal areas. Other recommendations include shifting to sustainable economies and investments; avoiding financial risk of development and redevelopment in highly hazardous coastal areas; enhancing preparedness and planning efforts to protect health, safety, and welfare; and protecting and restoring Maryland's natural shoreline and resources.¹¹³

Pacific States USA

The Washington Department of Natural Resources manages 2.6 million acres of state-owned aquatic lands and has a legal obligation to prepare for climate change impacts, such as sea level rise, ocean acidification, and erosion, as it holds these lands in the public trust. In preparing for sea level rise, the Department has to consider jurisdictional issues and property and ownership concerns because they have no existing authority over upland regions that may become state-owned aquatic lands as these areas are inundated, which

¹¹¹ [Alligator River National Wildlife Refuge/Albemarle-Pamlico Peninsula Climate Adaptation Project](#)

¹¹² [Climate Change Adaptation in Protected Areas in Mexico for the Conservation of Biodiversity, Ecosystems, and Ecosystem Services](#)

¹¹³ [Implementation of Maryland's Climate Action Plan](#)

decreases the Department's ability to proactively plan for climate change. The Department is working to implement policies to increase resilience (e.g., reduce non-climate stressors, encourage restoration and conservation), encourage new uses of state-owned aquatic lands (e.g., wind and tidal energy capabilities), and facilitate managed retreat (e.g., assist property owners in creating buffers to allow landward migration, utilize rolling easements).¹¹⁴

Nationwide USA

The National Park Service released its Climate Change Response Strategy in September 2010. As part of its adaptation goals, the National Park Service has committed to utilize adaptive management and scenario planning to integrate climate change into decision making, promote resilience and conservation of natural resources, develop strategies to preserve cultural resources that are vulnerable to climate change, require vulnerability assessments for funding decisions, and increase sustainability of park infrastructure.¹¹⁵

These adaptation strategies can all be used to address the complex issues surrounding climate change. Adaptation can help local, regional, national, and international entities deal with the sense of environmental fatalism – the idea that it is too late and too difficult to address climate change – when confronted with the reality of global climate change.

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¹¹⁴ [Preparing for Climate Change on State-Owned Aquatic Lands in Washington State](#)

¹¹⁵ [Planning for Climate Change in the National Park Service](#)

IV. Trends and Opportunities

In our interview and survey efforts, a number of participants mentioned real and perceived barriers to taking adaptation action, including:

- Lack of economic resources and budgetary constraints
- Lack of institutional support, governance, and mandates to take adaptation action
- Lack of institutional capacity and guidance on how to take action
- Lack of key information on local and regional specific climate projections, and tools to support assessments and monitoring
- Uncertainty about risk and vulnerability
- Lack of awareness, stakeholder support, and engagement, including climate skeptics, climate change deniers, and political opposition

Although these are common constraints to climate adaptation (see Adger et al. 2007; Snover et al. 2007; Kareiva et al. 2008; Glick et al. 2009), the majority of our projects exemplify that these barriers may often be overcome by systematically improving understanding of climate science, risks, and vulnerabilities; investing in capacity building, acquisition of resources, and outreach and education; and developing collaborative partnerships. We have broken down these measures to the following trends:

- A. Assessments of vulnerability and risk to natural resources and coastal communities
- B. Scientific research on climate change with policy implications for adaptation
- C. Integration of climate change concerns in the development and implementation of committees and plans
- D. Integration of climate change and its effects into programmatic and collaborative approaches to research, management, and planning
- E. Incorporation of information on the effects of climate change and approaches to adaptation into outreach and education efforts
- F. Restoration and protection of ecosystems to increase resilience and reduce vulnerability to climate change

We present a discussion of each trend below. Because the majority of adaptation projects in our inventory are based in the United States and Canada, subsections A through F provide examples from these two countries; subsection G focuses specifically on climate change efforts in Mexico.

A. Assessments of vulnerability and risk to natural resources and coastal communities

Vulnerability assessments aim to identify the resources and communities that are at risk from climate change impacts and to ascertain why they are vulnerable (Glick and Stein 2010). Climate change vulnerability assessments are done both as stand-alone efforts or as part of broader vulnerability

assessments conducted for Environmental Impact Assessments, project planning efforts, and the like. These assessments are being used throughout marine and coastal environments in North America. The range of climatic variability and dispersed levels of information at all scales has led many groups to conduct localized analyses of vulnerability on natural resources and coastal communities.

Natural Resources

- The Gulf and Caribbean coasts of Mexico are extremely vulnerable to climate change impacts, especially sea level rise. Researchers have examined impacts to the coastal biodiversity and natural areas and provided recommendations for habitat restoration of dunes, wetlands, lagoons, and estuaries and protection of mangroves in the area in order to support integrated coastal zone management.¹¹⁶
- The Washington Department of Natural Resources contracted a pilot assessment of the state's wild geoduck fishery. Results concluded that this economically valuable resource will likely be degraded by climate change and that the department should address ecosystem services in its broader adaptation plan.¹¹⁷

Coastal Communities

- The South Florida Regional Planning Council examined the effects of long-term sea level rise on seven coastal counties – Broward, Monroe, Miami-Dade, Indian River, Palm Beach, Martin, and St. Lucie – to determine effects on natural resources, infrastructure, and communities. Each county now has inundation maps under different sea level rise scenarios available for use by planners and local decision makers.¹¹⁸
- Actual and potential damage to infrastructure has increased the use of vulnerability assessments. Indian and Northern Affairs Canada funded the City of Iqaluit on Baffin Island, Nunavut, to identify risks to and develop adaptation strategies for infrastructure. Of primary concern are the effects of warming temperatures on permafrost and increases in extreme weather events on the city's buildings, roads, water supply, and wastewater treatment facilities. The existing infrastructure was designed based on historic climate data but obvious changes in permafrost and temperatures are already causing damage and proving to be incompatible with existing building codes.¹¹⁹

Other examples include:

- [Salt Marsh Vulnerability Assessment and Adaptation Plan Development in San Francisco Bay, California](#)

¹¹⁶ [Impacts of Climate Change on Coastal Zone of Mexico: An Integrated Ecosystem Approach in the Gulf of Mexico on Climate Mitigation and Adaptation to Support Coastal Zone Management Legislation](#)

¹¹⁷ [Preparing for Climate Change on State-Owned Aquatic Lands in Washington State](#)

¹¹⁸ [The South Florida Sea Level Rise Project](#)

¹¹⁹ [Sustainable Development Initiatives in the Polar Town of Iqaluit, Canada](#)

- [Vulnerability of King County, Washington Wastewater Treatment Facilities to Sea Level Rise](#)
- [Alligator River National Wildlife Refuge/Albemarle-Pamlico Peninsula Climate Adaptation Project](#)
- [Mexico: Adaptation to Climate Change Impacts on the Coastal Wetlands](#)
- [Systematically Prioritizing Restoration Projects in Terrebonne Parish, Louisiana](#)
- [Oyster River Watershed Culvert Study – Climate Ready Estuaries Program](#)
- [Massachusetts Bays Project - Climate Ready Estuaries Program](#)
- [Mapping Future Climate Change in Alaska’s National Parks](#)
- [Future Climate and Water Availability in Alaska](#)
- [Vulnerability of British Columbia Landscapes](#)
- [Shoreline Sensitivity to Sea Level Rise in British Columbia](#)

B. Scientific research on climate change with policy implications for adaptation

Research on climatic variability and its effects on marine and coastal ecosystems are also present in the adaptation inventory, although predominantly in Canada and the United States. The availability and access to data allows scientists in these areas to fill information gaps and improve long-term data sets, tools, and monitoring efforts.

- Many studies incorporate climate change as an ancillary concern. For example, two research initiatives by the U.S. Geological Survey’s St. Petersburg Coastal and Marine Science Center in Florida address climate change as one of the variables. The Coral Reef Ecosystem Studies (CREST) project investigates the health and resilience of coral reefs to future ecosystem changes, including climate change. CREST examines the interactions between stressors while improving the understanding of the current status and function of coral reefs and investigating likely future changes in reef ecosystems in the Dry Tortugas, Virgin Islands, and Biscayne National Parks, and selected areas of the Florida Keys National Marine Sanctuary. The primary purpose is to provide data to inform public policy and best management practices.¹²⁰ The Florida Shelf Habitat (FLaSH) Ecosystem Project builds upon earlier efforts to conduct benthic habitat mapping in Florida by including consideration of climate change impacts, especially ocean acidification, on living marine resources along the shelf. Scientists are studying ocean chemistry to better understand the impacts of higher levels of atmospheric CO₂ on marine and coastal resources. Results of this project will inform policy and science decisions on potential remediation efforts to protect living marine resources along Florida’s shelf.¹²¹

¹²⁰ [Coral Reef Ecosystem Studies \(CREST\) Project](#)

¹²¹ [Response of Florida Shelf Ecosystems to Climate Change: The FLaSH Project](#)

- Fisheries managers also benefit from scientific studies on climate variability, which affects marine productivity, community structure, and species assemblages. The North Pacific Climate Regimes and Ecosystem Productivity (NPCREP) program is charged with conducting research on ecosystem response to climate variability in the Bering Sea and Gulf of Alaska. The main tasks of NPCREP are to develop climate models and tools to assist managers with predictions and stock assessments and provide managers with relevant and accessible ecosystem data. The tools are used by the North Pacific Fishery Management Council, the State of Alaska, and other resource managers to establish sustainable harvest policies and support ecosystem-based approaches to management. These tools include ecosystem models, assessments and forecasts, an ecosystem monitoring network, and real-time data for the Bering Sea, which allows the Council to adjust management decisions based on current trends.¹²²
- In the Arctic North, a permafrost study on coastal areas of Inuvialuit, Nunatsiavut, Nunavut, and Yukon is providing scientific research and tools that may assist land use planning and management decisions in the future. Increased temperatures are expected to completely thaw or melt permafrost, which covers more than half of Northern Canada's landmass; this will likely result in ecosystem degradation and infrastructure instability. Researchers are modeling ground surface temperatures under different scenarios and monitoring for coastal erosion and landform development across a broad range of environments. When completed, managers, planners, and decision makers will have access to map and tools to assist land use planning.¹²³
- The U.S. Department of the Interior's climate change strategy strengthens the coordination of climate research and management in its internal bureaus and offices and will support local, regional, and national responses to climate change. For example, the strategy designated eight regional Climate Science Centers and 21 Landscape Conservation Cooperatives. The centers will facilitate scientific research, modeling, forecasting, and monitoring of climate impacts on the nation's resources and serve as information centers for stakeholders in each region – Alaska, Pacific Islands, Northwest, Southwest, North Central, South Central, Northeast, and Southeast. These centers will provide climate data and tools for management to their associated Landscape Conservation Cooperatives.¹²⁴
- In Canada, the collaborative [Canadian Climate Impacts and Adaptation Research Network](#) (C-CIARN) was created in 2001 by Natural Resources Canada to act as a coordinating body to promote research on climate impacts and adaptation and to facilitate collaboration between scientists and other stakeholders. Although the network shut down in 2007, products from its six regional hubs are still archived and available on its website. Natural Resources Canada also created the [Climate Change Impacts and Adaptation Program](#), which currently funds research initiatives, and Canada is also currently creating a national network of adaptation hubs.

¹²² [North Pacific Climate Regimes and Ecosystem Productivity Program](#)

¹²³ [Evaluating the Effects of Climate Change on Permafrost in Northern Coastal Canada](#)

¹²⁴ [U.S. Department of the Interior Climate Change Strategy](#)

Other examples include:

- [Integrating Climate Change into the National Estuarine Research Reserve System](#)
- [Stream Temperature Monitoring Network for Cook Inlet Salmon Streams](#)
- [North Bay Climate Adaptation Initiative](#)
- [Climate Change Action Plan for the Florida Reef Tract – 2010-2015](#)
- [Oyster Emergency Project](#)

C. Integration of climate change concerns in the development and implementation of committees and plans

In many marine and coastal areas of North America, even with high levels of awareness, capacity, and resources related to climate change, action on climate change is not a given. In fact, sometimes climate change is completely excluded from decision making (e.g., building in flood risk zones). Despite these idiosyncrasies, many projects in our inventory exhibit the integration of climate change adaptation in the development and implementation of committees and plans, primarily in the United States.

Committees

- Many adaptation committees have been created by mandate. For example, the Maine State Legislature directed the Department of Environmental Protection to develop and present adaptation recommendations for the built, natural, coastal, and social environments. Modeling much of their process on Washington State’s efforts, the Department created a coordinating committee and subcommittees to research and develop the recommendations that were presented to the Legislature in February 2010.¹²⁵ The same is true for the Maryland Adaptation and Response Working Group¹²⁶, Washington’s Preparation and Adaptation and 5560 Interagency Working Groups¹²⁷, and Florida’s Broward County and Miami-Dade Climate Change Task Forces.^{128, 129} A national committee was formed at the request of President Obama; the U.S. Interagency Climate Change Adaptation Task Force comprises more than 20 federal agencies and departments working to create a federal adaptation strategy.¹³⁰

Plans

- Two grant recipients of the U.S. Environmental Protection Agency’s Climate Ready Estuaries Program – Charlotte Harbor and Indian River Lagoon – are developing adaptation plans for cities in south Florida. The Charlotte Harbor National Estuary Program developed an adaptation plan for the City of

¹²⁵ [Adapting People and Nature to Maine’s Changing Climate](#)

¹²⁶ [Implementation of Maryland’s Climate Action Plan](#)

¹²⁷ [Developing a Washington State Climate Change Impacts Response Strategy](#)

¹²⁸ [Broward County Climate Change Task Force and Climate Change Initiatives](#)

¹²⁹ [Miami-Dade Climate Change Advisory Task Force](#)

¹³⁰ [U.S. Interagency Climate Change Adaptation Task Force](#)

Punta Gorda, which was approved in November 2009 by the City Council. The next steps are to incorporate recommendations from the plan into the city's next Comprehensive Plan Evaluation and Appraisal Report.¹³¹ The Indian River Lagoon National Estuary Program is working with the City of Satellite Beach to incorporate sea level rise projections and policies into the city's Comprehensive Growth Management Plan. The three components of the project are a vulnerability assessment, public outreach, and policy development. The next phase of the project is the development of an adaptation plan for the City of Satellite Beach, expected to be completed by 2010.¹³²

- New York City released PlaNYC in 2007, which reviews potential climate impacts and outlines mitigation and adaptation strategies. The adaptation measures include creating an Intergovernmental Task Force on Climate Change to protect infrastructure such as the water supply, power plants, sewer and wastewater systems, and underground subways; developing local strategies in vulnerable waterfront neighborhoods; and launching a city-wide process to assess risks, costs, and solutions.¹³³

Other examples include:

- [Preparing for Climate Change in California's East Bay Municipal Utility District](#)
- [Florida Governor's Action Team on Energy and Climate Change: Developing an Energy and Climate Action Plan](#)
- [Climate Change Action Plan for the Florida Reef Tract – 2010-2015](#)
- [Identifying Opportunities for Climate Adaptation in the Delaware Estuary](#)
- [City of New Castle, Delaware Coastal Resiliency Action Plan](#)
- [Coastal Adaptation Plan for the Town of Groton, Connecticut](#)
- [Town of Bowers Beach, Delaware Coastal Resiliency Action Plan](#)

D. Integration of climate change and its effects into programmatic and collaborative approaches to research, management, and planning

Many of the projects in our inventory are the result of collaborative approaches to adaptation through integration into research programs, management, and planning efforts. These projects demonstrate that coordination and collaboration can increase capacity for taking on climate adaptation by improving and sharing resources, tools, funds, and knowledge. This coordination is evident at different levels, including national, regional, state, and sectoral.

