



The Coastal State Climate Change Planning Act (HR 764)

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Graphic Source: The Wall Street Journal: Market Watch

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I. Introduction

A. The Coastal Zones

Climate change particularly impacts the welfare of coastal zones because these regions are situated at the lively interface of land and water. Aquatic and terrestrial areas strongly influence each other through physical, hydrological, and geochemical processes to produce distinctive ecosystems that cannot be found elsewhere. Ecosystems located on these coastlines, such as salt marshes, wetlands, and estuaries, provide critical habitats for a diverse and unique array of wildlife (Scavia *et al.*, 2002). The ecosystem goods and services provided by coastal zones have an estimated value of \$14 trillion per year; therefore, efforts that protect freshwater, saltwater, and terrestrial ecosystems would benefit both the ecosystem and people (Harley *et al.*, 2006).

B. The Coastal States

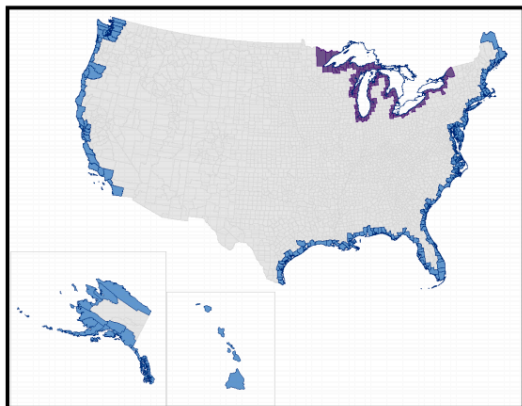


Figure 1: US coastal counties. 39% of the American population occupies 401 coastal counties, which will be seriously affected by climate change without the legislative action offered by HR 764. (Source: NOAA)

The Coastal States are states that border the Atlantic Ocean, Pacific Ocean, Gulf of Mexico, or one of the Great Lakes. The coastal effects of climate change include sea level rise, intense storm events, ocean acidification, and warmer sea temperatures. These changes threaten the economic, social, and ecological health of coastal communities and ecosystems. 80% of the US population resides in coastal states, and Figure 1 depicts about half of that population, or 123 million people, living in counties bordering the coast (NOAA, 2013). Coastal states also contribute approximately 83% of the nation's economic output (NOEP, 2009). Climate change can exacerbate environmental threats along the coasts, resulting in economic losses and quicker degradation of coastal communities.

C. Climate Change and its Causes

Climate change occurs over several decades or longer and consists of a significant change in temperature, precipitation, or wind patterns (EPA, 2013). It is caused by increases in greenhouse gases such as carbon dioxide, water, and methane in the atmosphere. Greenhouse gases absorb the Sun's energy that is radiated by the Earth and then trap energy within the atmosphere as heat, causing the planet to warm. Over the past 250 years, human activities such as the burning of fossil fuels, land use changes, and agriculture contributed to a significant increase in atmospheric

greenhouse gas concentrations (IPCC, 2007). Increases in average global temperatures produce positive feedback to worsen the impacts of climate change.

II. Science of the Problem

Climate change and its interconnected effects result in the advent of numerous environmental issues. Many of these problems that are unique to coastal regions include sea level rise, increased storm intensity, reduced water quality, wetland damage, and biodiversity loss.

A. Sea Level Rise

Figure 1 depicts sea levels having risen 9 inches since 1870. The 2007 Intergovernmental Panel on Climate Change report puts the current rate of sea level rise at 3.0 millimeters per year and projects a sea level rise of an additional 0.2 to 0.6 meters by 2100. In the United States, sea level rise of 25 inches is expected to threaten 3.7 million homes in low lying areas by 2100 (Straus *et al.*, 2012; Yohe *et al.*, 1995). Increasing global temperatures result in both the expansion of warming seawater and the melting of glaciers, polar ice caps, and sea ice (IPCC, 2007). The melting of these large ice masses at an escalating rate introduces more liquid water into the oceans. For instance, Antarctica and Greenland are losing ice mass at a combined rate of about 125 gigatons per year, which would raise global sea levels by 0.35 mm each year (Shepherd & Wingham, 2007, Cazenave & Llove, 2010).

