

Climate Change Adaptation

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Overview

Today's coasts face an unprecedented challenge, struggling to cope and adapt in the midst of a changing climate. In coastal areas, the consequences of climate change are already evident, with global sea-level rising 10 to 25 cm over the last century (Pew, 2009). By 2100, this number is expected to increase anywhere from 0.5 to 1.4 meters above the 1990 level (Rhamstorf, 2007). Increased incidence and severity of coastal storms and hurricanes are also predicted to result from warming oceans and weather anomalies. Coastal zones are particularly vulnerable to sea-level rise and enhanced storms, facing serious impacts including: (1) inundation and displacement of wetlands and lowlands; (2) increased coastal erosion; (3) increased coastal storm flooding; and (4) salinization (Barth & Titus, 1984). Widespread human development in many of these areas further compromises the coastal system's natural integrity, simultaneously augmenting erosion and forfeiting inherent resiliency. Yet due to differences in regional oceanographic responses to climate change, as well as the extent of local/regional uplift/subsidence of the land surface, the impacts of sea-level rise will vary according to location (Nicholls & Mimura, 1998).

While present and future climate changes pose serious threats to our coastal zones and resources, Surfrider's current [beach health indicators](#) do not completely measure environmental quality or assess the status of coastal management in light of climate change impacts. In 2011 the [State of the Beach](#) report therefore focused on re-defining the [Erosion Response](#) indicator to more completely address coastal climate change adaptation, specifically concentrating on the response of coastal areas to sea level rise. Although climate change can affect coastal regions in a variety of ways, the scope of this article is limited to analyzing the following aspects of climate change adaptation: (1) coastal erosion; (2) shoreline armoring; (3) beach fill (aka nourishment); (4) set-backs; and (5) restoration of natural beach and wetland ecosystems. The report evaluates the adequacy of coastal states' climate change preparedness by determining if existing policies are able to address climate change issues, and the extent to which states are proactively responding to these issues.

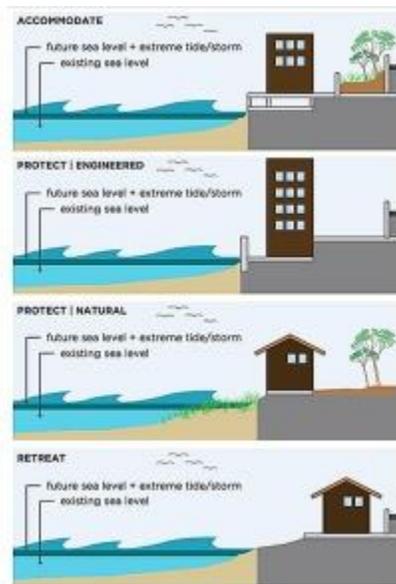
The vast majority of greenhouse gases (GHGs) exhibit relatively long atmospheric residence times, some upwards of a hundred years, creating a lag time between the release of atmospheric pollution and realization of the actual side-effects. Thus regardless of future greenhouse gas emissions, some degree of human-induced climate change will occur for at least the next 100 years. Mitigation measures to remedy global warming, while essential aspects of reducing the impacts of future climate change, alone will be inadequate in addressing the present challenges. Our ability to cope with the effects of today's climate changes instead hinges largely on our ability to adapt to future changes.

"Climate change adaptation" is a term increasingly used to describe social efforts dealing with the effects of climate change, yet is unfortunately defined by a number of conflicting environmental and social goals. In one of the more comprehensive definitions, the Intergovernmental Panel on Climate Change (IPCC) defines climate change adaptation as an "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 TAR, 2001)^[4]. Adopting a relatively broad stance, the IPCC definition attempts to merge both environmental and social considerations, and importantly, avoids specifying a defensive approach to climate change management. A number of contrasting definitions more fully embrace the notion of "resiliency", choosing to retroactively address the consequences rather than anticipate and cope with the immediate changes^[2].