National Collaboration

- The U.S. Environmental Protection Agency's Climate Ready Estuaries Program works to build capacity in different National Estuary Programs to prepare for and adapt to climate change. The Program

¹³¹ [Incorporating Climate Change Impacts into Activities in Charlotte Harbor, Florida](#)

¹³² [Indian River Lagoon and City of Satellite Beach, Florida Adaptation Project](#)

¹³³ [PlaNYC- A Comprehensive Sustainability Plan for New York City, New York](#)

provides support through grants and technical assistance. Grants are used to provide financial and resource assistance, either for new start-up projects or for ones building upon pre-existing work. Technical assistance occurs in the form of tailored support provided by Environmental Protection Agency staff and contractors. Examples of this kind of support include climate change vulnerability assessments, habitat modeling, monitoring plan development, and stakeholder engagement and communication. Twelve National Estuary Programs received grants or technical assistance in 2008 and 2009.¹³⁴

- [ArcticNet](#) is one of the Centres of Excellence of Canada. Scientists, managers, agencies, indigenous people, and private businesses collaborate on coastal climate change studies in Arctic Canada. These include collaborations with international teams from the United States, Scandinavia, Russia, and Greenland.

Regional Collaboration

- The [National Oceanic and Atmospheric Administration's Regional Integrated Sciences and Assessments \(RISA\) program](#) supports scientists in developing tools for regional and local managers and planners. Currently funded groups are the [Alaska Center for Climate Assessment and Policy](#), [California Applications Project](#), [Carolinas Integrated Sciences and Assessments](#), [Climate Assessment of the Southwest](#), [Climate Impacts Group](#), [Pacific RISA](#), [Southeastern Climate Consortium](#), [Southern Climate Impacts Planning Program](#), and [Western Water Assessment](#).
- The Gulf of Mexico Research Plan is funded by the National Sea Grant College Program and is a collaboration among four Gulf of Mexico Sea Grants, state and federal agencies, universities, non-profits, and private industry groups to prioritize research and information needs in the region.¹³⁵
- The [Centre for Indigenous Environmental Resources](#) is a First Nation non-profit in Canada created to address environmental concerns to indigenous communities throughout the country. Its research includes partnering with First Nations to develop community plans, hosting climate workshops, and studying the impacts of climate change on fisheries, food availability, and communities.

State Collaboration

- The Connecticut Adaptation Subcommittee is comprised of representatives from the state Departments of Environmental Protection, Public Works, Public Health, Transportation, Economic and Community Development, Agriculture, and Emergency and Homeland Security, among others.¹³⁶
- The Florida Reef Resilience Program covers the area from the southeast Florida mainland to the Dry Tortugas and includes the Florida Keys. Scientists, managers, and other user groups are developing

¹³⁴ [U.S. Environmental Protection Agency's Climate Ready Estuaries Program](#)

¹³⁵ [Gulf of Mexico Research Plan](#)

¹³⁶ [Assessing Impacts and Developing Adaptation Strategies for Connecticut's Natural and Built Environments](#)

management approaches and tools to help combat stressors (e.g., climate change, overfishing, eutrophication, invasive species) and increase the long-term resilience of the system. This program is the result of a large partnership that includes The Nature Conservancy, EcoAdapt, World Wildlife Fund, National Oceanic and Atmospheric Administration, Florida Keys National Marine Sanctuary, National Park Service, Florida Department of Environmental Protection, Florida Fish and Wildlife Conservation Commission, Mote Marine Laboratory, University of South Florida, Florida Institute of Technology, Great Barrier Reef Marine Park Authority, Southeast Florida Coral Reef Initiative, and Royal Caribbean and Celebrity Cruises.¹³⁷

Sectoral Collaboration

- The Water Utility Climate Alliance (WUCA) is a coalition that was formed in 2007 to help water and wastewater utilities prepare for the impacts of climate change. Members include Denver Water, the Metropolitan Water District of Southern California, New York City Department of Environmental Protection, Portland Water Bureau and San Diego County Water Authority, San Francisco Public Utilities Commission, Seattle Public Utilities, and Southern Nevada Water Authority. One of the major limitations facing water utilities is their ability to project changes within their watershed and then, develop adaptive management techniques to adjust to changes that occur with climate change. The WUCA is partnering with the climate science community to develop down-scaled climate models that are able to more accurately predict changes in the hydrological cycle at the sub-basin scale.¹³⁸
- After a three day adaptation conference in 2009, the North Bay Climate Adaptation Initiative was created by natural resource managers, scientific experts, and community leaders dedicated to developing a collaborative approach to reducing climate impacts on the North San Francisco Bay area. The goal of the Initiative is to promote information exchange and research to develop strategies to effectively adapt the North Bay area to climate change. The collaborative is divided into three working groups that meet monthly: habitat conservation and stewardship; science, technology, and land management nexus; and policy and funding development.¹³⁹

Other examples include:

- [Alligator River National Wildlife Refuge/Albemarle-Pamlico Peninsula Climate Adaptation Project](#)
- [Implementation of Maryland's Climate Action Plan](#)
- [Impacts of Climate Change on Coastal Zone of Mexico: An Integrated Ecosystem Approach in the Gulf of Mexico on Climate Mitigation and Adaptation to Support Coastal Zone Management Legislation](#)

¹³⁷ [Florida Reef Resilience Program](#)

¹³⁸ [Water Utility Climate Alliance](#)

¹³⁹ [North Bay Climate Adaptation Initiative](#)

E. Incorporation of information on the effects of climate change and approaches to adaptation into outreach and education efforts

Outreach and education efforts have been very successful in marine and coastal North America. Materials, events, and citizen science/volunteer efforts engage individuals and groups, increase support and capacity, and help assuage feelings of environmental fatalism.

Materials

- The Tampa Bay Estuary Program and Coastal Bend Bays and Estuaries Program are working together to create a Gulf Coast Community Handbook to identify strategies that incorporate resilience to climate change as a component of habitat restoration and protection. The handbook is meant to assist Gulf Coast communities to incorporate climate change into habitat protection and restoration activities by providing specific adaptation recommendations and strategies.¹⁴⁰
- The South Florida Regional Planning Council created a Climate Change Community Toolbox, commissioned by the Miami-Dade Climate Change Advisory Task Force, to assist local officials plan for and adapt to climate change. The Toolbox includes fact sheets on likely climate impacts on Miami-Dade's economy, environment, and community; inundation maps with different sea level rise scenarios; and links to national and international sources on adaptation planning.¹⁴¹
- The U.S. Global Change Research Program created the *Climate Change, Wildlife, and Wildlands Toolkit for Formal and Informal Educators* to aid educators in communicating how climate change will affect the environment and how people can become "climate stewards."

Outreach Events

- The Albemarle-Pamlico National Estuary Program in North Carolina is working to communicate climate change risks to the public and policymakers through two means: 1) a series of public listening sessions; and 2) direct interaction with policy makers. Public listening sessions in 2008 attracted more than 100 residents who came to voice concerns about sea level rise and population growth and discuss potential solutions. The program is also working with the Nicholas Institute for Environmental Policy Solutions at Duke University to interview local and state elected officials about climate change issues and actions. The findings from the listening sessions and the interviews have greatly informed the creation of a comprehensive outreach campaign to develop adaptation solutions to sea level rise.¹⁴²
- The National Estuarine Research Reserve's *Planning for Climate Change* workshops were piloted in Washington State in March 2009 to educate and train coastal managers and planners on climate impacts and adaptation strategies. These workshops were developed by an interdisciplinary team

¹⁴⁰ [Creating a Gulf Coast Community Handbook for Restoration and Adaptation](#)

¹⁴¹ [Florida's Climate Change Community Toolbox](#)

¹⁴² [Albemarle-Pamlico National Estuary Program – Climate Ready Estuaries Project](#)

from the Padilla Bay National Estuarine Research Reserve, Washington Sea Grant, the University of Washington's Climate Impacts Group, and King County with assistance from NOAA and the Washington Department of Ecology. Presentations on projected climate impacts and case studies on adaptation strategies were presented and discussed by participants. The methods and materials used in these workshops are available for use by other groups.¹⁴³ In September 2009, this model was adapted for a workshop with planners in San Francisco Bay.¹⁴⁴

Citizen Science/Volunteer Efforts

- The Salmon Watcher Program in Washington State trains volunteers to collect information on spawning salmon in streams and rivers throughout two counties; these monitoring efforts help scientists determine natural and climate-based fluctuations in populations. Many salmon species in Washington State have been designated as threatened or endangered due to disease, overfishing, and dam construction; climate change is also a threat. The Salmon Watcher Program trains volunteers to identify and monitor different salmon species, including Chinook, coho, sockeye, kokanee, and chum. The information collected is then passed on to scientists so that they can determine fluctuations and variability in populations.¹⁴⁵

Other examples include:

- [Incorporating Climate Change into Research and Management at Mass Audubon](#)
- [Alabama's Baldwin County Grasses in Classes Program](#)
- [Monitoring Lake Ice and Snow in Alaska – The Alaska Lake Ice and Snow Observatory Network \(ALISON\) Project](#)
- [Alligator River National Wildlife Refuge/Albemarle-Pamlico Peninsula Climate Adaptation Project](#)

F. Restoration and protection of ecosystems to increase resilience and reduce vulnerability to climate change

In our inventory, we have only considered those restoration projects that were explicitly designed to address climate change impacts, although we acknowledge that many restoration efforts will enhance the generic resilience of natural systems. While protection and conservation measures can also reduce ecosystem vulnerability to global climate change by reducing non-climate stressors, including habitat destruction, fragmentation, and cumulative impacts of these and other factors, a net reduction of climate vulnerability by such measures is not guaranteed if they do not explicitly incorporate climate change.

¹⁴³ [The National Estuarine Research Reserve's "Planning for Climate Change" Workshop](#)

¹⁴⁴ [Planning for Climate Change: A Workshop for San Francisco Bay Area Planners](#)

¹⁴⁵ [Washington's Salmon Watcher Program](#)

- In 2008, the U.S. National Park Service removed two dams in California’s Drakes Estero Estuary, part of Point Reyes National Seashore’s Estero de Limantour coastal watershed, to restore habitat, fish passage, and connectivity in the park’s tidal marshes. These dams altered freshwater flows, created fish passage barriers, and restricted connectivity between freshwater and saltwater habitats in the area. The estuary currently supports the federally threatened steelhead trout (*Oncorhynchus mykiss*) and California red-legged frog (*Rana aurora draytonii*); scientists believe that the area could also support the federally endangered coho salmon (*Oncorhynchus kisutch*) if natural processes and connectivity are restored to support anadromous passage. In addition to acting as barriers, these dams were also believed to be at risk of failure, making them extremely vulnerable to sea level rise and increased flooding associated with climate change. By restoring natural ecological processes, the area will be more resilient to climate change.¹⁴⁶
- In the Waihe’e Refuge on the north coast of Maui, Hawaii, managers are working with volunteers to remove invasive plant species and replant native plants to increase the native ecosystem’s resilience to climate change. The refuge is an important historical site for native Hawaiians and has a wide variety of natural habitats, including wetlands, dune systems, marine shoreline and riparian systems, all of which are at risk to rising sea levels. In order to restore the area, managers and volunteers are removing the invasive plants that covered about 95% of the refuge when the project began; the wetland is now up to 70% native species, and native plants and birds are starting to repopulate the surrounding landscape.¹⁴⁷
- Save the Bay in Providence, Rhode Island, has improved the ability of coastal zones to absorb storm surges and rising sea levels by creating more vibrant, living shorelines that are adaptive by nature through restoration of eelgrass, scallop, and salt marsh habitats in Narragansett Bay.¹⁴⁸

Other examples include:

- [Oyster Reef Breakwater Restoration Project on Alabama’s Gulf Coast](#)
- [Alligator River National Wildlife Refuge/Albemarle-Pamlico Peninsula Climate Adaptation Project](#)
- [Systematically Prioritizing Restoration Projects in Terrebonne Parish, Louisiana](#)
- [Incorporating Climate Change into Landscape Connectivity Plans](#)
- [Wellfleet Bay Oyster Reef Habitat Restoration Project](#)
- [Kayak Point Restoration Feasibility and Design Technical Memorandum: Sea Level Rise Projections](#)

¹⁴⁶ [Estero de Limantour Coastal Watershed Restoration Project](#)

¹⁴⁷ [Waihe’e Refuge Restoration Project](#)

¹⁴⁸ [Increasing Coastal Resilience through Restoration and Education in Narragansett Bay, Rhode Island](#)

G. Climate change efforts in Mexico

Most of the aforementioned trends in subsections A through F are geographically biased toward Canada and the United States. In our interview and survey efforts, we found that in Mexico, some organizations and individuals are still struggling to understand the concept of climate change adaptation, which may explain the lack of content in the inventory. Some areas of Mexico have climate change projects that focus on forests and agriculture, but there is not much adaptation activity in marine and coastal environments. This section presents an overview and discussion of climate change efforts in Mexico.

Mexico is highly vulnerable to climate change impacts, including sea level rise, droughts, and extreme weather events. These are compounded by socioeconomic and environmental challenges throughout the country, such as high poverty rates, low education, inadequate water resources, deforestation, and rapid coastal development. These complex issues, combined with insufficient information, stakeholder support, funding, and capacity makes the development of climate change action challenging. However, Mexico has recently started to develop plans for climate change mitigation and adaptation.

In 2005, the Mexican government established the Intersecretarial Commission on Climate Change (Comisión Intersecretarial de Cambio Climático – CICC) to coordinate development of climate change policy, oversee formulation of prevention and mitigation of greenhouse gases, direct the development of climate change adaptation strategies, and facilitate climate change research. In 2007, the CICC developed the National Climate Change Strategy (Estrategia Nacional de Cambio Climático – ENACC), which identified measures for reducing greenhouse gas emissions, acknowledged the vulnerability of diverse economic and social sectors, and recommended the development of a national adaptation approach. The ENACC created a Special Program on Climate Change (Programa Especial de Cambio Climático) and a National Development Plan to promote the development of state climate action plans. Since its establishment, the CICC's focus has been on developing mitigation policies and programs, including regulating energy generation and use, creating vegetation and land use policies, and participating in the United Nations Reducing Emissions from Deforestation and Forest Degradation program (REDD). Recently there has been a push for building support for climate adaptation through State Action Plan initiatives, led by the National Institute of Ecology (Instituto Nacional de Ecología – INE). These include reviewing existing comprehensive plans, building institutional capacity, enhancing ecological land use planning, promoting actions to reduce vulnerability, and designing broad education and outreach efforts.

All states in Mexico are mandated to develop a Climate Change Action Plan. The challenges to developing these plans are the same as the national challenges listed above, and include lack of capacity, insufficient funds, limited local knowledge and understanding of the valuation of natural resources, and stakeholder support. The first state Climate Action Plan completed and approved by the government was in 2008 in the State of Veracruz.¹⁴⁹ Veracruz was selected because of its high vulnerability to climate change impacts. Veracruz is the third most populated state in Mexico and is already affected by increased frequency of

¹⁴⁹ [Veracruz, Mexico Country's First State Action Plan on Climate Change](#)

hurricanes, urban floods, droughts, saltwater intrusion, and shoreline erosion associated with sea level rise over the last decade. In response, the government created the Veracruz Program Against Climate Change to oversee the development of an action plan, along with the INE, the Secretary of Environment and Natural Resources, and Veracruz University. The Veracruz Climate Change Action Plan serves as a model for other states in Mexico to develop similar plans and includes preliminary greenhouse gas emission mitigation strategies, biodiversity and adaptation actions, and lays out the implications of inaction. The State of Campeche is currently in the process of developing a similar plan. Although not perfect, the collaborative process in the State of Veracruz was successful in building support for a climate action plan. It was also successful because of generous funding from the United Kingdom Global Opportunities Funds and the National University of Mexico. Funds need to be made available and allocated by the government for other states to successfully develop and implement these plans.