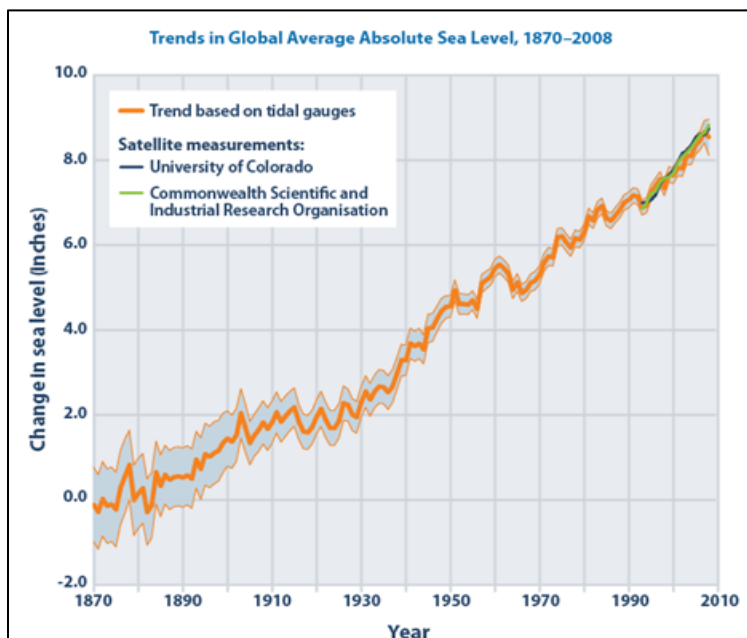


Figure 2 Trends in Global Average Absolute Sea Level, 1870 – 2008 (Source: EPA)

One direct and costly impact of sea level rise is coastal flooding, a phenomenon when seawater inundates normally dry, low-lying land. When the coastline moves further inland, coastal areas may experience permanent flooding. Temporary flooding, however, still occurs during storm surges in intensified storm events. It is anticipated that flash flooding will become more frequent and dangerous, especially when coupled with the permanent flooding from rising sea levels (IPCC, 2007).

Coastal erosion is yet another impact of climate change. Both the rise in sea level and the increase in extreme storm events result in larger and rougher wave action in coastal areas. Waves destroy the foundations of structures built near shorelines and deposit sedimentation load in waters near the shore. Extensive and high-rate coastal erosion also destroys coastal marine habitats and changes shorelines, while inlet areas like

river mouths and lagoons experience basin infilling due to sediment transport and deposition (UNESCO, 2012).

B. Increased Intensity of Severe Weather Events

Severe storm events will likely be one of the most economically detrimental results of climate change in coastal states because these states contain approximately 83% of the nation's economic output (NRDC, 2008; NOEP, 2009). Climate change results in the increased severity of extreme coastal weather events such as hurricanes and tsunamis (Leichenko, 2012). This stems from the fact that warmer air is able to hold more moisture, resulting in increased and heavier precipitation in coastal communities (NWF, 2013). Convective forces driven by increased temperature and moisture gradients above water bodies and land masses stimulate the creation of more severe storms.

Increased intensity of major storm events can cause heavy precipitation and flash flooding. Heavy storms that would historically occur around once every hundred years are predicted to occur every 3 to 20 years by the end of the century (Lin *et al.*, 2012). Flood waters are not the only destructive agents to these coastal communities; related impacts such as water-borne disease transmission, sewage overflows, and surface runoff are also expensive and detrimental. During storm events, runoff contaminated with nitrogen from fertilizers would flow to the ocean. Excess nutrients nourish algae populations that deplete dissolved oxygen from the water. Without oxygen to breathe, fish and other aquatic life would die. Agricultural runoff containing phosphorus initiates a similar process in bodies of freshwater, most notably producing algal blooms in the Great Lakes (Great Lakes Commission, 2012).