Passed in 1972, the [Coastal Zone Management Act](#)^[3] (CZMA) sought to balance economic development with environmental conservation, mainly by avoiding the scenario described above. Outlined in the National Coastal Zone Management Program, CZMA encourages states to develop and implement coastal zone management plans to protect, restore, and develop the resources of the Nation's coastal zone for present and future generations. A number of states are also recognizing the importance of pre-emptive action to address their vulnerability to climate change (Pew, 2009). As such, a majority of coastal states have adopted, or are in the process of adopting, adaptation plans that fall within their larger state Climate Action Plans (Pew, 2009). Yet many of these adaptation plans are quite broad or vague, and thus fail to sufficiently address more specific adaptation issues. The independent nature of creating and implementing adaptation plans also tends to create disconnects between states, making it difficult to adequately evaluate and compare individual adaptation programs. It is therefore necessary to define adaptation plans in more precise terms and develop specific baseline criteria by which to compare state plans.

The point of coastal management is not to pit environmental and social goals against one other, but rather forge a degree of sustainable compatibility. The future of our coasts, along with the livelihoods of millions, rests in our ability to respect the coastline for the dynamic and vibrant system it is. By recognizing this basic principle, and learning to live *with* a changing coast rather than *against* it, both environmental and social objectives can be more fully satisfied. It is therefore essential to replace current reactive management schemes with ones inherently proactive. An anticipatory approach, one accounting for current and future erosion rates and climate change perturbation, will force communities to develop accordingly. This approach will help better preserve coastlines by maintaining or restoring

their natural functions, ensuring the safety and longevity of coastal communities, and minimizing the long-term costs associated with climate change response.



Sea level rise adaptation options. Source: San Francisco Planning Dept.

In order to protect human development and beachside communities from the destructive impacts of climate changes, management efforts in many cases center on coastal fortification, a reactionary approach which can include one or more of the following: seawall, groin, and jetty construction, beach re-nourishment, and inshore artificial reefs^[4]. Environmental consequences are frequently overlooked or disregarded in the process, often resulting in significant ecosystem disruption and perturbation of natural accretion and erosion cycles. In many areas, for example, the coast is threatened not only from its seaward side by physical ocean processes, but also from its landward side by encroaching development. Trapped between these two competing forces, natural sand and sediment transport is largely interrupted, forcing the coast to undergo a number of unnatural restructuring processes.



Surfer's Point Plan

The only *real* long-term option for coastal areas facing significant threats from sea level rise is thus adoption of a [managed retreat](#) policy, whereby homes and development are moved away from the shoreline so as to allow natural oceanic processes to run their course. Yet managed retreat is a hotly contested issue among private property owners, who stand to lose not only millions of dollars in property value, but even their homes. Managed retreat can also be extremely costly to state and local municipalities, and when considering such coastal cities as Miami, Los Angeles, and New York City, seems highly unfeasible. It is obvious, then, why the managed retreat option has been slow to catch on at either the state or national level. Nevertheless, some local communities facing especially severe erosion issues have begun to accept the fact that the sea can only be withheld for so long. The beachside community of Pacifica, California, for example, is in the process of buying up private property along the coast, and relocating coastal structures further inland. The same scenario has played out at Surfer's Point in Ventura, California, where the first phase of a managed retreat project has been implemented to effectively relocate a parking lot and bike path. Likewise, Texas, Rhode Island, Maine, and South Carolina's coastal zones all benefit from a degree of rolling setbacks, a policy akin to managed retreat that allows private coastal property owners to develop their land, but prohibits the erection of seawalls and barriers once sea levels begin to threaten the structures. Other states (e.g., Hawai'i, North Carolina) are choosing instead to adopt strict setback requirements based on past and future sea level rises, and while not conferring the same long-term benefits as managed retreat, nevertheless represent a step in the right direction.

In the wake of the destruction caused by Hurricane Sandy in October 2012, coastal managers in New York, New Jersey and other states are re-thinking their options for dealing with future major storms and future [sea level rise](#). New York offered coastal homeowners in certain areas a [buyout program to incentivize moving away from the coast](#) and [turning that land into greenspace](#) intended to provide protection from future storms. Former New York City mayor Michael Bloomberg has spoken in favor of limited retreat as well as the development of natural buffer zones. An Op-Ed [In a Global Warming](#)

[World: Protect and Rebuild or Retreat?](#) by Bill Chameides, Dean, Nicholas School of the Environment, Duke University further explores these options.

NOAA has developed a [map](#) showing the relative vulnerability of our nation's coasts to sea level rise.