V. Conclusions

Climate change is affecting ecosystems from pole to pole. To address the disruptions caused by climate and ensure the future of ecosystems, we need to make conservation and resource management less vulnerable and more climate savvy. Managers, planners, and decision makers already have many of the necessary adaptation tools at their disposal. By integrating climate change adaptation and flexibility into existing activities, these stakeholders will be able to bring a new perspective to conservation.

In our interview efforts, we found the majority of the participants agree that:

- Global climate change will have very real short- and long-term effects on natural and built environments and human communities.
- Adaptation should include a range of local, state, federal, and regional stakeholders in developing, implementing, and evaluating efforts.
- Reduction of non-climate stressors will be important to increase resilience and reduce vulnerability, whether by controlling pollution, limiting destructive fishing practices, removing invasive species, or alleviating any other additive or synergistic stress.
- Not all climate change effects will be negative. For example, some areas will have access to new fisheries resources as warmer ocean temperatures cause poleward expansions and contractions of species' ranges.
- Although new legal efforts may be needed, there are existing laws, regulations, and programs that can be strengthened with the integration of climate change considerations.
- The vulnerability of natural and human systems will vary between sectors, communities, and environments, and some areas may be disproportionately affected.
- Adaptation to global climate change should not be viewed as a substitute for mitigation; greenhouse gas emissions must be reduced to prevent further damage while increasing resilience and reducing vulnerability.

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VII. Appendices

- A. Glossary
- B. Methodology
- C. List of reports that assess climate change impacts in geographic and sectoral detail from North America
- D. List of reports that address climate change adaptation in North America
- E. Tools for adaptation
- F. Inventory of adaptation projects by geographic region
- G. Adaptation projects by type of strategy

A. Glossary

The IPCC (2007b) provides key words and definitions commonly used in reference to climate adaptation. These include:

- Adaptation – Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.
- Adaptive capacity – The ability of systems to adjust to or accommodate changes in climate (including climate variability and climate extremes) to moderate potential damages, take advantage of opportunities, or deal with consequences.
- Anticipatory/Proactive adaptation – Adaptation that takes place before impacts of climate change are observed.
- Planned adaptation – Adaptation that is the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state.
- Autonomous/spontaneous adaptation – Adaptation that does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems.
- Reactive adaptation – Adaptation that takes place after impacts of climate change have been observed.
- Resilience – The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change.
- Resistance – The ability of a social or ecological system to withstand disturbances without a significant loss of function.
- Sensitivity – The degree to which a system is affected, either adversely or beneficially, directly or indirectly, by climate variability or change.
- Vulnerability – The degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity.

B. Methodology

With the support of the Gordon and Betty Moore Foundation, this project was initiated to survey, inventory, and, where possible, assess past, current, and proposed climate change adaptation activities and projects in North America. The primary outputs are case studies of adaptation projects and this synthesis report; in addition, we integrated the information collected on projects, people, and organizations into the [Climate Adaptation Knowledge Exchange](#) (CAKE). The steps involved in creating these products included:

1. Contacting identified individuals who have or are likely to have adaptation projects and create an inventory of marine and coastal adaptation activities in North America
 2. Creating a project database to house adaptation case study inventory and create directory for adaptation network
 3. Conducting a literature search and collect relevant information on impacts and adaptation theory
 4. Writing case study summaries of relevant adaptation activities and projects and compile into the report and CAKE
1. Contacting identified individuals who have or are likely to have adaptation projects and create an inventory of marine and coastal adaptation activities in North America

A contact list was compiled of organizations and individuals who were believed to have adaptation projects, likely to know about adaptation in their region, or referred by other contacts. A unified set of questions and interview guide were created and a coding scheme for answers was designed in order to make tracking and cross-referencing possible. An online survey was also used to determine the existence of projects and to invite individuals to be listed in the CAKE directory. The survey was sent out in multiple rounds (both an English and Spanish version) through emails and announcements in newsletters and listservs.

2. Creating a project database to house adaptation case study inventory and create directory for adaptation network

Case studies are the primary information units that inform the synthesis report and the CAKE database. A data entry tool was designed with technical assistance from Blue Raster to upload and store these case studies. The data entry tool has been useful in tracking the individuals and organizations interested in participating in the adaptation network. This directory consists of those organizations and people who have case studies and/or who have indicated that they would be interested in being listed in the directory.

3. Conducting a literature search and collect relevant information on impacts and adaptation theory

The synthesis report is designed to include a review of observed, expected, and possible impacts of and vulnerabilities to climate change in marine and coastal systems; a summary and evaluation of the theory and

practice of adaptation approaches in marine and coastal systems; our list of completed, existing, and proposed marine adaptation projects in North America; and a list of trends and potential opportunities for action. We have designed the report to be iterative, however, allowing for continued updates as more information becomes available.

4. Writing case study summaries of relevant adaptation activities and projects and compile into the report and CAKE

All case study summaries follow the same format: *Project Summary/Overview*, *Project Background*, *Project Implementation*, and *Project Outcomes and Conclusions*.

Interview/Survey Question

1. Are you working on adaptation? Are you planning to work on adaptation? Are you/do you have a specific project(s) that addresses adaptation or are you integrating adaptation into your work overall?
2. How did the project get started? What is motivating you to work on adaptation? What is keeping you from working on adaptation?
3. What is the scale of your adaptation project? Are you focused in a particular location or region? Are you working alone or with partners?
4. What are the foci of your project? Natural resource setting? Sociopolitical setting? Habitat type?
5. What are the primary impacts that you are targeting through this project?
6. What is the overall time frame for this project?
7. Was an impact/vulnerability assessment conducted? What information was used in assessment and planning?
8. Outreach component/Stakeholder involvement – Who involved? Measures to increase public awareness?
9. Are there any barriers (actual or foreseen) to taking adaptation action? Anything done to address those barriers?
10. Are there any factors that facilitate(d) adaptation action?
11. Do metrics for success exist? What are they?
12. What are the goals for this project in the future? What do you want the future to look like for incorporating climate change adaptation in your work?
13. How is it funded? Is there a mechanism for long-term funding to support monitoring, analysis, information exchange, modification, or is it a one shot thing?
14. What information sources do you consult about climate change/adaptation (e.g., scientific literature, friends/colleagues)?
15. What information would be most useful for you [e.g., training materials, reports, individual consultation (in person or on the phone)]?
16. Are there people/organizations in your region or in general that you see as particularly important when it comes to climate change adaptation that you would recommend we speak to?

C. Partial list of reports that assess climate change impacts in geographic and sectoral detail from North America.

Report Name	Region covered	Sectors Addressed	Impact Addressed	Citation/Link (if available)
<i>United States</i>				
The Potential Effects of Global Climate Change on the United States	Nationwide	Economy and Infrastructure, Ecosystems	Changes in air and water temperature, Sea level rise	EPA 1989 http://www.epa.gov/climatechange/effects/coastal/1989report.html
Sea Level Rise and Global Climate Change: A Review of Impacts to U.S. Coasts	Nationwide	Economy and Infrastructure, Ecosystems	Sea level rise	Pew Center 2000 http://www.pewclimate.org/publications/report/sea-level-rise-global-climate-change-review-impacts-us-coasts
Impacts of a warming Arctic	Alaska	Economy and Infrastructure, Ecosystems, Species	Changes in air and water temperature, Sea level rise, Changes in precipitation	ACIA 2004 http://www.acia.uaf.edu/
Arctic Climate Impact Assessment (ACIA)	Alaska	Economy and Infrastructure, Ecosystems, Species	Changes in air and water temperature, Sea level rise, Changes in precipitation	ACIA 2005 http://www.acia.uaf.edu/
Climate change in the U.S. Northeast	Northeast USA	Economy and Infrastructure, Ecosystems	Changes in air and water temperature, Sea level rise, Changes in precipitation	NECIA 2006 http://www.northeastclimateimpacts.org/
Coastal Wetlands and Global Climate Change - Gulf Coast Wetland Sustainability in a Changing Climate	Southeast/Gulf USA	Ecosystems	Changes in air and water temperature,	Pew Center 2007 http://www.pewclimate.org/docUploads/Regional-Impacts-

			Sea level rise, Changes in precipitation	Gulf.pdf
Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions	Northeast USA	Economy and Infrastructure, Ecosystems	Changes in air and water temperature, Sea level rise	NECIA 2007 http://www.northeastclimateimpacts.org/
The Washington Climate Change Impacts Assessment	Pacific States USA	Economy and Infrastructure, Ecosystems	Changes in air and water temperature, precipitation, circulation, ocean chemistry, and sea level rise,	CIG 2007 http://cses.washington.edu/cig/res/ia/waccia.shtml#report
Climate Impacts on U.S. Living Marine Resources: National Marine Fisheries Service Concerns, Activities, and Needs.	Nationwide	Fisheries	Changes in air and water temperature, precipitation, circulation, ocean chemistry, and sea level rise,	Osgood 2008 http://spo.nmfs.noaa.gov/tm/TM%20SPO%2089.pdf
Coastal Sensitivity to Sea-Level Rise: A Focus on the Mid-Atlantic Region	Mid-Atlantic USA	Economy and Infrastructure, Ecosystems	Sea level rise	CCSP 2008, SAP 4.1 http://www.epa.gov/climatechange/effects/coastal/sap4-1.html
The effects of climate change on agriculture, land resources, water resources, and biodiversity in the United States	Nationwide	Economy and Infrastructure	Changes in air and water temperature, Changes in precipitation	CCSP 2008, SAP 4.3 http://www.climate-science.gov/Library/sap/sap4-3/final-report/default.htm
Scientific Assessment of the Effects of Global Change on the United States	Nationwide	Economy and Infrastructure, Ecosystems	Changes in air and water temperature, Sea level rise, Changes in precipitation	CENR 2008 http://www.climate-science.gov/Library/scientific-assessment/Scientific-AssessmentFINAL.pdf

Global Climate Change Impacts in the United States	Nationwide	Economy and Infrastructure	Changes in air and water temperature, Sea level rise, Changes in precipitation	USGCRP 2009 http://www.globalchange.gov/publications/reports/scientific-assessments/us-impacts
The Impacts of Sea Level Rise on the California Coast	Pacific States	Economy and Infrastructure, Ecosystems	Sea level rise	Pacific Institute 2009 http://www.pacinst.org/reports/sea_level_rise/report.pdf
<i>Canada</i>				
The Canada Country Study: Climate Impacts and Adaptation	Nationwide	Economy and Infrastructure, Ecosystems	Changes in air and water temperature, Changes in precipitation	CCS 1998 http://dsp-psd.pwgsc.gc.ca/Collection/En56-119-7-1998E.pdf
Adapting to Climate Change: An Introduction for Canadian Municipalities	Nationwide	Economy and Infrastructure	Changes in air and water temperature, Sea level rise	C-CIARN 2006a http://www.gnb.ca/0009/0369/0018/0006-e.pdf
Climate Change and First Nations South of 60: Impacts, Adaptation, and Priorities	Nationwide	First Nations populations, Ecosystems, Species	Changes in air and water temperature, Sea level rise, Changes in precipitation	CIER 2007 http://www.cier.ca/information-and-resources/publications-and-products.aspx?id=1178
From Impacts to Adaptation: Canada in a Changing Climate 2007	Nationwide	Economy and Infrastructure, Ecosystems	Changes in air and water temperature, Sea level rise, Changes in precipitation	NRCAN 2007 http://adaptation.nrcan.gc.ca/assess/2007/index_e.php
Northwest Territories (NWT) Climate Change Impacts and Adaptation Report	Arctic Canada	First Nations populations, Ecosystems, Species	Changes in air and water temperature, Sea level rise, Changes in precipitation	ENR 2008 http://www.enr.gov.nt.ca/live/documents/documentManagerUpload/NWT_Climate_Change_Impacts_and_Adaptation_Report.pdf

<i>Mexico</i>				
Climate Change 2007: Impacts, Adaptation and Vulnerability – Chapter 13	Mexico	Agriculture, Water Resources, Human Health, Natural Resources	Changes in air and water temperature, Sea level rise, Changes in precipitation	IPCC 2007b http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_wg2_report_impacts_adaptation_and_vulnerability.htm
Mexico, the Caribbean, and Central America: The impact of climate change to 2030	Mexico	Economy and Infrastructure, Ecosystems	Changes in air and water temperature, Sea level rise, Changes in precipitation	NIC 2009 http://www.dni.gov/nic/PDF_GIF_otherprod/climate_change/climate2030_MexicoCaribCentralAm.pdf
<i>General/International (North America)</i>				
Climate Change 2007: Impacts, Adaptation and Vulnerability – Chapter 14	United States, Canada	Natural Resources, Agriculture, Forestry, Fisheries, Human Health, Tourism/Recreation, Energy Development, Transportation	Changes in air and water temperature, Sea level rise, Changes in precipitation	IPCC 2007b http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_wg2_report_impacts_adaptation_and_vulnerability.htm

D. Partial list of reports that address climate change adaptation in North America.

Report Name	Region/Sector covered	Type of Adaptation Strategies	Citation/Link (if available)
<i>United States</i>			
Hands on Habitat	Nationwide	Natural resources management and policy	NOAA CBRP 2006 http://cooperativeconservation.gov/pdfs/HandsonHabitat.pdf
Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments	Nationwide	Institutional structure and design	CIG 2007 http://www.cses.washington.edu/db/pdf/snoveretalgb574.pdf
Preliminary review of adaptation options for climate-sensitive ecosystems and resources	Nationwide	Natural resources management and policy	CCSP 2008, SAP 4.4 http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=180143
Preparing Oregon's Fish, Wildlife, and Habitats for Future Climate Change: A Guide for State Adaptation Efforts	Pacific States	Natural resources management and policy	OGWC 2008 http://www.defenders.org/resources/publications/programs_and_policy/gw/oregon_adaptation_efforts.pdf
Synthesis of Adaptation Options for Coastal Areas	Nationwide	Natural resources management and policy	U.S. EPA 2009 http://www.epa.gov/climate/readyestuaries/downloads/CRE_Synthesis_1.09.pdf
Climate Ready Communities: A Strategy for Adapting to Impacts of Climate Change on the Oregon Coast	Pacific States	Institutional structure and design	ODLCD 2009 http://www.oregon.gov/ENERGY/GBLWRM/docs/climate_ready_communities.pdf?ga=t
U.S. Climate Action Plans	Nationwide	Institutional structure and design	NAF 2009 http://www.us-cap.org/
<i>Canada</i>			
Adapting to Climate Change: An Introduction for Canadian Municipalities	Nationwide	Institutional structure and design, Building capacity	C-CIARN 2006a http://www.c-ciarn.ca/adapting_e.html

C-CIARN Coastal Zone: State-of-Play Report 2006-2007	Nationwide	Institutional structure and design	C-CIARN 2006b http://www.c-ciarn.ca/pdf/cciarncoastal_e.pdf
Climate Change and First Nations South of 60: Impacts, Adaptation, and Priorities	Arctic Canada	Building capacity	CIER 2007 http://www.cier.ca/information-and-resources/publications-and-products.aspx?id=1178
Report on Adaptation to Climate Change Activities in Arctic Canada	Arctic Canada	Building capacity	INAC 2007 http://www.ainc-inac.gc.ca/enr/clc/adp/pubs/adap/adap-eng.asp
Canadian communities' guidebook for adaptation to climate change	Nationwide	Institutional structure and design	Bizikova et al. 2008 http://www.forestry.ubc.ca/LinkClick.aspx?fileticket=xsexCSatHjo%3D&tabid=2455&mid=5415&language=en-US
Northwest Territories (NWT) Climate Change Impacts and Adaptation Report	Arctic Canada	Natural resources management and policy	ENR 2008 http://www.enr.gov.nt.ca/live/documents/documentManagerUpload/NWT_Climate_Change_Impacts_and_Adaptation_Report.pdf
Mexico			
National Climate Change Strategy: México	Mexico		ICCC 2007
General/International (North America)			
Buying Time: A User's Manual for Building Resistance and Resilience to Climate Change in Natural Systems	General	Natural resources management and policy	Hansen, Biringer, and Hoffman 2003 http://assets.panda.org/downloads/buyingtime_unfe.pdf
Global Climate Change and Wildlife in North America	North America	Natural resources management and policy	Inkley et al. 2004 http://www.nwf.org/nwfwebadmin/binaryvault/wildlife_society_report2.pdf
Climate Proofing A Risk-based Approach to Adaptation	General	Infrastructure, planning, and development	ADB 2005 http://www.adb.org/Docume

			nts/Reports/Climate-Proofing/climate-proofing.pdf
Adapting to Climate Variability and Change: A Guidance Manual for Development Planning	General	Building capacity	USAID 2007 http://www.usaid.gov/our_work/environment/climate/docs/reports/cc_vamanual.pdf
Climate Change 2007: Impacts, Adaptation and Vulnerability	General	Natural resources management and policy, Building capacity, Institutional structure design and reform	IPCC 2007b http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_wg2_report_impacts_adaptation_and_vulnerability.htm
Strategies for Managing the Effects of Climate Change on Wildlife and Ecosystems	General	Natural resources management and policy	Heinz Center 2008 http://www.heinzctr.org/publications/PDF/Strategies_for_managing_effects_of_climate_change_on_wildlife_Nov_4_2008.pdf

E. Tools for Adaptation

[Climate Wizard](#)

A web-based mapping program that allows non-technical as well as technical users to view historic and projected future temperature and rainfall maps around the world (with finer-scale data for the United States).