C. Reduced Water Quality

Climate change impacts water quality by causing water temperature changes, ocean acidification, and saltwater intrusion. Coastal water temperatures have been predicted to increase as much as 4 to 8°F in the 21st century (USGCRP, 2009). This temperature increase impairs the survival and reproduction of species, such as coral, which relies on a consistent temperature to maintain biological functions like filtering water (National Geographic, 2013).

Climate change exacerbates ocean acidification because oceans absorb carbon dioxide (CO₂) from the atmosphere. When atmospheric CO₂ reacts with water, the resulting carbonic acid lowers the pH of ocean. An increase in acidity permanently alters local ecosystems and affects the formation of the calcium carbonate shells of many marine organisms. (National Geographic, 2013).

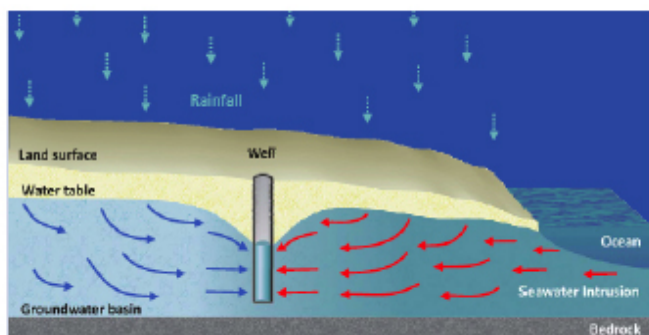


Figure 3. Saltwater Intrusion on the coast. (Source: transitions.org)

Saltwater intrusion, the seeping of saltwater into freshwater aquifers, is a climate change impact. In coastal areas, gravity and pressure gradients pull salt water from oceans in the “transition

zone” into freshwater aquifers. Drinking water wells, depicted in Figure 3, would further draw up the seawater from the coast and thus cause the aquifer to fill up with non-potable saltwater. More inland transition zones along with prevalent exploitation of aquifers reduce the coastal availability of fresh drinking water for human and animal consumption (USGS, 2000).

D. Wetland Damage

Wetlands are ecosystems characterized by water saturation either seasonally or year-round, and they comprise 5.5% of the total surface area of the United States (Dahl, 2006). They serve as flood barriers, fish nurseries, and water purifiers. Climate change poses a threat to wetlands due to sea level rise and severe storm events. Sea level rise brings higher salinity waters further inland, exposing freshwater and estuarine wetlands to increased salt concentrations. This change in environment is detrimental to the survival of some wetland plants, whose roots anchor the ecosystem’s sediment in place. (Duke University, 2001). Storm surges during severe storm events bring a sudden rush of saltwater that kill native species by the sudden change in water quality. The force of these initial surges uproots and breaks plant structures, but the eventual receding water following a storm surge can further erode the roots of wetland plants (Rastogi, 2010).

E. Biodiversity Loss

Biodiversity is the degree of variation of life forms within a given species, ecosystem, or biome (Gaston and Spicer, 2004). The permanent and irreversible loss of habitat and species due to coastal and flash flooding is one of the primary impacts of climate change on coastal biodiversity. Flooding destroys coastal habitats by changing the ecological properties of an originally dry habitat, and it kills animals and plants that are not adapted to survive in waterlogged conditions. Increased severe precipitation also worsens agricultural runoff and eutrophication, which causes water to be depleted of oxygen and uninhabitable for aquatic organisms (USGCRP, 2009). Changes in water quality such as salinity and pH also adversely impact biodiversity because some species are not able to adapt their biological functions to the dramatic biochemical changes.

III. The Solution to the Problem: HR 764

Congresswoman Lois Capps of California introduced the Coastal State Climate Change Planning Act, also known as House Resolution 764, in the House of Representatives in February 2013. The legislation amends its precedent, the Coastal Zone Management Act of 1972, by authorizing the Secretary of Commerce to offer financial and technical assistance for coastal states to develop voluntary adaptation and response plans.

A. Financial Assistance

The proposed grant program issues two types of grants.