Despite these initiatives, the adoption of state and local adaptation plans, and the recognition that climate change will pose unprecedented threats to our coastal areas, no state is adequately prepared to handle the impacts of climate change in the coastal zone. Formidable obstacles in the form of private property owners, million dollar investments, and difficulties in facilitating and implementing widespread retreat have served to severely stall adaptation progress throughout the nation. Adaptation isn't easy, and requires a shift in mindset both on behalf of coastal managers as well as local communities and individuals. It takes willingness to change, in addition to an understanding of the importance of that change to the long-term health of our coastlines. Yet how do we even begin to address climate change adaptation in states that don't even acknowledge the issue of climate change itself? Slowly, though, states are recognizing the importance of education and collaboration, creating Web portals and outreach materials designed to educate coastal property owners and communities on the issues surrounding climate change and sea level rise. Instead of the top-down approach employed widely in the past, there is an increasing propensity towards bottom-up initiatives and capacity building. The following highlights the "Good", the "Bad" and the "Rad" with respect to adaptation initiatives. Yet as previously suggested, all states need to continue to work towards enhancing their coastal zone management programs and policies, and begin to consider the future of their coastal areas in the face of rising seas.

The Good

1. Hawaii

Setback policies on Maui and Kaua'i represent some of the most aggressive regulations in the country, incorporating both historic erosion rates and the idea of managed retreat ([Managed Retreat in Maui, Hawaii](#) and [Kaua'i Shoreline Setback Bill](#)). In November 2003, Maui County set a precedent for shoreline protection among Hawaiian counties by being the first to adopt erosion rate-based construction setback rules. Utilizing the Average Annual Erosion Rate ("AAER"), the [Maui Shoreline Setback Rules](#) established a formula based on an annual erosion rate times a planning period of 50 years, plus a buffer of 25 feet. In the case of Kaua'i County, passage of the [Kaua'i Shoreline Setback Bill](#) in 2008 heralded one of the most aggressive shoreline building setback laws in the United States. The Kauai County setback is based on the AAER times a planning period of 70 to 100 years, plus a buffer of 40 feet. The State has also published such important documents as the recently released **Shoreline Impacts, Setback Policy, and Sea Level Rise** report.

2. Massachusetts

In 2008, Massachusetts CZM launched the innovative [StormSmart Coasts](#) initiative, a program designed to help local officials in coastal communities address the challenges arising from storms, floods, sea level rise, and climate change. Garnering much praise and attention for its proactive approach to coastal hazard mitigation and preparedness, the initiative is important as it represents a centralized data and information source for coastal communities and planners in Massachusetts. Adaptation tools, case studies, maps, guidance documents, and outreach materials are easily accessible, stimulating a greater connectivity among planners, managers, and the public alike. Entering Phase Two, the [StormSmart Coasts](#) initiative is currently working with seven different pilot programs to implement integrative and comprehensive coastal floodplain and sea level rise management tools and strategies.

3. Maine

Maine is one of only four states that employs the use of rolling easements, as explicitly articulated in the **Natural Resources Protection Act Chapter 355 Section D** (updated in 2006):

"If the shoreline recedes such that a coastal wetland extends to any part of the structure for a period of six months or more, then the approved structure along with appurtenant facilities must be removed and the site must be restored to natural conditions within one year." (Ch. 355, Sec. 10-A)

This contingency is applied to all projects receiving a permit for construction in the coastal sand dune system and is appended to the property deed and passed on to subsequent property owners when a title is transferred. For a complete version See Maine's [Dune Rules](#).

4. Delaware

In one of the most progressive actions to date, Delaware's Coastal Program has embarked on a **Sea Level Rise Adaptation Initiative**, and is in the processes of completing its **Sea Level Rise Adaptation Plan**. Susan Love, a Coastal Program Planner, describes the state's approach to climate change adaptation and its response to sea-level rise as a "ground-up, organic initiative", versus those of states like California that are more "top-down". She points out that since adaptation and sea-level rise issues are in actuality local issues, it is very difficult to implement effective strategies from the state level. The uniqueness of each locality further lends itself to handling adaptation issues on a case-by-case basis, rather than attempting a "one-size-fits-all" approach.