[Sea Level Rise Affecting Marshes Model \(SLAMM\)](#)

Easy-to-use web-based visualization and modeling tool for sea level rise; limited geographic coverage.

[Community-based Risk Screening Tool – Adaptation and Livelihoods \(CRiSTAL\)](#)

Designed to help incorporate climate change adaptation into community-level development planning.

[Building Coast-Smart Communities Role Play Exercise](#)

A role-play exercise designed to engage business, environmental, and government stakeholders in discussions about possible community responses to climate-related risks in coastal communities.

[UK Climate Impacts Program Adaptation Wizard](#)

A web-based tool that guides users through a five-step adaptation planning process and provides relevant resources for each step.

[Nonpoint-Source Pollution and Erosion Comparison Tool \(N-SPECT\)](#)

Allows users to visualize existing runoff, sediment, and pollution patterns as well as analyzing possible future scenarios relating to land use and climate change.

[Local Government Climate Change Adaptation Toolkit](#)

This comprehensive manual provides a conceptual framework for adaptation and step-by-step instructions for 14 tools geared towards different stages of adaptation planning.

[Providing REgional Climates for Impacts Studies \(PRECIS\)](#)

Freely available software for generating high-resolution climate projections.

[Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments](#)

Describes a step-by-step process for achieving a set of climate change preparedness milestones within the context of municipal planning

[Climate Witness Community Toolkit](#)

Step-by-step description of a process to develop a community-driven adaptation plan that incorporates community values and can be implemented by the community.

[NOAA Risk and Vulnerability Assessment Tool \(RVAT\)](#)

A risk and vulnerability assessment helps to identify people, property, and resources that are at risk of injury, damage, or loss from hazardous incidents or natural hazards.

[StormSmart Coasts Network](#)

StormSmart Coasts is a resource for coastal decision makers looking for the latest and best information on how to protect their communities from weather and climate hazards.

[USFS Climate Change Resource Center \(CCRC\)](#)

The site offers educational information, including basic science modules that explain climate and climate impacts, decision-support models, maps, simulations, case studies, and toolkits.

[WWF Adaptation to Climate Change Toolkit: Coasts](#)

The Adaptation to Climate Change Toolkit: Coasts is a series of tools and resources aimed at anyone with an interest in climate change adaptation for marine turtle habitats, including coastal managers, conservation practitioners, scientists and educators.

[Climate Change Wildlife and Wildlands: A Toolkit for Formal and Informal Educators](#)

Sponsored by the U.S. Environmental Protection Agency, this toolkit was developed to aid educators in communicating how climate change will affect the environment and provide examples of climate stewardship.

[Coastal Resilience Long Island: Adapting Natural and Human Communities to Sea Level Rise and Coastal Hazards](#)

This web-based tool provides users with access to information on resources at risk from coastal hazards and sea level rise to support planning and management decisions.

[Coral Reef Watch Satellite Monitoring](#)

Allows users to access up-to-date environmental conditions and identify areas at risk for bleaching events.

[The Climate Change LEADS Project](#)

Designed to explore and improve the resilience of south Florida's coral reefs to climate change.

[Georgetown Climate Center: Legislative Tracker](#)

Designed to allow users to easily access information, analysis, and reports on federal legislation in the United States that address climate change.

[Massachusetts Office of Coastal Zone Management's StormSmart Coasts Program](#)

The StormSmart Coasts program is designed to help coastal communities address the challenges arising from storms, floods, sea level rise, and climate change, and provides a menu of tools for successful coastal floodplain management

[NOAA Coastal Hazard Assessment Tool](#)

A Hazard Assessment Tool is an easy-to-use Internet mapping application that helps users identify the potential hazards that affect a location.

[The Coastal Risk Atlas](#)

Data provided within the Coastal Risk Atlas include acquired model outputs of hazards such as storm surge, maximum winds, and inland flooding. Demographic data help in locating vulnerable populations. The Atlas also provides mapping, assessment tools, and other information.

[NOAA's Online Climate Services Portal](#)

The goal of NCS Portal is to become the "go-to" website for NOAA's climate data, products, and services for all users. The initial content highlights some of most popular datasets/products based on customer usage of the data.

[NOAA Topographic and Bathymetric Data Inventory](#)

Topographic and Bathymetric Data Inventory is an index of the best-available elevation data sets by region. Users can zoom in to an area on the map and click on the data set to access up to 20 data attributes, including vertical accuracy, datums, and point spacing.

[Pacific Climate Change Virtual Library](#)

This website was created for Pacific Island communities looking to implement climate change adaptation plans and includes a virtual library and open forum.

[Reef Resilience \(R2\) 2008 Version](#)

The two Toolkit modules, Coral Reefs and Fish Spawning Aggregations, provide coral reef managers with guidance on building resilience to climate change into the design of MPAs and daily management activities.

[NOAA Habitat Priority Planner](#)

Designed to support local level practitioners, this tool helps decision makers in prioritizing areas for conservation or restoration.

F. Inventory of adaptation projects by geographic region

Organization	Project/Case Study Title	Project Status (as of January 2011)
Arctic Canada		
City of Iqaluit	Sustainable Development Initiatives in the Polar Town of Iqaluit, Canada	Completed
McGill University Centre d'études Nordiques (CEN)	Evaluating the Effects of Climate Change on Permafrost in Northern Coastal Canada	In progress
Sea Ice Knowledge and Use (SIKU)	The Igliniit Inuit Sea Ice Use and Occupancy Project	In progress
Center for Indigenous Environmental Resources	Climate Change Risk Assessment Training Workshop for Nunavut Communities	Completed
UNEP/GRID- Arendal	Climate Change and Food Security in Canadian Arctic	Completed
ArcticNorth Consulting	Climate Change Adaptation for the Community of Paulatuk	In progress
Canadian Institute of Planners	Planning for Melting Permafrost in Salluit	In progress
UNEP/GRID- Arendal- Polar Programme	Portraits of Resilience	Completed
Center for Indigenous Environmental Resources	Climate Risks and Adaptive Capacity in Aboriginal Communities South of 60 Degrees Latitude	In progress
ArcticNorth Consulting	Climate Change Adaptation for the Community of Ulukhaktok	In progress
Canadian Institute of Planners	Atuliquuq: A Collaborative Approach in Support of the Nunavut Climate Change Adaptation Plan	In progress
Government of Nunavut	Nunavut Climate Change Strategy	In progress
Ecology North	Preparing Communities of the Northwest Territories for the Impacts of Climate Change on Municipal Water and Wastewater Systems	In planning
Eastern Canada and Northeast USA		
Mass Audubon	Incorporating Climate Change into Research and Management at Mass Audubon	In progress
Great Bay National Estuarine Research Reserve	Assessing the Risk of 100-year Freshwater Floods in the Lamprey River Watershed of New Hampshire Resulting from Climate Change and Land Use	In progress
Halifax Regional Municipality	Halifax Climate SMART: The Climate Sustainable Mitigation and Adaptation Risk Toolkit	In progress
Wellfleet Bay Wildlife Sanctuary	Wellfleet Bay Oyster Reef Habitat Restoration Project	In progress
Piscataqua Region Estuaries Partnership	Oyster River Watershed Culvert Study	In progress
Casco Bay Estuary Partnership	Incorporating Climate Change into the Casco Bay Estuary Partnership	In progress
Wells National Estuarine Research Reserve	Sentinel Monitoring of Salt Marshes in the Wells National Estuarine Research Reserve	In progress

Narragansett Bay National Estuarine Research Reserve	Sentinel Monitoring of Salt Marshes in the Narragansett Bay National Estuarine Research Reserve	In progress
Clean Annapolis River Project Nova Scotia Community College	Annapolis Royal Tidal Surge Analysis	Completed
Ouranos	Causes and Adaptation Strategies to Shoreline Erosion in Sept-Îles	Completed
Massachusetts Bays National Estuary Program	Massachusetts Bays Project	In progress
Long Island Sound Study Connecticut Department of Environmental Protection	Coastal Adaptation Plan for the Town of Groton, Connecticut	In progress
Cape Cod Commission	Disaster Preparedness and Response Planning in Barnstable County, Cape Cod	In progress
Clean Nova Scotia	Community Consultations on Climate Change Adaptation	In progress
Strait Crossing Bridge Limited	Sea Level Rise and the Construction of the Confederation Bridge in the Gulf of Saint Lawrence	Completed
Connecticut Department of Environmental Protection	Assessing Impacts and Developing Adaptation Strategies for Connecticut's Natural and Built Environments	In planning
Save The Bay	Increasing Coastal Resilience through Restoration and Education in Narragansett Bay, Rhode Island	In progress
Maine Department of Environmental Protection	Adapting People and Nature to Maine's Changing Climate	In progress
Massachusetts Department of Fish and Game	Integrating Climate Change into the Massachusetts State Wildlife Action Plan Using an Expert Panel-based Vulnerability Assessment	In progress
Rhode Island Coastal Resources Management Council	Planning for Sea Level Rise in Rhode Island's Coastal Management Program	In progress
Mi'kmaq Confederacy of Prince Edward Island	Atlantic Aboriginal Climate Change Adaptation Workshop	Completed
Birch Hill GeoSolutions	Climate Change Adaptations for Land Use Planners	Completed
Memorial University of Newfoundland	Climate Change and Renewable Resources in Labrador	Completed
Southern Maine Regional Planning Commission	Municipal Adaptations to Create Resilient Beach Communities in Southern Maine: The Coastal Hazard Resiliency Tools Project	In progress
Massachusetts Water Resources Authority	Proactive Incorporation of Sea Level Rise in the Design of the Deer Island Wastewater Treatment Plant	Completed
Canadian Institute of Planners	Preparing for Climate Change and Sea Level Rise in New Brunswick	Completed
Maine Sea Grant	Coastal Community Resilience in Maine	Completed
New Brunswick Department of Environment	Atlantic Climate Adaptation Solutions (ACASA)	In progress
New Brunswick Department of	Atlantic Canada Climate Change Adaptation Strategy	Completed

Environment		
Mid-Atlantic USA (Delaware, Maryland, New Jersey, New York, Pennsylvania, Washington DC, Virginia)		
Barnegat Bay National Estuary Program	Barnegat Bay Climate Change Adaptation Strategy Development	In progress
Worcester County Development Review & Permitting	Planning for Sea Level Rise and Storm Surge in Worcester County, Maryland	Completed
Maryland Department of Natural Resources	Implementation of Maryland's Climate Action Plan	In progress
Chesapeake Bay National Estuarine Research Reserve in Virginia	Sentinel Monitoring of Salt Marshes in the Chesapeake Bay National Estuarine Research Reserve in Virginia	In progress
Delaware Department of Natural Resources and Environmental Control	Delaware Sea Level Rise Adaptation Initiative	In progress
Partnership for the Delaware Estuary	Identifying Opportunities for Climate Adaptation in the Delaware Estuary	In progress
Delaware Department of Natural Resources and Environmental Control	City of New Castle, Delaware Coastal Resiliency Action Plan	In progress
Delaware Department of Natural Resources and Environmental Control	Town of Bowers Beach, Delaware Coastal Resiliency Action Plan	In progress
New Jersey Office of Smart Growth	New Jersey Climate Change Adaptation Using Community Plan Endorsements	In progress
Maryland Department of Natural Resources	Integrating Climate Change Adaptation Strategies into Maryland's Coastal Land Conservation Targeting	In progress
New York City	PlaNYC: A Comprehensive Sustainability Plan for New York City, New York	Completed
Scenic Hudson	Scenic Hudson Land Trust: Prioritizing Lands in Light of Sea Level Rise	In progress
Maryland Department of Natural Resources	Maryland's Coast-Smart Communities Initiative	In progress
Maryland Department of Natural Resources	Sea Level Rise Guidance for Dorchester County, Maryland	In progress
Maryland Department of Natural Resources	Sea Level Rise Guidance for Somerset County, Maryland	In progress
The Nature Conservancy	Rising Waters: Helping Hudson River Communities Adapt to Climate Change	In progress
The Nature Conservancy	Coastal Resilience: Visualizing Climate Change Impacts and Coastal Hazards and Implementing Solutions in Long Island Sound	In progress
Southeast/Gulf USA (North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Texas)		
The Nature Conservancy Dauphin Island Sea Lab	Oyster Reef Breakwater Restoration Project on Alabama's Gulf Coast	In progress
Tampa Bay Estuary Program	Creating a Gulf Coast Community Handbook for Restoration and	In planning

Coastal Bend Bays and Estuaries Program	Adaptation	
The Nature Conservancy	Alligator River National Wildlife Refuge/Albemarle-Pamlico Peninsula Climate Adaptation Project	In progress
Charlotte Harbor National Estuary Program	Incorporating Climate Change Impacts into Activities in Charlotte Harbor, Florida	In progress
Terrebonne Parish Consolidated Government	Systematically Prioritizing Restoration Projects in Terrebonne Parish, Louisiana	Completed
The Nature Conservancy	Florida Reef Resilience Program	In progress
Florida Atlantic University	Florida Planning Toolbox: Climate Change Tools	Completed
City of Wilmington	Sea Level Rise Adaptation Report for the City of Wilmington, North Carolina	In progress
North Carolina Coastal Reserve/NERR	Sentinel Monitoring of Salt Marshes in the North Carolina National Estuarine Research Reserve	In progress
Indian River Lagoon National Estuary Program	Indian River Lagoon and City of Satellite Beach, Florida Adaptation Project	In progress
Weeks Bay National Estuarine Research Reserve	Alabama's Baldwin County Grasses in Classes Program	Completed
Albemarle-Pamlico National Estuary Program	Albemarle-Pamlico National Estuary Program's Climate Ready Estuaries Project	In progress
Miami-Dade Climate Change Advisory Task Force	Miami-Dade Climate Change Advisory Task Force	In progress
Broward County Natural Resources Planning and Management Division	Broward County Climate Change Task Force and Climate Change Initiatives	Completed
Florida Energy and Climate Commission	Florida Energy and Climate Commission	In planning
Florida Department of Environmental Protection	Florida Governor's Action Team on Energy and Climate Change: Developing an Energy and Climate Action Plan	Completed
Florida Department of Environmental Protection	Florida Oceans and Coastal Council	In progress
EcoAdapt	Climate Change Action Plan for the Florida Reef Tract – 2010-2015	In progress
South Florida Regional Planning Council	Florida's Climate Change Community Toolbox	Completed
South Florida Regional Planning Council	The South Florida Sea Level Rise Project	Completed
U.S. Geological Survey	Response of Florida Shelf Ecosystems to Climate Change: The FLASH Project	In progress
U.S. Geological Survey	Coral Reef Ecosystem Studies (CREST) Project	In progress
Broward County Commission	Southeast Florida Regional Climate Change Compact	Completed
Mississippi Alabama Sea Grant	Gulf of Mexico Regional Sediment Management Master Plan	In progress