1. Climate Change Adaptation Planning Grants are awarded to develop adaptation plans that protect biodiversity, protect water quality, and establish habitat buffer zones in response to the consequences of climate change.
2. Coastal Adaptation Projects Grants are awarded to prevent physical disturbance within the coastal zones, control etiological and invasive species, protect wildlife habitats, and mitigate potential natural hazards that arise as byproducts of climate change.

For either grant to be approved by the Secretary of Commerce, each proposal must address three components:

Steps to Securing Grant	Examples
1. Clearly identify the land or water uses within a coastal zone that would be impacted by climate change.	Public facilities, working waterfronts, energy facilities, coastal waters, and coastal resources
2. Outline the adaptive management strategies of how the land or water uses will be protected climate change impacts.	Promoting biodiversity, ensuring water quality, and protecting wildlife resources through habitat buffer zones, migration corridors, or climate refugia
3. Ascertain how to carry out long-term monitoring of the environmental change to assess adaptation progress.	Use of indicators like extent of sea level encroachment to barrier, water quality measures, and ecosystem health scores

B. Technical Assistance

The bill provides training and technical assistance to coastal states to enable them to implement their adaptation plans. It also provides training to local coastal policy makers to increase awareness of potential adaptation strategies and management information.

C. Pilot Projects

The program promotes pilot and demonstration projects at National Estuarine Research Reserves in order to ascertain the feasibility and effectiveness of the proposed adaptation plans.

IV. Science of the Solution

The adaptation plans eligible for the HR 764's grants run the gamut of possible approaches to reduce the negative consequences and threats of climate change on coastal zones. These activities can lower the threat of sea level rise, protect coasts from severe weather, ensure water quality, protect wetlands, and preserve biodiversity.

A. Protection from Sea Level Rise and Severe Weather Events

Beaches are one of the strongest natural defenses against weather events such as hurricanes and storm surges in coastal states. Long, flat areas of sand dissipate wave energy in a storm surge, allowing the destructive forces of the storm to be absorbed by the sandy coast rather than by the fragile built environment (Seelig & Ahrens, 1981). Additionally, dunes on these beaches act as natural sea walls, reflecting waves back to the ocean. These reflected waves contact other incoming waves to further dissipate the wave energy (Leatherman, 1979). As storm surges are blocked by dunes, waves will erode and transport the sediment offshore to create sand bars, which can also serve to absorb more wave energy in the ocean (Heathershaw, 1982). Since storms erode away a significantly large amount of sand from the coastline, natural replacement by physical weathering takes a long time. Thus, beach nourishment is a feasible solution that involves the addition of sand to beaches or dunes. Additional sand improves the ability of beaches to prevent sea level encroachment and to absorb storm energy.

B. Protection from Flooding

Integrated flood protection systems are flexible and adaptable systems that can combine a variety of elements to offer flood protection to susceptible areas. These systems improve upon traditional protection methods like floodwalls, bulkheads, and levees to enhance the overall protection value of coastal protection infrastructures (Walton *et al*, 1989). Floodwalls are vertical barriers used to control flooding due to sea level rise by offering a higher level of surge protection for vulnerable neighborhoods and infrastructure. Figure 4 illustrates the construction of these defenses, which can be deployed during extreme weather events and be removed immediately after a threat recedes. This flexibility allows the waterfront to remain accessible at all times unless weather events dictate otherwise (The City of New York, 2013).

Bulkheads are vertical retaining walls used on coasts to hold shorelines in place and control erosion. They can break waves and reduce the destructive energy of storm surges during large storm events. A levee, also known as a floodbank, is an elongated ridge that is either naturally occurring or artificially constructed. Levees are similarly able to regulate water



Figure 4: Installation of deployable floodwalls
(Source: BNAVC)

levels and protect coastal neighborhood from flooding during rising water levels (Petroski, 2006). Multipurpose levees are engineered to serve as land for future development such as transportation infrastructure, public spaces, and other commercial or residential uses. In the long run, this might even provide a cost-saving mechanism to pay for protection from coastal flooding.