5. South Carolina

South Carolina's Coastal Program launched a multi-year **Shoreline Change Initiative** in 2007 to address beachfront and estuarine shoreline management issues, as well as concerns about intensifying sea level rise and coastal storms. As part of its increased effort to focus on coastal communities' resilience to erosion, hurricanes, and sea-level rise, the **Shoreline Change Initiative** charged the **Shoreline Change Advisory Committee (SCAC)** with conducting analyses of the risks to South Carolina's coastal communities and habitats, reexamine policies, and develop new approaches for coastal regulators, planners, local governments, and the public to prepare for and adapt to shoreline changes in the state. The SCAC recently published [Adapting to Shoreline Change: A Foundation for Improved Management and Planning in South Carolina - Final Report of the Shoreline Change Advisory Committee](#) (April 2010), providing a comprehensive overview of South Carolina's current shoreline management strategy, while also outlining adaptation recommendations for future coastal changes.

6. California

In response to **Executive Order S-13-2008: the Climate Adaptation and Sea Level Rise Planning Directive**, the California Natural Resources Agency (CNRA), working through the state's Climate Action Team (CAT), released the [State Climate Change Adaptation Strategy](#) in December 2009. Recognizing that climate change is already affecting California, and noting that almost half a million Californians will be at risk from sea level rise along bay and coastal areas, the report both summarizes the most recent science predicting potential climate change impacts and recommends response strategies. Members of the Climate Adaptation Working Group identified six priority strategies in addressing climate adaptation for state agencies, three of which relate specifically to sea-level rise:

- Strategy 3: State Agencies should prepare sea-level rise and adaptation plans to be completed by September 2010 and regularly updated, modified, and refined based on new information.
- Strategy 4: Support Local Planning for Addressing Sea-Level Rise Impacts by 2011, all coastal jurisdictions should begin development of amended Local Coastal Programs and general plans that include climate change impacts.
- Strategy 5: Complete a Statewide Sea-Level Rise Vulnerability Assessment Every Five Years

The Bad

1. Louisiana

Despite spotty coastal adaptation initiatives and the abundance of knowledge concerning sea-level rise and coastal subsidence along Louisiana's shoreline, the state struggles to implement a more comprehensive and effective coastal management plan. Louisiana's current strategy provides a lesson in paradox, as

coastal managers pursue climate change adaptation in a state that barely recognizes the phenomena itself. Many of the proposed adaptation measures focus on resiliency of structures rather than other measures (setbacks, managed relocation) which might prove more effective in the long-term.

2. **Indiana**

No substantial information could be obtained concerning Indiana's climate change mitigation initiatives, and few adaptation actions were identified. The state has yet to develop either a Climate Action Plan or a State Adaptation Plan, and does not appear well prepared to address climate change impacts, along its lake-front or elsewhere. It is suggested that Indiana undertake simple, yet effective steps towards climate change mitigation and adaptation in the near future, beginning with establishing a state-sponsored climate change website, and gradually increasing its involvement in regional climate change agreements.

3. **Florida**

Released in 2008 by the [Florida Coastal and Ocean Coalition](#), the report [Preparing for a Sea Change - A Strategy to Cope with the Impacts of Global Warming on the State's Coastal and Marine Systems](#) criticizes the ineffectiveness of Florida's coastal management policies, including inadequacies of the Coastal Construction Control Line (CCCL). The report notes that Florida's current coastal management and coastal development policies, updated [Strategic Beach Management Plan](#), and CCCL make no mention of climate change or sea-level rise, do not consider sea-level rise scenarios, nor do they stipulate specific dune setbacks that will ensure the future protection of coastal dune systems. The State furthermore continues to encourage, allow, and subsidize high risk coastal communities through loopholes in the CCCL and inherent problems with the Citizens Property Insurance Corporation that results in a subsidy for ill-advised construction in coastal high hazard areas.

The Rad

1. Currently, **Maine, Texas, South Carolina, and Rhode Island** represent the only four states in the country that have adopted a strategy of "rolling easements", a policy that allows development, but explicitly prevents property owners from holding back the sea. Under these arrangements, private landowners along oceanfront can continue to use and develop their properties, as long as they refrain from armoring the shoreline. Ownership of portions of the property would revert to the state if they become inundated because of a rise in the sea level. In doing so, the state allows for the natural progression of the sea inland.
2. In **California**, coastal areas threatened by severe erosion, including [Ormond Beach](#), [Surfer's Point in Ventura](#), Pacifica, and San Francisco Bay, are already adopting policies of managed retreat.