Consortium		
Bald Head Island Conservancy	Bald Head Island Conservancy Climate Change Adaptation: Using Outreach to Catalyze Small Changes	In progress
NOAA: Center for Sponsored Coastal Ocean Research	North Carolina Sea Level Rise Project	In progress
NOAA: Center for Sponsored Coastal Ocean Research	Planning for the Impacts of Sea Level Rise and Climate Change in North Carolina	In progress
NOAA: Center for Sponsored Coastal Ocean Research	Ecological Effects of Sea Level Rise in the Florida Panhandle and Coastal Alabama	In progress
USACE South Florida Restoration Office	Responding to Sea Level Rise under the Comprehensive Everglades Restoration Plan (CERP)	In progress
Florida Fish and Wildlife Conservation Commission	Florida Fish and Wildlife Conservation Commission: Planning for Climate Change	In progress
Florida Sea Grant	Sea Level Rise in the Gulf of Mexico: Awareness and Action Tools for the Climate Outreach Community of Practice	In progress
Mission-Aransas National Estuarine Research Reserve	Mission-Aransas National Estuarine Research Reserve's Ecosystem Based Management Tools Project	Completed
North Carolina Department of Environment and Natural Resources	North Carolina Climate Change Initiative	In progress
South Carolina Department of Health and Environmental Control	South Carolina's Shoreline Change Initiative	In progress
Gulf of Mexico and Yucatan Peninsula – Mexico		
The World Bank	Adaptation to Climate Change Impacts on the Coastal Wetlands in the Gulf of Mexico	In progress
Centro Ecológico Akumal	Increasing Awareness and Resilience of Coastal Wetlands and Reefs in Quintana Roo, Mexico	In progress
INECOL - INSTITUTO DE ECOLOGÍA, AC, Institute of Ecology A. C., Coastal Ecosystems Unit	Impacts of Climate Change on the Coastal Zone of Mexico: An Integrated Ecosystem Approach in the Gulf of Mexico to Support Coastal Zone Management Legislation	In progress
Veracruz University, Mexico; Universidad Veracruzana	Veracruz State Climate Change Action Plan	Completed
United Nations Environment Programme (UNEP)	Mesoamerican Biological Corridor Project	In progress
Mississippi-Alabama Sea Grant Consortium	Gulf of Mexico Research Plan	Completed
The Nature Conservancy	Promoting Resilience in the Mesoamerican Reef	Completed
Alaska and British Columbia		
Cook Inletkeepers	Stream Temperature Monitoring Network for Cook Inlet Salmon Streams	In progress

The Wilderness Society	Mapping Future Climate Change in Alaska's National Parks	Completed
The Wilderness Society	Future Climate and Water Availability in Alaska	In progress
British Columbia Ministry of Environment	Vulnerability of British Columbia Landscapes	Completed
British Columbia Ministry of Environment	Shoreline Sensitivity to Sea Level Rise in British Columbia	In progress
University of Alaska - Fairbanks	Monitoring Lake Ice and Snow in Alaska – The Alaska Lake Ice and Snow Observatory Network (ALISON) Project	In progress
City of Homer, Alaska	Homer, Alaska Climate Action Plan	In progress
Metro Vancouver	Greater Vancouver's Stormwater Management Program	In planning
Ecosystems and Fisheries-Oceanography Coordinated Investigations (EcoFOCI)	North Pacific Climate Regimes and Ecosystem Productivity Program	In progress
U.S. Fish and Wildlife Service	The Tongass National Forest Conservation Strategy	In progress
The Nature Conservancy	Considering Climate Change in the Tongass National Forest and Southeast Alaska through the Tongass Futures Roundtables	In progress
North Pacific Fisheries Management Council	Using a Precautionary Approach to Manage North Pacific Fisheries Under Uncertainty	In progress
Kotzebue IRA	Documenting Traditional Ecological Knowledge in Northwest Alaska	Completed
The Newtok Planning Group	Relocating the Village of Newtok, Alaska due to Coastal Erosion	In progress
U.S. Department of the Interior	Polar Bear Designation under the U.S. Endangered Species Act	Completed
Alaska Office of the Governor	Alaska's Climate Change Strategy	In progress
British Columbia Ministry of Environment	British Columbia Climate Change Adaptation Strategy	Completed
Canadian Institute of Planners	Preparing for Sea Level Rise on Graham Island	In progress
Kivalina Relocation Planning Committee	Relocating the Village of Kivalina, Alaska due to Coastal Erosion	In progress
Alaska Inter-Tribal Council	Nunat Climate Observations Database	In progress
Seabird Island Indian Band	Emergency Preparedness on Seabird Island	In progress
Shishmaref Erosion and Relocation Coalition	Relocating the Native Village of Shishmaref, Alaska Due to Coastal Erosion	In progress
The Nature Conservancy	Alaskan Marine Arctic Conservation Action Plan for the Chukchi and Beaufort Seas	Completed
Pacific States USA		
University of Washington - Seattle	Incorporating Climate Change into Landscape Connectivity Plans	In planning
Coastal Geologic Services	Kayak Point, Washington Restoration Feasibility and Design Technical Memorandum: Sea Level Rise Projections	In progress
San Lorenzo Valley Water District	Incorporating Climate Change into the San Lorenzo Watershed Management Plan	Completed
South Slough National Estuarine	Sentinel Monitoring of Salt Marshes in the South Slough National	In progress

Research Reserve	Estuarine Research Reserve	
King County	Washington's Salmon Watcher Program	In progress
Pacific Coast Shellfish Growers Association	Responding to Ocean Acidification: Oyster Emergency Project	In progress
Padilla Bay National Estuarine Research Reserve	The National Estuarine Research Reserve's "Planning for Climate Change" Workshop	Completed
San Francisco Estuary Partnership	Salt Marsh Vulnerability Assessment and Adaptation Plan Development in San Francisco Bay, California	In progress
King County Wastewater Treatment Division	Vulnerability of King County, Washington Wastewater Treatment Facilities to Sea Level Rise	Completed
City of Olympia- Department of Public Works	Planning for Sea Level Rise in Olympia, Washington	Completed
Washington State Department of Ecology	Developing a Washington State Climate Change Impacts Response Strategy	In progress
North Bay Climate Adaptation Initiative	North Bay Climate Adaptation Initiative	In progress
San Francisco Bay National Estuarine Research Reserve	Planning for Climate Change: A Workshop for San Francisco Bay Area Planners	Completed
California State Department of Parks and Recreation	California State Parks Preparation for Climate Change	In progress
Point Reyes National Seashore	Estero de Limantour Coastal Watershed Restoration Project	Completed
San Francisco Bay Conservation and Development Commission	San Francisco Bay Conservation and Development Commission: Climate Change Planning Program	In progress
The San Diego Foundation	The San Diego Foundation's Climate Initiative Program	In progress
Pacific Fishery Management Council	Using Ecosystem-Based Management as an Adaptation Strategy in the Pacific Fishery Management Council	In planning
Rand Corporation	Using Robust Decision Making as a Tool for Water Resources Planning in Southern California	In progress
Maui Coastal Land Trust	Waihe'e Refuge Restoration Project	In progress
East Bay Municipal Utility District	Preparing for Climate Change in California's East Bay Municipal Utility District	In progress
Washington Department of Natural Resources	Preparing for Climate Change on State-Owned Aquatic Lands in Washington State	In progress
National Park Service	Scenario Planning Pilot Study for Kaloko-Honokōhau National Historical Park	Completed
Surfrider Foundation	Managed Retreat at Surfer's Point, California	In progress
San Francisco Bay Conservation and Development Commission	Adapting to Rising Tides (ART) in San Francisco Bay, California	In progress
Richardson Bay Audubon Center &	Aramburu Island Ecological Enhancement Project	In progress

Sanctuary		
Bay Area Ecosystems Climate Change Consortium	Bay Area Ecosystems Climate Change Consortium	Ongoing
Big Sur Land Trust	Adding the Impacts of Climate Change to a Strategic Plan: Big Sur Land Trust	In progress
California Department of Water Resources	California Department of Water Resources Adaptation Strategy	In progress
Channel Islands National Marine Sanctuary	The Channel Islands National Marine Sanctuary: Planning for Climate Change	Ongoing
City of Chula Vista	Climate Change Adaptation Planning in the City of Chula Vista	In progress
Gulf of the Farallones National Marine Sanctuary, Cordell Bank National Marine Sanctuary	Climate Change Effects and Management Responses in the Gulf of the Farallones and Cordell Bank National Marine Sanctuaries	Completed
USGS Hawaii Cooperative Fishery Research Center	Incorporating Climate Change Adaptation into the Papahānaumokuākea Marine National Monument Management Plan	In planning
Elkhorn Slough National Estuarine Research Reserve	Designing Salt Marsh Conservation Strategies in Elkhorn Slough National Estuarine Research Reserve	In progress
Santa Barbara County Parks	Goleta Beach 2.0: Managed Retreat to Mitigate Coastal Erosion	In progress
University of Hawaii	Adapting to Sea Level Rise and Coastal Erosion in Hawaii Through Coastal Construction Setbacks Policies	In planning
University of Hawaii	Hawaii's Changing Climate: Legislative Briefing Sheet 2010	In planning
ESA PWA	Adapting to Sea Level Rise in Hayward, California	In progress
United Nations University	Indigenous People's Global Summit on Climate Change	Completed
Pacific Institute ESA PWA	Preparing for the Impacts of Sea Level Rise on the California Coast	In progress
University of Hawaii Sea Grant College Program	Kailua Beach and Dune Management Plan	In progress
City of Malibu	Malibu Land Use Implementation Plan: Setbacks and Sea Level Rise	Completed
Oregon Department of Land Conservation and Development	The Oregon Climate Change Adaptation Framework	In planning
Oregon Department of Energy	Oregon's Framework to Adapt to Rapid Climate Change	In progress
Hawaii Coastal Zone Management Program	A Framework for Climate Change Adaptation in Hawaii	Completed
ESA PWA	Restoration and Managed Retreat of Pacifica State Beach	In progress
The Nature Conservancy	Effects of Sea Level Rise in Port Susan Bay	In progress
State Coastal Conservancy	San Francisco Estuary Invasive Spartina Project	Ongoing
California State Coastal Conservancy	South Bay Salt Pond Restoration Project	In progress
Baja Peninsula and Pacific Coast – Mexico		

Scripps Institution of Oceanography-University of California, San Diego	Gulf of California Mangrove Ecosystem Services	In progress
The Nature Conservancy- Mexico	Vulnerable Mediterranean Climate Coastal Habitats in Bahía de San Quintín, Baja California, México	In progress
Nationwide – USA		
National Estuarine Research Reserve Association	Integrating Climate Change into the National Estuarine Research Reserve System	In progress
U.S. Environmental Protection Agency	U.S. Environmental Protection Agency’s Climate Ready Estuaries Program	In progress
National Oceanic and Atmospheric Administration	NOAA 2010 Workshop Series: Habitat Conservation in a Changing Climate	In progress
StormSmart Coasts	The National StormSmart Coasts Network: Linking Coastal Decision Makers to Resources	In progress
Water Utility Climate Alliance	Water Utility Climate Alliance	In progress
U.S. Department of the Interior	U.S. Department of the Interior Climate Change Strategy	In progress
National Oceanic and Atmospheric Administration	Proposed Listing of Coral Reef Species under U.S. Endangered Species Act	In planning
National Marine Protected Areas Center	Climate Change and the National Marine Protected Areas Center	In progress
U.S. Environmental Protection Agency	U.S. Environmental Program's Climate Ready Water Utilities Program	In progress
US Army Corps of Engineers	Planning for Climate Change in the U.S. Army Corps of Engineers	In planning
National Park Service	Planning for Climate Change in the National Park Service	In planning
National Park Service U.S. Geological Survey	Assessing the Relative Coastal Vulnerability of National Park Units to Sea Level Rise	In planning
U.S. Fish and Wildlife Service	Developing a National Fish and Wildlife Climate Change Adaptation Strategy for the United States	In planning
U.S. Global Change Research Program	U.S. Global Change Research Program	In progress
White House Council on Environmental Quality	Creating a National Adaptation Strategy for the United States: The Interagency Climate Change Adaptation Task Force	In planning
Nationwide – Canada		
Nationwide – Mexico		
The Nature Conservancy	Climate Change Adaptation in Protected Areas in Mexico for the Conservation of Biodiversity, Ecosystems, and Ecosystem Services	In progress

G. Adaptation projects by type of strategy

1. Natural Resource Management and Conservation

a) *Incorporate climate change into existing policies, plans, and regulations*

Eastern Canada and Northeast USA

[Incorporating Climate Change into Research and Management at Mass Audubon](#)
[Assessing the Risk of 100-year Freshwater Floods in the Lamprey River Watershed of New Hampshire Resulting from Climate Change and Land Use](#)
[Halifax Climate SMART: The Climate Sustainable Mitigation and Adaptation Risk Toolkit](#)
[Wellfleet Bay Oyster Reef Habitat Restoration Project](#)
[Oyster River Watershed Culvert Study – Climate Ready Estuaries Program](#)
[Casco Bay Estuary Partnership - Climate Ready Estuaries Program](#)
[Atlantic Aboriginal Climate Change Adaptation Workshop](#)
[Climate Change Adaptations for Land Use Planners](#)
[Proactive incorporation of sea level rise: The case of Deer Island Wastewater Treatment Plant](#)

Mid-Atlantic USA

[Barnegat Bay Climate Change Adaptation Strategy Development](#)
[Planning for Sea Level Rise and Storm Surge in Worcester County, Maryland](#)
[Implementation of Maryland's Climate Action Plan](#)
[Scenic Hudson Land Trust: Prioritizing lands in light of sea level rise](#)

Southeast/Gulf USA

[Oyster Reef Breakwater Restoration Project on Alabama's Gulf Coast](#)
[Creating a Gulf Coast Community Handbook for Restoration and Adaptation](#)
[Alligator River National Wildlife Refuge/Albemarle-Pamlico Peninsula Climate Adaptation Project](#)
[Incorporating Climate Change Impacts into Activities in Charlotte Harbor, Florida](#)
[Systematically Prioritizing Restoration Projects in Terrebonne Parish, Louisiana](#)
[Florida Reef Resilience Program](#)
[Florida's Resilient Coasts](#)
[Sea Level Rise Adaptation Report for the City of Wilmington, North Carolina](#)
[Florida Governor's Action Team on Energy and Climate Change](#)
[Broward County Climate Change Task Force](#)
[Florida Fish and Wildlife Conservation Commission: Planning for Climate Change Ecosystem Based Management Project](#)
[North Carolina Climate Change Initiative](#)

Gulf of Mexico and Yucatan Peninsula – Mexico

[Mexico: Adaptation to Climate Change Impacts on the Coastal Wetlands](#)

[Impacts of Climate Change on the Coastal Zone of Mexico \(Gulf of Mexico\)](#)

[Impacts of Climate Change on Coastal Zone, Mexican region in the Gulf of Mexico: analysis of an integrated ecosystem approach in assessing climate mitigation and adaptation as way to move coastal zone legislation MesoAmerican Reef \(MAR\)](#)

Alaska and British Columbia

[Stream Temperature Monitoring Network for Cook Inlet Salmon Streams](#)

[Mapping Future Climate Change in Alaska's National Parks](#)