3. One of the most famous examples of managed retreat involved the Cape Hatteras Lighthouse in **North Carolina**, which was moved inland at a cost of \$9.8 million in response to a shoreline that had eroded 1,340 feet over 117 years. For more information check out a Surfrider Foundation [Making Waves article](#) and in this article on [managed retreat](#).
4. Launched in 2001, **Oregon's Coastal Atlas** website serves as an interactive, searchable, downloadable archive of geo-spatial data that includes mapping and decision support tools. The Atlas is an extremely comprehensive and well developed portal for information and discussion concerning a wide variety of coastal issues, including coastal erosion, sea-level rise, climate change, and other coastal hazards, and thus also represents an exemplary educational outreach tool.
5. Modeled after **Oregon's** successful [Coastal Atlas](#), **Maryland's Coastal Atlas** features [Maryland Shorelines Online](#), a mapping application for statewide shoreline erosion data that also includes a comprehensive shoreline inventory depicting storm surge inundation areas and vulnerable high risk sea-level rise areas based on LiDAR data.
6. As part of its [Living Coasts Program](#), The [Cooperative Institute for Coastal and Estuarine Environmental Technology](#) (CICEET) announced in January 2009 that it had awarded \$1,212,000 to researchers working in **North Carolina** and **New York** who are evaluating the costs and benefits of different approaches to erosion prevention in sheltered coastlines. Each project is focused on understanding the environmental and economic tradeoffs of alternative erosion control measures.
7. **Virginia's** Coastal Zone Management Program has been especially active in promoting the [Living Shorelines](#) initiative, an effort aimed at decreasing shoreline hardening so as to allow wetlands to naturally migrate inland as sea levels rise. The initiative promotes the use of nonstructural or "hybrid" approaches to shoreline stabilization and can preserve, and in some cases expand, wetlands and natural shoreline features in the face of rising sea levels.
8. In **Georgia**, [Georgia Conservancy's](#) Design + Research Blueprints project concentrates on sea level rise challenges and adaptation opportunities for five communities along the Georgia coast: City of Savannah, Tybee Island, City of Darien, City of Brunswick, and City of St. Marys. These locations were selected because of their various geographic positions along the coast, as well as their different challenges and opportunities. A Blueprints team, composed of Blueprints staff, Professor Richard Dagenhart, Dr. Tom Debo and graduate students in a Georgia Tech College of Architecture Design + Research Studio spent almost six months preparing this report. The Studio developed alternative planning and design approaches for the five coastal communities and developed a set of draft recommendations for stakeholder consideration. These recommendations are supported by Blueprints advisors and form the basis of this report. The final output of the process is the report [Retreat. Adapt. Defend. Designing Community Response to Sea Level Rise in Five Coastal Georgia Communities](#), which aims to educate communities across the state and to begin considering responses to climate change and sea level rise. Although these recommendations are not aimed at immediate implementation, the team hopes the design and planning proposal will draw attention the issues of sea level rise, stimulate conversations, and help begin the

process of making appropriate decisions today that will guide future decision over the coming decades.

The following outlines essential elements of effective coastal management plans and state climate change adaptation plans, highlighting key criteria to guide future coastal development and management practices. Some of the criteria are further used as part of Surfrider Foundation's [Erosion Response](#) indicator.

Essential Elements of Coastal Climate Change Adaptation Management Plans

1. **Proactive adaptation:** Approach recognizes the need to factor climate change into decisions affecting long-term susceptibility of systems to the impacts of climate change. Process requires assessing the vulnerability of natural and man-made systems, as well as weighing the costs/benefits of action vs. inaction. Alternatives should then be planned accordingly.
2. **Maximize ecosystem resilience to climate change:** The overall goal of adaptation is to reduce the risk of adverse environmental outcomes through activities that increase the resilience of ecological systems to climate change. EPA has defined resilience in this context as the amount of change or disturbance that a system can absorb without fundamentally shifting to a different set of processes or undergoing ecosystem re-structuring. It is therefore necessary for management plans to incorporate options that protect key ecosystem features, and focus management protections on structural characteristics, organisms, or areas that represent important underpinnings of the overall system.
3. **Dynamic management plans:** The uncertain nature of climate change and climate change impacts necessitates dynamic management systems that can accommodate and address such unpredictability. Management plans must have the ability to be flexible and responsive to sudden, and often times unforeseen, changes. Adaptive policies should therefore allow managers to focus not only on managing adaptation, but further be able to manage *change*. Dynamic management plans will also be able to incorporate new knowledge as it becomes available, and apply it to current management schemes.
4. **Establishment of current baselines, identify thresholds, and monitor for changes⁵¹:** Understanding where thresholds have been exceeded in the past, and where they may be exceeded in the future, will allow managers to plan accordingly and avoid tipping points where possible. Managers must therefore establish current baseline conditions, model a range of possible climate change impacts and system responses, monitor actions and systems to detect changes in baseline conditions and determine efficacy of adaptive measures, and respond by implementing adaptation actions at appropriate scales and times.

5. **Identification of key vulnerabilities^[6]**: Assessment of coastal areas to determine which are most at risk and *why*, using the following criteria;
 - Key vulnerabilities of coastal areas:
 - Differences in exposure to impacts
 - Differences in sensitivity to impacts
 - Differences in adaptive capacity
 - Differences in socio-economic factors
 - Importance (major cultural/natural resource)
 - Factors influencing severity of impact(s):
 - Magnitude of impact(s)
 - Timing (short-term vs. long-term) of impact(s)
 - Persistence vs. reversibility of impact(s)
 - Likelihood vs. certainty of impact(s)
6. **Prioritizing Actions^{[5][6]}**: Adaptive actions should be prioritized based on the nature of the projected and/or observed impacts, as well as the vulnerability of the coastal area in question. Managers should utilize a systematic framework for priority setting, which would help managers catalog information, design strategies, allocate resources, evaluate progress, and inform the public. Priority setting should occur in an ongoing way to address changing ecological conditions and incorporate new information.
7. **Careful assessment of adaptation options^[4]**: Adaptation options should be chosen based on a careful assessment of their efficacy, risks, and costs.
 - Various options include: profit/opportunity options, win-win options, low-regret or no-regret options, options averting catastrophic risk, and/or options that avoid unsustainable investments.
8. **Inclusion of short-term measures**: Management plans should include strategies that address short-term impacts and concerns, while long-term management plans are being developed.
9. **Collaboration^{[5][6]}**: Management plans should encourage collaboration between various ecological managers, stakeholders, and levels of government, and include a system that fosters the exchange of ideas, information, resources, best practices, and lessons learned. Expanding collaboration has the potential to broaden both the spatial and ecological scope of potential adaptation options.
10. **Recognition of potential barriers to implementation^[5]**: Management plans must recognize legal and social constraints, restrictive management procedures, limitations on human and financial capital, and information gaps, yet also view these barriers as potential opportunities. Management plans must therefore be flexible enough to work around particular barriers that may arise.
11. **Outreach & Education**: In order to increase public awareness and expand community involvement, management programs should include outreach and educational tools and considerations.

Addendum and Additional Resources

NOAA's [Digital Coast Sea Level Rise and Coastal Flooding Impacts Viewer](#) provides online access to several scenarios of future high tides, uncertainty maps, and information on marsh migration, social vulnerability, and flood frequency. These visualization tools can be used to improve understanding of potential impacts from sea level rise and assist planning efforts in coastal communities.

NOAA's Coastal Resources Center has developed [Roadmap for Adapting to Coastal Risk](#), an online, three-hour course where participants learn how to characterize community exposure to coastal hazards, and to assess how plans and policies already on the books can be used to jump-start adaptation strategies. [Here are examples](#) of how the Roadmap is being used by communities in New York, Florida and Pennsylvania to address their risk and vulnerability issues associated with hazards and climate change.

The Association of State Floodplain Managers has recently released [How-To Guide for No Adverse Impact: Mitigation](#) (PDF, 12.6 MB) and [How-To Guide for No Adverse Impact: Infrastructure](#) (PDF, 3 MB), the first two in a series of [No Adverse Impact \(NAI\) Toolkit How-To Guides](#). The publications were developed to expand on the knowledge base within the original NAI Toolkit and to provide specific tools for incorporating NAI floodplain management into local regulations, ordinances, requirements, design, standards, and practices.

The U.S. Army Corps of Engineers takes climate change and climate change adaptation seriously. They believe "The entire portfolio of USACE Civil Works water resources infrastructure and programs, existing and proposed, could be affected by climate change and adaptation to climate change. Numerous regulatory decisions made by USACE will need to be informed by climate change impacts and adaptation considerations throughout the U.S., especially in western states." Their [Responses to Climate Change](#) website addresses these concerns and includes an [Adaptation Policy and Plan](#).