[Future Climate and Water Availability in Alaska](#)

[Vulnerability of British Columbia Landscapes](#)

[Shoreline Sensitivity to Sea Level Rise in British Columbia](#)

Pacific States USA

[Incorporating Climate Change into Landscape Connectivity Plans](#)

[Kayak Point Restoration Feasibility and Design Technical Memorandum: Sea Level Rise Projections](#)

[Incorporating Climate Change into the San Lorenzo Watershed Management Plan](#)

[Scenario Planning Pilot Study for Kaloko-Honokōhau National Historical Park](#)

[Adding the impacts of climate change to a strategic plan: Big Sur Land Trust](#)

[The Channel Islands National Marine Sanctuary: Planning for Climate Change](#)

[Climate Change Effects and Management Responses in the Gulf of the Farallones and Cordell Bank National Marine Sanctuaries](#)

[Incorporating Climate Change Adaptation into the Papahānaumokuākea Marine National Monument Management Plan](#)

[Preparing for the Impacts of Sea Level Rise on the California Coast](#)

[Kailua Beach and Dune Management Plan](#)

[Malibu Land Use Implementation Plan: Setbacks and Sea Level Rise](#)

[The Oregon Climate Change Adaptation Framework](#)

[Effects of Sea Level Rise in Port Susan Bay](#)

[San Francisco Estuary Invasive Spartina Project](#)

[South Bay Salt Pond Restoration Project](#)

Baja Peninsula and Pacific Coast – Mexico

[Gulf of California Mangrove Ecosystem Services](#)

[Vulnerable Mediterranean climate coastal habitats in Bahía de San Quintín, Baja California, México](#)

Nationwide USA

[Integrating Climate Change into the National Estuarine Research Reserve System](#)

[U.S. Environmental Protection Agency's Climate Ready Estuaries Program](#)

b) Enhance connectivity and areas under protection

Mid-Atlantic USA

[Planning for Sea Level Rise and Storm Surge in Worcester County, Maryland](#)

[Implementation of Maryland's Climate Action Plan](#)

[Scenic Hudson Land Trust: Prioritizing lands in light of sea level rise](#)

Southeast/Gulf USA

[Alligator River National Wildlife Refuge/Albemarle-Pamlico Peninsula Climate Adaptation Project](#)

[North Carolina Climate Change Initiative](#)

Alaska and British Columbia

[Mapping Future Climate Change in Alaska's National Parks](#)

[Future Climate and Water Availability in Alaska](#)

[Vulnerability of BC Landscapes](#)

Pacific States USA

[Adding the impacts of climate change to a strategic plan: Big Sur Land Trust](#)

[Climate Change Effects and Management Responses in the Gulf of the Farallones and Cordell Bank National Marine Sanctuaries](#)

[Preparing for the Impacts of Sea Level Rise on the California Coast](#)

[Restoration and Managed Retreat of Pacifica State Beach](#)

Gulf of Mexico and Yucatan Peninsula – Mexico

[Mesoamerican Biological Corridor Project](#)

Nationwide USA

[U.S. Environmental Protection Agency's Climate Ready Estuaries Program](#)

[Climate Change and the National Marine Protected Areas Center](#)

Nationwide Mexico

[Mesoamerican Biological Corridor Project](#)

c) Design protected areas to allow for inland, altitudinal, or latitudinal movement

Eastern Canada and Northeast USA

[Halifax Climate SMART: The Climate Sustainable Mitigation and Adaptation Risk Toolkit](#)

[Proactive incorporation of sea level rise: The case of Deer Island Wastewater Treatment Plant](#)

Mid-Atlantic USA

[Planning for Sea Level Rise and Storm Surge in Worcester County, Maryland](#)

[Implementation of Maryland's Climate Action Plan](#)

[Scenic Hudson Land Trust: Prioritizing lands in light of sea level rise](#)

Southeast, Gulf, and Mid-Atlantic USA

[Alligator River National Wildlife Refuge/Albemarle-Pamlico Peninsula Climate Adaptation Project](#)

[North Carolina Climate Change Initiative](#)

Pacific States USA

[Kayak Point Restoration Feasibility and Design Technical Memorandum: Sea Level Rise Projections](#)

[Climate Change Adaptation Planning in the City of Chula Vista](#)

[Preparing for the Impacts of Sea Level Rise on the California Coast](#)

[Malibu Land Use Implementation Plan: Setbacks and Sea Level Rise](#)

[Restoration and Managed Retreat of Pacifica State Beach](#)

[Effects of Sea Level Rise in Port Susan Bay](#)

[South Bay Salt Pond Restoration Project](#)

Baja Peninsula and Pacific Coast - Mexico

[Vulnerable Mediterranean climate coastal habitats in Bahía de San Quintín, Baja California, México](#)

Nationwide USA

[U.S. Environmental Protection Agency's Climate Ready Estuaries Program](#)

[Climate Change and the National Marine Protected Areas Center](#)

d) Monitor climate change impacts and adaptation efficacy

Arctic Canada

[Atuligtuq: A Collaborative Approach in Support of the Nunavut Climate Change Adaptation Plan](#)

[Nunavut Climate Change Strategy](#)

Eastern Canada and Northeast USA

[Climate Change Vulnerability Assessment for Long Island Sound via Sentinel Monitoring](#)

[Sentinel Monitoring of Salt Marshes in the Wells National Estuarine Research Reserve](#)

[Sentinel Monitoring of Salt Marshes in the Narragansett Bay National Estuarine Research Reserve](#)

[Atlantic Aboriginal Climate Change Adaptation Workshop](#)

[Proactive incorporation of sea level rise: The case of Deer Island Wastewater Treatment Plant](#)

Mid-Atlantic USA

[Sentinel Monitoring of Salt Marshes in the Chesapeake Bay National Estuarine Research Reserve in Virginia](#)

[Implementation of Maryland's Climate Action Plan](#)

Southeast/Gulf USA

[Sentinel Monitoring of Salt Marshes in the North Carolina National Estuarine Research Reserve Alligator River National Wildlife Refuge/Albemarle-Pamlico Peninsula Climate Adaptation Project](#)
[Incorporating Climate Change Impacts into Activities in Charlotte Harbor, Florida](#)
[Florida Energy and Climate Commission](#)
[Broward County Climate Change Task Force](#)
[Ecosystem Based Management Project](#)
[North Carolina Climate Change Initiative](#)

Gulf of Mexico and Yucatan Peninsula – Mexico

[Impacts of Climate Change on the Coastal Zone of Mexico \(Gulf of Mexico\)](#)
[MesoAmerican Reef \(MAR\)](#)

Alaska and British Columbia

[Monitoring Lake Ice and Snow in Alaska – The Alaska Lake Ice and Snow Observatory Network \(ALISON\) Project](#)

Pacific States USA

[Sentinel Monitoring of Salt Marshes in the South Slough National Estuarine Research Reserve](#)
[Washington’s Salmon Watcher Program](#)
[Oyster Emergency Project](#)
[Climate Change Adaptation Planning in the City of Chula Vista](#)
[Incorporating Climate Change Adaptation into the Papahānaumokuākea Marine National Monument Management Plan](#)

Nationwide USA

[Integrating Climate Change into the National Estuarine Research Reserve System](#)
[U.S. Environmental Protection Agency’s Climate Ready Estuaries Program](#)

Nationwide Mexico

[Climate Change Adaptation in Protected Areas in Mexico for the conservation of biodiversity, ecosystems, and ecosystems services](#)

e) Reduce local climate or related change

Eastern Canada and Northeast USA

[Halifax Climate SMART: The Climate Sustainable Mitigation and Adaptation Risk Toolkit](#)
[Climate Change Adaptations for Land Use Planners](#)

Mid-Atlantic USA

[New Jersey Climate Change Adaptation Using Community Plan Endorsements](#)

Southeast/Gulf USA

[Florida Energy and Climate Commission](#)

[Florida Governor's Action Team on Energy and Climate Change](#)

Gulf of Mexico and Yucatan Peninsula – Mexico

[Centro Ecológico Akumal-Mexico](#)

Alaska and British Columbia

[Homer, Alaska Climate Action Plan](#)

Pacific States USA

[Kailua Beach and Dune Management Plan](#)

[The Oregon Climate Change Adaptation Framework](#)

f) Reduce non-climate stressors likely to interact with climate change

Alaska and British Columbia

[Relocating the Village of Newtok, Alaska due to Coastal Erosion](#)

[Nunavut Climate Change Strategy](#)

Eastern Canada and Northeast USA

[Climate Change Adaptations for Land Use Planners](#)

Southeast/Gulf USA

[Florida Reef Resilience Program](#)

[Florida Governor's Action Team on Energy and Climate Change](#)

[Florida Energy and Climate Commission](#)

[Gulf of Mexico Regional Sediment Management Master Plan](#)

[Ecosystem Based Management Project](#)

Pacific States USA

[Oyster Emergency Project](#)

[Climate Change Adaptation Planning in the City of Chula Vista](#)

[Kailua Beach and Dune Management Plan](#)

[The Oregon Climate Change Adaptation Framework](#)

[Restoration and Managed Retreat of Pacifica State Beach](#)

[San Francisco Estuary Invasive Spartina Project](#)

[South Bay Salt Pond Restoration Project](#)

Nationwide- USA

[Climate Change and the National Marine Protected Areas Center](#)

g) Initiate targeted research program(s)

Arctic Canada

[The Igliniit Inuit Sea Ice Use and Occupancy Project](#)

[Atuliquq: A Collaborative Approach in Support of the Nunavut Climate Change Adaptation Plan](#)

Alaska and British Columbia

[Documenting Traditional Ecological Knowledge in Northwest Alaska](#)

Eastern Canada and Northeast USA

[Sentinel Monitoring of Salt Marshes in the Wells National Estuarine Research Reserve](#)

[Sentinel Monitoring of Salt Marshes in the Narragansett Bay National Estuarine Research Reserve](#)

[Assessing the Risk of 100-year Freshwater Floods in the Lamprey River Watershed of New Hampshire](#)

[Resulting from Climate Change and Land Use](#)

Mid-Atlantic USA

[Sentinel Monitoring of Salt Marshes in the Chesapeake Bay National Estuarine Research Reserve in Virginia](#)

Southeast/Gulf USA

[Sentinel Monitoring of Salt Marshes in the North Carolina National Estuarine Research Reserve](#)

[Alligator River National Wildlife Refuge/Albemarle-Pamlico Peninsula Climate Adaptation Project](#)

[Florida Reef Resilience Program](#)

[Sea Level Rise Adaptation Report for the City of Wilmington, North Carolina](#)

[Florida Governor's Action Team on Energy and Climate Change](#)

[Florida Oceans and Coastal Council](#)

Gulf of Mexico and Yucatan Peninsula – Mexico

[Impacts of Climate Change on the Coastal Zone of Mexico \(Gulf of Mexico\)](#)

[Gulf of Mexico Research Plan](#)

Pacific States USA

[Sentinel Monitoring of Salt Marshes in the South Slough National Estuarine Research Reserve](#)

[Oyster Emergency Project](#)

[Adapting to Sea Level Rise and Coastal Erosion in Hawaii Through Coastal Construction Setbacks Policies](#)

[Effects of Sea Level Rise in Port Susan Bay](#)

[San Francisco Estuary Invasive Spartina Project](#)

Baja Peninsula and Pacific Coast – Mexico

[Gulf of California Mangrove Ecosystem Services](#)

[Vulnerable Mediterranean climate coastal habitats in Bahía de San Quintín, Baja California, México](#)

2. Capacity Building

a) Create new institutions (training staff, establishing committees)

Arctic Canada

[Atuligtuq: A Collaborative Approach in Support of the Nunavut Climate Change Adaptation Plan](#)
[Nunavut Climate Change Strategy](#)

Eastern Canada and Northeast USA

[Causes and Adaptation Strategies to Shoreline Erosion in Sept-Îles](#)
[Atlantic Climate Adaptation Solutions \(ACASA\)](#)

Mid-Atlantic USA

[Identifying Opportunities for Climate Adaptation in the Delaware Estuary](#)
[Maryland's Coast-Smart Communities Initiative](#)

Southeast/Gulf USA

[Florida Governor's Action Team on Energy and Climate Change](#)
[Miami-Dade Climate Change Advisory Task Force](#)

Pacific States USA

[Developing a Washington State Climate Change Impacts Response Strategy](#)

Nationwide USA

[U.S. Environmental Program's Climate Ready Water Utilities Program](#)
[Planning for Climate Change in the U.S. Army Corps of Engineers](#)
[Planning for Climate Change in the National Park Service](#)
[Creating a National Adaptation Strategy for the United States: The Interagency Climate Change Adaptation Task Force](#)

b) Enhance existing institutions - Increase organizational capacity

Arctic Canada

[Atuligtuq: A Collaborative Approach in Support of the Nunavut Climate Change Adaptation Plan](#)
[Nunavut Climate Change Strategy](#)

Eastern Canada and Northeast USA

[Atlantic Aboriginal Climate Change Adaptation Workshop](#)

[Climate Change Adaptations for Land Use Planners](#)

[Atlantic Climate Adaptation Solutions \(ACASA\)](#)

Mid-Atlantic USA

[Barnegat Bay Climate Change Adaptation Strategy Development](#)

[Implementation of Maryland's Climate Action Plan](#)

[Scenic Hudson Land Trust: Prioritizing lands in light of sea level rise](#)

[Rising Waters: Helping Hudson River Communities Adapt to Climate Change](#)

[Maryland's Coast-Smart Communities Initiative](#)

Southeast/Gulf USA

[Alligator River National Wildlife Refuge/Albemarle-Pamlico Peninsula Climate Adaptation Project](#)

[Sea Level Rise Adaptation Report for the City of Wilmington, North Carolina](#)

[Florida Governor's Action Team on Energy and Climate Change](#)

[Broward County Climate Change Task Force](#)

[Miami-Dade Climate Change Advisory Task Force](#)

[North Carolina Climate Change Initiative](#)

Alaska and British Columbia

[Greater Vancouver's Stormwater Management Program](#)

Pacific States USA

[Oyster Emergency Project](#)

[California Department of Water Resources Adaptation Strategy](#)

[Kailua Beach and Dune Management Plan](#)

[Restoration and Managed Retreat of Pacifica State Beach](#)

Nationwide USA

[U.S. Environmental Protection Agency's Climate Ready Estuaries Program](#)

[U.S. Environmental Program's Climate Ready Water Utilities Program](#)

[Planning for Climate Change in the U.S. Army Corps of Engineers](#)

[Planning for Climate Change in the National Park Service](#)

[Developing a National Fish and Wildlife Climate Change Adaptation Strategy for the United States](#)

[U.S. Global Change Research Program](#)

[Creating a National Adaptation Strategy for the United States: The Interagency Climate Change Adaptation Task Force](#)

c) Enhance existing institutions – Coordinate planning and management across institutional boundaries

Arctic Canada

[Climate Change Adaptation for the Community of Paulatuk](#)

[Planning for Melting Permafrost in Salluit](#)

[Climate Change Adaptation for the Community of Ulukhaktok](#)

[Atuligtuq: A Collaborative Approach in Support of the Nunavut Climate Change Adaptation Plan](#)

[Nunavut Climate Change Strategy](#)

Eastern Canada and Northeast USA

[Halifax Climate SMART: The Climate Sustainable Mitigation and Adaptation Risk Toolkit](#)

[Casco Bay Estuary Partnership - Climate Ready Estuaries Program](#)

[Atlantic Aboriginal Climate Change Adaptation Workshop](#)

[Climate Change Adaptations for Land Use Planners](#)

[Preparing for Climate Change and Sea Level Rise in New Brunswick](#)

[Atlantic Climate Adaptation Solutions \(ACASA\)](#)

Mid-Atlantic USA

[Barnegat Bay Climate Change Adaptation Strategy Development](#)

[Implementation of Maryland's Climate Action Plan](#)

[Scenic Hudson Land Trust: Prioritizing lands in light of sea level rise](#)

[Maryland's Coast-Smart Communities Initiative](#)

Southeast/Gulf USA

[Alligator River National Wildlife Refuge/Albemarle-Pamlico Peninsula Climate Adaptation Project](#)

[Florida Governor's Action Team on Energy and Climate Change](#)

[Broward County Climate Change Task Force](#)

[Miami Dade Climate Change Advisory Task Force](#)

[North Carolina Sea Level Rise Project](#)

[Ecological Effects of Sea Level Rise in the Florida Panhandle and Coastal Alabama](#)

[North Carolina Climate Change Initiative](#)

Gulf of Mexico and Yucatan Peninsula – Mexico

[Impacts of Climate Change on the Coastal Zone of Mexico \(Gulf of Mexico\)](#)

Alaska and British Columbia

[Homer, Alaska Climate Action Plan](#)

[Stream Temperature Monitoring Network for Cook Inlet Salmon Streams](#)

[Vulnerability of British Columbia Landscapes](#)

[Preparing for Sea Level Rise on Graham Island](#)

Pacific States USA

[Developing a Washington State Climate Change Impacts Response Strategy](#)
[Oyster Emergency Project](#)
[Adding the impacts of climate change to a strategic plan: Big Sur Land Trust](#)
[California Department of Water Resources Adaptation Strategy](#)
[Climate Change Adaptation Planning in the City of Chula Vista](#)
[Hawaii's Changing Climate: Legislative Briefing Sheet 2010](#)
[Indigenous People's Global Summit on Climate Change](#)
[Kailua Beach and Dune Management Plan](#)
[The Oregon Climate Change Adaptation Framework](#)
[South Bay Salt Pond Restoration Project](#)

Nationwide USA

[U.S. Environmental Protection Agency's Climate Ready Estuaries Program](#)
[NOAA 2010 Workshop: Habitat Conservation in a Changing Climate- Tools and Strategies](#)
[U.S. Environmental Program's Climate Ready Water Utilities Program](#)
[Planning for Climate Change in the U.S. Army Corps of Engineers](#)
[Planning for Climate Change in the National Park Service](#)
[Developing a National Fish and Wildlife Climate Change Adaptation Strategy for the United States](#)
[U.S. Global Change Research Program](#)
[Creating a National Adaptation Strategy for the United States: The Interagency Climate Change Adaptation Task Force](#)

d) Invest in/enhance emergency services planning and training

Arctic Canada

[Sustainable Development Initiatives in the Polar Town of Iqaluit, Canada](#)
[Climate Change and Food Security in the Canadian Arctic](#)
[Climate Change Adaptation for the Community of Paulatuk](#)
[Climate Change Adaptation for the Community of Ulukhaktok](#)

Eastern Canada and Northeast USA

[Annapolis Royal Tidal Surge Analysis](#)
[Halifax Climate SMART: The Climate Sustainable Mitigation and Adaptation Risk Toolkit](#)
[Atlantic Aboriginal Climate Change Adaptation Workshop](#)
[Atlantic Climate Adaptation Solutions \(ACASA\)](#)

Mid-Atlantic USA

[Planning for Sea level Rise and Storm Surge in Worcester County, Maryland](#)

Southeast/Gulf USA

[Florida Energy and Climate Commission](#)

[Florida Governor's Action Team on Energy and Climate Change](#)

Gulf of Mexico and Yucatan Peninsula – Mexico

[Impacts of Climate Change on the Coastal Zone of Mexico \(Gulf of Mexico\)](#)

Alaska and British Columbia

[Homer, Alaska Climate Action Plan](#)

[Emergency Preparedness on Seabird Island](#)

Pacific States USA

[Preparing for the Impacts of Sea Level Rise on the California Coast](#)

Nationwide- USA

[U.S. Environmental Program's Climate Ready Water Utilities Program](#)

[Planning for Climate Change in the U.S. Army Corps of Engineers](#)

e) Increase/improve public awareness, education, and outreach efforts

Arctic Canada

[Climate Change and Food Security in the Canadian Arctic](#)

[Climate Change Adaptation for the Community of Paulatuk](#)

[Planning for Melting Permafrost in Salluit](#)

[Portraits of Resilience](#)

[Climate Change Adaptation for the Community of Ulukhaktok](#)

[Atuliqtuq: A Collaborative Approach in Support of the Nunavut Climate Change Adaptation Plan](#)

[Nunavut Climate Change Strategy](#)

Eastern Canada and Northeast USA

[Incorporating Climate Change into Research and Management at Mass Audubon](#)

[Assessing the Risk of 100-year Freshwater Floods in the Lamprey River Watershed of New Hampshire](#)

[Resulting from Climate Change and Land Use](#)

[Causes and Adaptation Strategies to Shoreline Erosion in Sept-Îles](#)

[Halifax Climate SMART: The Climate Sustainable Mitigation and Adaptation Risk Toolkit](#)

[Casco Bay Estuary Partnership - Climate Ready Estuaries Program](#)

[Climate Change Adaptations for Land Use Planners](#)

[Climate Change and Renewable Resources in Labrador](#)

[Preparing for Climate Change and Sea Level Rise in New Brunswick](#)

[Atlantic Climate Adaptation Solutions \(ACASA\)](#)

Mid-Atlantic USA

[Delaware Sea Level Rise Adaptation Initiative](#)

[Barnegat Bay Climate Change Adaptation Strategy Development](#)

[Implementation of Maryland's Climate Action Plan](#)

[Bald Head Island Conservancy Climate Change Adaptation: Using Outreach to Catalyze Small Changes](#)

[Scenic Hudson Land Trust: Prioritizing lands in light of sea level rise](#)

[Coastal Resilience: Visualizing Climate Change Impacts and Coastal Hazards and Implementing Solutions in Long Island Sound](#)

Southeast/Gulf USA

[Creating a Gulf Coast Community Handbook for Restoration and Adaptation](#)

[Indian River Lagoon and City of Satellite Beach, Florida Adaptation Project](#)

[Alabama's Baldwin County Grasses in Classes Program](#)

[Albemarle-Pamlico National Estuary Program – Climate Ready Estuaries Project](#)

[Alligator River National Wildlife Refuge/Albemarle-Pamlico Peninsula Climate Adaptation Project](#)

[Incorporating Climate Change Impacts into Activities in Charlotte Harbor, Florida](#)

[Florida Governor's Action Team on Energy and Climate Change](#)

[Florida Fish and Wildlife Conservation Commission: Planning for Climate Change](#)

[North Carolina Climate Change Initiative](#)

Gulf of Mexico and Yucatan Peninsula

[Gulf of Mexico Research Plan](#)

[MesoAmerican Reef \(MAR\)](#)

Alaska and British Columbia

[Monitoring Lake Ice and Snow in Alaska – The Alaska Lake Ice and Snow Observatory Network \(ALISON\) Project](#)

[Stream Temperature Monitoring Network for Cook Inlet Salmon Streams](#)

[Preparing for Sea Level Rise on Graham Island](#)

[Emergency Preparedness on Seabird Island](#)

Pacific States USA

[Washington's Salmon Watcher Program](#)

[The National Estuarine Research Reserve's "Planning for Climate Change" Workshop](#)

[Incorporating Climate Change into the San Lorenzo Watershed Management Plan](#)

[California Department of Water Resources Adaptation Strategy](#)

[The Channel Islands National Marine Sanctuary: Planning for Climate Change](#)

[Designing Salt Marsh Conservation Strategies in Elkhorn Slough National Estuarine Research Reserve](#)



[Goleta Beach 2.0: Managed Retreat to Mitigate Coastal Erosion](#)
[Adapting to Sea Level Rise and Coastal Erosion in Hawaii Through Coastal Construction Setbacks Policies](#)
[Hawaii's Changing Climate: Legislative Briefing Sheet 2010](#)
[Indigenous People's Global Summit on Climate Change](#)
[Kailua Beach and Dune Management Plan](#)
[The Oregon Climate Change Adaptation Framework](#)
[Oregon's Framework to Adapt to Rapid Climate Change](#)
[Restoration and Managed Retreat of Pacifica State Beach](#)
[South Bay Salt Pond Restoration Project](#)

Nationwide USA

[U.S. Environmental Protection Agency's Climate Ready Estuaries Program](#)
[U.S. Environmental Program's Climate Ready Water Utilities Program](#)
[Planning for Climate Change in the National Park Service](#)
[Developing a National Fish and Wildlife Climate Change Adaptation Strategy for the United States](#)
[U.S. Global Change Research Program](#)
[Creating a National Adaptation Strategy for the United States: The Interagency Climate Change Adaptation Task Force](#)

f) Conduct/gather additional research, data, and products

Arctic Canada

[Sustainable Development Initiatives in the Polar Town of Iqaluit, Canada](#)
[The Igliniit Inuit Sea Ice Use and Occupancy Project](#)
[Climate Change and Food Security in the Canadian Arctic](#)
[Planning for Melting Permafrost in Salluit](#)
[Climate Risks and Adaptive Capacity in Aboriginal Communities South of 60 Degrees Latitude](#)
[Atuligtuq: A Collaborative Approach in Support of the Nunavut Climate Change Adaptation Plan](#)
[Nunavut Climate Change Strategy](#)

Eastern Canada and Northeast USA

[Incorporating Climate Change into Research and Management at Mass Audubon](#)
[Causes and Adaptation Strategies to Shoreline Erosion in Sept-Îles](#)
[Halifax Climate SMART: The Climate Sustainable Mitigation and Adaptation Risk Toolkit](#)
[Casco Bay Estuary Partnership - Climate Ready Estuaries Program](#)
[Oyster River Watershed Culvert Study - Climate Ready Estuaries Program](#)
[Climate Change Adaptations for Land Use Planners](#)
[Preparing for Climate Change and Sea Level Rise in New Brunswick](#)
[Atlantic Climate Adaptation Solutions \(ACASA\)](#)

Mid-Atlantic USA

[Delaware Sea Level Rise Adaptation Initiative](#)

[Barnegat Bay Climate Change Adaptation Strategy Development](#)

[Implementation of Maryland's Climate Action Plan](#)

[Scenic Hudson Land Trust: Prioritizing lands in light of sea level rise](#)

[Coastal Resilience: Visualizing Climate Change Impacts and Coastal Hazards and Implementing Solutions in Long Island Sound](#)

Southeast/Gulf USA

[Alligator River National Wildlife Refuge/Albemarle-Pamlico Peninsula Climate Adaptation Project](#)

[Incorporating Climate Change Impacts into Activities in Charlotte Harbor, Florida](#)

[Florida Governor's Action Team on Energy and Climate Change](#)

[Florida Energy and Climate Commission](#)

[Gulf of Mexico Regional Sediment Management Master Plan](#)

[North Carolina Climate Change Initiative](#)

Gulf of Mexico and Yucatan Peninsula – Mexico

[Impacts of Climate Change on the Coastal Zone of Mexico \(Gulf of Mexico\)](#)

[Gulf of Mexico Research Plan](#)

[MesoAmerican Reef \(MAR\)](#)

Alaska and British Columbia

[Monitoring Lake Ice and Snow in Alaska – The Alaska Lake Ice and Snow Observatory Network \(ALISON\) Project](#)

[Homer, Alaska Climate Action Plan](#)

[Stream Temperature Monitoring Network for Cook Inlet Salmon Streams](#)

[Future Climate and Water Availability in Alaska](#)

[Vulnerability of British Columbia Landscapes](#)

Pacific States USA

[Washington's Salmon Watcher Program](#)

[Incorporating Climate Change into Landscape Connectivity Plans](#)

[Incorporating Climate Change into the San Lorenzo Watershed Management Plan](#)

[Oyster Emergency Project](#)

[The Channel Islands National Marine Sanctuary: Planning for Climate Change](#)

[The Oregon Climate Change Adaptation Framework](#)

[Restoration and Managed Retreat of Pacifica State Beach](#)

[San Francisco Estuary Invasive Spartina Project](#)

[South Bay Salt Pond Restoration Project](#)

Nationwide USA

[Integrating Climate Change into the National Estuarine Research Reserve System](#)

[U.S. Environmental Protection Agency's Climate Ready Estuaries Program](#)

[U.S. Environmental Program's Climate Ready Water Utilities Program](#)

[Planning for Climate Change in the U.S. Army Corps of Engineers](#)

[Planning for Climate Change in the National Park Service](#)

[Assessing the Relative Coastal Vulnerability of National Park Units to Sea Level Rise](#)

[Developing a National Fish and Wildlife Climate Change Adaptation Strategy for the United States](#)

[U.S. Global Change Research Program](#)

[Creating a National Adaptation Strategy for the United States: The Interagency Climate Change Adaptation Task Force](#)

g) Conduct vulnerability assessments and studies

Arctic Canada

[Sustainable Development Initiatives in the Polar Town of Iqaluit, Canada](#)

[Climate Change and Food Security in the Canadian Arctic](#)

[Climate Change Adaptation for the Community of Paulatuk](#)

[Climate Risks and Adaptive Capacity in Aboriginal Communities South of 60 Degrees Latitude](#)

[Climate Change Adaptation for the Community of Ulukhaktok](#)

[Atuligtuq: A Collaborative Approach in Support of the Nunavut Climate Change Adaptation Plan](#)

[Nunavut Climate Change Strategy](#)

Eastern Canada and Northeast USA

[Annapolis Royal Tidal Surge Analysis](#)

[Halifax Climate SMART: The Climate Sustainable Mitigation and Adaptation Risk Toolkit](#)

[Oyster River Watershed Culvert Study – Climate Ready Estuaries Program](#)

[Massachusetts Bays Project - Climate Ready Estuaries Program](#)

[Casco Bay Estuary Partnership - Climate Ready Estuaries Program](#)

[Climate Change Adaptations for Land Use Planners](#)

[Preparing for Climate Change and Sea Level Rise in New Brunswick](#)

[Atlantic Climate Adaptation Solutions \(ACASA\)](#)

Mid-Atlantic USA

[Identifying Opportunities for Climate Adaptation in the Delaware Estuary](#)

[City of New Castle, Delaware Coastal Resiliency Action Plan](#)

[Delaware Sea Level Rise Adaptation Initiative](#)

[Town of Bowers Beach, Delaware Coastal Resiliency Action Plan](#)

[Barnegat Bay Climate Change Adaptation Strategy Development](#)

[Implementation of Maryland's Climate Action Plan](#)

[Scenic Hudson Land Trust: Prioritizing lands in light of sea level rise](#)

Southeast/Gulf USA

[Indian River Lagoon and City of Satellite Beach, Florida Adaptation Project](#)

[Alligator River National Wildlife Refuge/Albemarle-Pamlico Peninsula Climate Adaptation Project](#)

[Incorporating Climate Change Impacts into Activities in Charlotte Harbor, Florida](#)

[Systematically Prioritizing Restoration Projects in Terrebonne Parish, Louisiana](#)

[Florida Energy and Climate Commission](#)

[Florida Governor's Action Team on Energy and Climate Change](#)

[North Carolina Climate Change Initiative](#)

Gulf of Mexico and Yucatan Peninsula – Mexico

[Impacts of Climate Change on the Coastal Zone of Mexico \(Gulf of Mexico\)](#)

[Gulf of Mexico Research Plan](#)

[MesoAmerican Reef \(MAR\)](#)

Alaska and British Columbia

[Stream Temperature Monitoring Network for Cook Inlet Salmon Streams](#)

[Mapping Future Climate Change in Alaska's National Parks](#)

[Future Climate and Water Availability in Alaska](#)

[Vulnerability of British Columbia Landscapes](#)

[Shoreline Sensitivity to Sea Level Rise in British Columbia](#)

[Preparing for Sea Level Rise on Graham Island](#)