The October 2011 report [Federal Actions for a Climate Resilient Nation: Progress Report of the Interagency Climate Change Adaptation Task Force](#) provides an update on actions in key areas of Federal adaptation, including: building resilience in local communities, safeguarding critical natural resources such as freshwater, and providing accessible climate information and tools to help decision-makers manage climate risks. This report follows the Task Force's [October 2010 Progress Report](#) to the President that recommended the Federal Government strengthen the Nation's capacity to better understand and manage climate-related risks.

A report [The State of Marine and Coastal Adaptation in North America: A Synthesis of Emerging Ideas](#) was published by EcoAdapt in January 2011. The report, which is the culmination of a nearly 18 month survey of marine and coastal climate change adaptation

projects and initiatives in North America, summarizes climate impacts and provides summaries and examples of adaptation actions implemented throughout the United States, Canada, and Mexico.

NOAA's Digital Coast has recently released [What Will Adaptation Cost?: An Economic Framework for Coastal Community Infrastructure](#), a report designed to help communities make more economically informed decisions about adapting to sea level rise and storm flooding. The report's four-step framework can be used to perform an assessment of the costs and benefits of different adaptation approaches across a community. An [executive summary](#) (PDF, 318 KB) and [full report](#) (PDF, 2.9 MB) are available.

U.S. EPA maintains a [State Water Agency Practices for Climate Adaptation Database](#). This compilation of practices highlights some of the innovative actions or planning efforts by various state agencies that help address a changing climate.

In 2016 the National Parks Service released the [Coastal Adaptation Strategies Handbook](#), which highlights the processes, tools, and examples that parks have available for response and recovery from tropical storms and hurricanes and offers strategies to address rising sea levels. The handbook also includes a chapter on lessons learned from Hurricane Sandy.

In 2016 the Lloyd's Tercentenary Research Foundation released [Coastal Wetlands and Flood Damage Reduction: Using Risk Industry-based Models to Assess Natural Defenses in the Northeastern USA](#) (PDF, 3.4 MB), the first report from the two-year research project, The Role of Coastal Habitats in Managing Natural Hazards and Risk Reduction. The report quantifies the economic benefits of coastal wetlands in reducing property damage from storms and flooding in the northeastern United States. For more information on this project, see the [Lloyd's website](#).

Surfrider's State of the Beach Erosion Response (contains a subsection on climate change adaptation) – evaluates each state's adaptation efforts and provides links to relevant info and tools. Direct links to each state's page are here:

West Coast: [Alaska](#), [British Columbia](#), [California](#), [Oregon](#), [Washington](#)

Islands: [Hawaii](#), [Puerto Rico](#)

Great Lakes: [Illinois](#), [Indiana](#), [Michigan](#), [Minnesota](#), [Ohio](#), [Pennsylvania](#), [Wisconsin](#)

Gulf States: [Alabama](#), [Louisiana](#), [Mississippi](#), [Texas](#)

Northeast: [Connecticut](#), [Maine](#), [Massachusetts](#), [New Hampshire](#), [New York](#), [Rhode Island](#)

Mid-Atlantic: [Delaware](#), [Maryland](#), [New Jersey](#), [Virginia](#)

Southeast: [Florida](#), [Georgia](#), [North Carolina](#), [South Carolina](#)

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1. [Jump up](#)↑ This definition can also be found on the website of the UNFCCC Secretariat: http://unfccc.int/essential_background/glossary/items/3666.php
 2. [Jump up](#)↑ For alternative "climate change adaptation" definitions, reference Organisation for Economic Co-operation and Development (OECD) & International Energy Agency (IEA).
 3. [Jump up](#)↑ Coastal Zone Management Act. Title 16. Chapter 33. Section 1451
 4. [Jump up to:4.0](#) [4.1](#) For more information refer to Chapter 8 in *Greenhouse Effect and Sea Level Rise: A Challenge for this Generation*. Chapter 8: [Planning for Sea Level Rise before and after a Coastal Disaster](#) by James G. Titus
 5. [Jump up to:5.0](#) [5.1](#) [5.2](#) [5.3](#) See USGCRP
 6. [Jump up to:6.0](#) [6.1](#) [6.2](#) See Pew Center on Global Climate Change