Pacific States USA

[Salt Marsh Vulnerability Assessment and Adaptation Plan Development in San Francisco Bay, California](#)

[Vulnerability of King County, WA Wastewater Treatment Facilities to Sea Level Rise](#)

[Incorporating Climate Change into the San Lorenzo Watershed Management Plan](#)

[Oyster Emergency Project](#)

[Adapting to Sea Level Rise in Hayward, California](#)

[Preparing for the Impacts of Sea Level Rise on the California Coast](#)

[Kailua Beach and Dune Management Plan](#)

Nationwide USA

[U.S. Environmental Protection Agency's Climate Ready Estuaries Program](#)

[U.S. Global Change Research Program](#)

- h) Provide new job training for people whose livelihoods are threatened by climate change*

Southeast/Gulf USA

[Florida Energy and Climate Commission](#)

- i) Create/host adaptation training and planning workshops*

Arctic Canada

[Atuligtuq: A Collaborative Approach in Support of the Nunavut Climate Change Adaptation Plan](#)

Eastern Canada and Northeast USA

[Coastal Adaptation Plan for the Town of Groton, Connecticut](#)

[Atlantic Aboriginal Climate Change Adaptation Workshop](#)

[Climate Change and Renewable Resources in Labrador](#)

[Atlantic Climate Adaptation Solutions \(ACASA\)](#)

Mid-Atlantic USA

[Implementation of Maryland's Climate Action Plan](#)

Southeast/Gulf USA

[Alligator River National Wildlife Refuge/Albemarle-Pamlico Peninsula Climate Adaptation Project](#)

[Incorporating Climate Change Impacts into Activities in Charlotte Harbor, Florida](#)

[Florida Fish and Wildlife Conservation Commission: Planning for Climate Change](#)

[North Carolina Climate Change Initiative](#)

Gulf of Mexico and Yucatan Peninsula

[Gulf of Mexico Research Plan](#)

[MesoAmerican Reef \(MAR\)](#)

Pacific States USA

[The National Estuarine Research Reserve's "Planning for Climate Change" Workshop](#)

[Indigenous People's Global Summit on Climate Change](#)

Nationwide USA

[Integrating Climate Change into the National Estuarine Research Reserve System](#)

[U.S. Environmental Protection Agency's Climate Ready Estuaries Program](#)

[NOAA 2010 Workshop: Habitat Conservation in a Changing Climate- Tools and Strategies](#)

[Developing a National Fish and Wildlife Climate Change Adaptation Strategy for the United States](#)

j) Create stakeholder engagement processes

Pacific States USA

[Scenario Planning Pilot Study for Kaloko-Honokōhau National Historical Park](#)

k) Conduct scenario planning exercises

Arctic Canada

[Nunavut Climate Change Strategy](#)

Eastern Canada and Northeast USA

[Assessing the Risk of 100-year Freshwater Floods in the Lamprey River Watershed of New Hampshire Resulting from Climate Change and Land Use](#)

[Causes and Adaptation Strategies to Shoreline Erosion in Sept-Îles](#)

[Halifax Climate SMART: The Climate Sustainable Mitigation and Adaptation Risk Toolkit](#)

[Climate Change Adaptations for Land Use Planners](#)

[Atlantic Climate Adaptation Solutions \(ACASA\)](#)

Mid-Atlantic USA

[Implementation of Maryland's Climate Action Plan](#)

[Rising Waters: Helping Hudson River Communities Adapt to Climate Change](#)

Southeast/Gulf USA

[Florida Fish and Wildlife Conservation Commission: Planning for Climate Change](#)

Gulf of Mexico and Yucatan Peninsula – Mexico

[Impacts of Climate Change on the Coastal Zone of Mexico \(Gulf of Mexico\)](#)

Pacific States USA

[Scenario Planning Pilot Study for Kaloko-Honokōhau National Historical Park](#)

[Kailua Beach and Dune Management Plan](#)

Nationwide USA

[U.S. Environmental Protection Agency's Climate Ready Estuaries Program](#)

Nationwide Mexico

[Climate Change Adaptation in Protected Areas in Mexico for the conservation of biodiversity, ecosystems, and ecosystems services](#)

3. Infrastructure, Planning, and Development

a) *Make infrastructure resistant or resilient to climate change*

Arctic Canada

[Sustainable Development Initiatives in the Polar Town of Iqaluit, Canada](#)

[Climate Change Adaptation for the Community of Paulatuk](#)

[Climate Change Adaptation for the Community of Ulukhaktok](#)

Eastern Canada and Northeast USA

[Incorporating Climate Change into Research and Management at Mass Audubon](#)

[Assessing the Risk of 100-year Freshwater Floods in the Lamprey River Watershed of New Hampshire Resulting from Climate Change and Land Use](#)

[Annapolis Royal Tidal Surge Analysis](#)

[Oyster River Watershed Culvert Study – Climate Ready Estuaries Program](#)

[Atlantic Climate Adaptation Solutions \(ACASA\)](#)

Mid-Atlantic USA

[Planning for Sea Level Rise and Storm Surge in Worcester County, Maryland](#)

[Scenic Hudson Land Trust: Prioritizing lands in light of sea level rise](#)

Southeast/Gulf USA

[Florida Energy and Climate Commission](#)

[Florida Governor’s Action Team on Energy and Climate Change](#)

[Ecosystem Based Management Project](#)

[North Carolina Climate Change Initiative](#)

Gulf of Mexico and Yucatan Peninsula – Mexico

[Centro Ecológico Akumal-Mexico](#)

Alaska and British Columbia

[Greater Vancouver’s Stormwater Management Program](#)

[Homer, Alaska Climate Action Plan](#)

Pacific States USA

[Vulnerability of King County, WA Wastewater Treatment Facilities to Sea Level Rise](#)

[Planning for Sea Level Rise in Olympia, WA](#)

[Incorporating Climate Change into Landscape Connectivity Plans](#)

[Kayak Point Restoration Feasibility and Design Technical Memorandum: Sea Level Rise Projections](#)

[Goleta Beach 2.0: Managed Retreat to Mitigate Coastal Erosion](#)

[Adapting to Sea Level Rise in Hayward, California](#)

Nationwide USA

[U.S. Environmental Protection Agency's Climate Ready Estuaries Program](#)

[U.S. Environmental Program's Climate Ready Water Utilities Program](#)

[Planning for Climate Change in the U.S. Army Corps of Engineers](#)

Nationwide Mexico

[Climate Change Adaption Policy for the Water Sector in Mexico](#)

b) Community planning

Arctic Canada

[Climate Change Adaptation for the Community of Paulatuk](#)

[Climate Change Adaptation for the Community of Ulukhaktok](#)

Eastern Canada and Northeast USA

[Assessing the Risk of 100-year Freshwater Floods in the Lamprey River Watershed of New Hampshire Resulting from Climate Change and Land Use](#)

[Annapolis Royal Tidal Surge Analysis](#)

[Climate Change Adaptations for Land Use Planners](#)

[Atlantic Climate Adaptation Solutions \(ACASA\)](#)

Southeast/Gulf USA

[Florida Energy and Climate Commission](#)

Alaska and British Columbia

[Greater Vancouver's Stormwater Management Program](#)

Pacific States USA

[Climate Change Adaptation Planning in the City of Chula Vista](#)

[Adapting to Sea Level Rise and Coastal Erosion in Hawaii Through Coastal Construction Setbacks Policies](#)

[Adapting to Sea Level Rise in Hayward, California](#)

[Preparing for the Impacts of Sea Level Rise on the California Coast](#)

[Kailua Beach and Dune Management Plan](#)

[Restoration and Managed Retreat of Pacifica State Beach](#)

Nationwide- USA

[U.S. Environmental Program's Climate Ready Water Utilities Program](#)

c) Protect water supply systems from saltwater contamination

Eastern Canada and Northeast USA

[Sentinel Monitoring of Salt Marshes in the Narragansett Bay National Estuarine Research Reserve](#)
[Assessing the Risk of 100-year Freshwater Floods in the Lamprey River Watershed of New Hampshire Resulting from Climate Change and Land Use](#)
[Atlantic Aboriginal Climate Change Adaptation Workshop](#)
[Atlantic Climate Adaptation Solutions \(ACASA\)](#)

Southeast/Gulf USA

[Florida Energy and Climate Commission](#)
[North Carolina Climate Change Initiative](#)

Pacific States USA

[Adapting to Sea Level Rise in Hayward, California](#)

Nationwide USA

[U.S. Environmental Program's Climate Ready Water Utilities Program](#)

d) Create or modify shoreline management measures

Eastern Canada and Northeast USA

[Assessing the Risk of 100-year Freshwater Floods in the Lamprey River Watershed of New Hampshire Resulting from Climate Change and Land Use](#)
[Causes and Adaptation Strategies to Shoreline Erosion in Sept-Îles](#)
[Halifax Climate SMART: The Climate Sustainable Mitigation and Adaptation Risk Toolkit](#)
[Planning for Sea Level Rise in Rhode Island's Coastal Management Program](#)
[Atlantic Climate Adaptation Solutions \(ACASA\)](#)

Mid-Atlantic USA

[New Jersey Climate Change Adaptation Using Community Plan Endorsements](#)
[Planning for Sea Level Rise and Storm Surge in Worcester County, Maryland](#)
[Implementation of Maryland's Climate Action Plan](#)
[Scenic Hudson Land Trust: Prioritizing lands in light of sea level rise](#)

Southeast/Gulf USA

[Alligator River National Wildlife Refuge/Albemarle-Pamlico Peninsula Climate Adaptation Project](#)
[Florida Energy and Climate Commission](#)
[Florida Governor's Action Team on Energy and Climate Change](#)
[Gulf of Mexico Regional Sediment Management Master Plan](#)
[Ecosystem Based Management Project](#)

[North Carolina Climate Change Initiative](#)

Alaska and British Columbia

[Homer, Alaska Climate Action Plan](#)

Pacific States USA

[The National Estuarine Research Reserve's "Planning for Climate Change" Workshop](#)

[Planning for Sea Level Rise in Olympia, WA](#)

[Kayak Point Restoration Feasibility and Design Technical Memorandum: Sea Level Rise Projections](#)

[Goleta Beach 2.0: Managed Retreat to Mitigate Coastal Erosion](#)

[Adapting to Sea Level Rise in Hayward, California](#)

[Kailua Beach and Dune Management Plan](#)

[Restoration and Managed Retreat of Pacifica State Beach](#)

[South Bay Salt Pond Restoration Project](#)

Nationwide USA

[U.S. Environmental Protection Agency's Climate Ready Estuaries Program](#)

[U.S. Environmental Program's Climate Ready Water Utilities Program](#)

4. Governance and Policy

a) Managed retreat of built infrastructure, relocation of people/communities

Arctic Canada

[Climate Change Adaptation for the Community of Paulatuk](#)

[Climate Change Adaptation for the Community of Ulukhaktok](#)

Eastern Canada and Northeast USA

[Climate Change Adaptations for Land Use Planners](#)

[Climate Change and Renewable Resources in Labrador](#)

Alaska and British Columbia

[Relocating the Village of Newtok, Alaska due to Coastal Erosion](#)

[Relocating the Native Village of Shishmaref, Alaska Due to Coastal Erosion](#)

b) Develop a disaster preparedness plan

Arctic Canada

[Climate Change Adaptation for the Community of Paulatuk](#)

[Climate Change Adaptation for the Community of Ulukhaktok](#)

Alaska and British Columbia

[Relocating the Village of Newtok, Alaska due to Coastal Erosion](#)

Southeast/Gulf USA

[Broward County Climate Change Task Force](#)

c) Maintain adequate financial resources for adaptation

Eastern Canada and Northeast USA

[Disaster Preparedness and Response Planning in Barnstable County, Cape Cod](#)

Nationwide USA

[U.S. Environmental Protection Agency's Climate Ready Estuaries Program](#)

d) Create/enhance technological resources

Arctic Canada

[Planning for Melting Permafrost in Salluit](#)

Eastern Canada and Northeast USA

[Atlantic Aboriginal Climate Change Adaptation Workshop](#)

[Climate Change Adaptations for Land Use Planners](#)

[Climate Change and Renewable Resources in Labrador](#)

[Preparing for Climate Change and Sea Level Rise in New Brunswick](#)

Mid-Atlantic USA

[Implementation of Maryland's Climate Action Plan](#)

[Scenic Hudson Land Trust: Prioritizing lands in light of sea level rise](#)

[Coastal Resilience: Visualizing Climate Change Impacts and Coastal Hazards and Implementing Solutions in Long Island Sound](#)

Southeast/Gulf USA

[North Carolina Sea Level Rise Project](#)

[Ecological Effects of Sea Level Rise in the Florida Panhandle and Coastal Alabama](#)

[North Carolina Climate Change Initiative](#)

Alaska and British Columbia

[Vulnerability of BC Landscapes](#)

[Preparing for Sea Level Rise on Graham Island](#)

Pacific States USA

[Oyster Emergency Project](#)

[Hawaii's Changing Climate: Legislative Briefing Sheet 2010](#)

[Indigenous People's Global Summit on Climate Change](#)

[Oregon's Framework to Adapt to Rapid Climate Change](#)

[South Bay Salt Pond Restoration Project](#)

e) Develop/implement adaptation or adaptive management plan

Arctic Canada

[Climate Change Adaptation for the Community of Paulatuk](#)

[Climate Change Adaptation for the Community of Ulukhaktok](#)

Eastern Canada and Northeast USA

[Coastal Adaptation Plan for the Town of Groton, Connecticut](#)

[Causes and Adaptation Strategies to Shoreline Erosion in Sept-Îles](#)

[Halifax Climate SMART: The Climate Sustainable Mitigation and Adaptation Risk Toolkit](#)

[Atlantic Climate Adaptation Solutions \(ACASA\)](#)

Mid-Atlantic USA

[Identifying Opportunities for Climate Adaptation in the Delaware Estuary](#)

[City of New Castle, Delaware Coastal Resiliency Action Plan](#)

[Delaware Sea Level Rise Adaptation Initiative](#)

[Town of Bowers Beach, Delaware Coastal Resiliency Action Plan](#)

[Barneгат Bay Climate Change Adaptation Strategy Development](#)

[Implementation of Maryland's Climate Action Plan](#)

Southeast/Gulf USA

[Indian River Lagoon and City of Satellite Beach, Florida Adaptation Project](#)

[Alligator River National Wildlife Refuge/Albemarle-Pamlico Peninsula Climate Adaptation Project](#)

[Incorporating Climate Change Impacts into Activities in Charlotte Harbor, Florida](#)

[Florida Energy and Climate Commission](#)

[Florida Governor's Action Team on Energy and Climate Change](#)

[Broward County Climate Change Task Force](#)

[Florida Fish and Wildlife Conservation Commission: Planning for Climate Change](#)

[North Carolina Climate Change Initiative](#)

Gulf of Mexico and Yucatan Peninsula – Mexico

[Impacts of Climate Change on the Coastal Zone of Mexico \(Gulf of Mexico\)](#)

Pacific States USA

[Developing a Washington State Climate Change Impacts Response Strategy](#)
[Salt Marsh Vulnerability Assessment and Adaptation Plan Development in San Francisco Bay, California](#)
[Incorporating Climate Change into the San Lorenzo Watershed Management Plan](#)
[Adapting to Sea Level Rise and Coastal Erosion in Hawaii Through Coastal Construction Setbacks Policies](#)
[Kailua Beach and Dune Management Plan](#)
[South Bay Salt Pond Restoration Project](#)

Nationwide Mexico

[Climate Change Adaptation in Protected Areas in Mexico for the conservation of biodiversity, ecosystems, and ecosystems services](#)

f) Create new or enhance existing policy

Southeast/Gulf USA

[Broward County Climate Change Task Force](#)
[Florida Energy and Climate Commission](#)
[Gulf of Mexico Regional Sediment Management Master Plan](#)