C. Tackling Adverse Impacts on Water Quality

Rising sea levels and more severe storms events complicate coastal water quality. During intense precipitation events, outfall sewers cannot contain the sudden rush of storm water and can back up. Tide gates are dam-like structures that can be implemented in order to prevent the rapid inflow of seawater and the backup of outfall sewers. Salt water intrusion into both the city's fresh water supply and into treatment facilities could occur without such barriers. When heavy rainfall washes fertilizers and other harmful anthropogenic chemicals into rivers and estuaries, high levels of algae growth and low levels of oxygen endanger coastal state marine ecosystems. Coastal states can implement fertilizer and chemical control in order to decrease levels of hypoxia in their watersheds, especially as climate change stands to worsen current conditions (Burkett 2012)

D. Restoring Wetlands

Wetlands are another ecosystem that naturally occurs along much of the United States' coastline and can be effective in protecting the coast from storm damage. Some wetland vegetation thrives in wet soil, allowing these plants to survive and even flourish as storm water enters the system (Morris *et al.* 2002). The ability of storm water to safely inundate some wetlands allows this land to absorb much of the wave energy from the ocean (Ozeren *et al.*, 2013). The root structures of wetland vegetation reduce erosion in a way that beaches cannot and the roots also absorb nutrients in the water to improve water quality (Anderson & Mulder, 2008). Additionally, wetlands serve to retain stormwater, letting the stored water infiltrate into the ground or evaporate into the air rather than allowing it to enter the wastewater system, which might overflow combined sewer systems. Wetlands that become restored and managed can meet storm protection goals and become habitats pulsating with ecological biodiversity.

V. Does the Solution Address the Problem?

A. Effectiveness of the Bill

The Coastal State Climate Change Planning Act compels states to become proactive in preparing for the adverse consequences of climate change by competing for grants. Because adaptation plans are voluntary and not mandated by the federal government, states are given a high degree of flexibility in developing plans that are customized for their specific problems. Grants help states to invest money in adaptation in the present to save money from damages in the future. The bill addresses the problem of climate change on coasts scientifically through adaptation plans that provide practical solutions to the adverse effects of climate change. Although the bill does not provide money to mitigation plans that tackle the causes of climate change, it gives states the necessary financial and technical assistance to take the first step in preparation for its effects.

HR 764 proposes a solution that is also politically viable. First, states are already asking for federal aid and cooperation. For example, state governments recently sent managers to Congress to request federal involvement in strategies to reduce invasive species (Malewitz, 2012). Also, following the devastation of Hurricane Sandy in 2012, the Governor of Maryland issued an executive order stipulating that state managers fully cooperate with federal agencies to develop joint climate adaptation plans for the state's coastline (Office, 2012). Second, recent cuts to specific programs in the federal budget endanger adaptation and preparedness capacities. For example, the recent sequestration shut down a large percentage of the nation's remaining active gauges for the national flooding early warning system. Enhancing state capacity to support weakened federal capacity is vital at this time (Malewitz, 2013).

B. Controversies

The large variability and uncertainty in the effects of climate change on coasts could affect the ability of regulators to formulate successful climate change adaptation plans. Should a coastal state invest in adaptation measures, it must make assumptions concerning climate change effects. For example, if a state assumes that sea level will rise 3 inches in the next three decades, it might invest resources in infrastructure and strategies that account for a low sea level rise; however, it will be unprepared for a higher sea level rise. The benefits from these measures and the suitability of the implemented infrastructure are unknown because future forecasts can only be anticipated. An uncertain future may cause states to postpone implementing costly measures if they do not know the potential effectiveness of their approaches.

Decision-makers must also consider trade-offs when planning and implementing adaptation strategies. While adaptations can be beneficial to combat climate change, they also create counterproductive and negative impacts. One example of an adaptation strategy with trade-offs is beach nourishment. In some instances, the use of heavy machinery to add and move sand to beaches disturbs valuable habitats. These disturbed beach habitats can be the home to threatened species such as piping plovers and other beach-nesting birds. Also, adding sand to a beach can accelerate erosion

rates when large quantities of this additional sand is eroded during the next storm and taken out to sea (Cohen, 2005). Although some strategies are controversial by combating climate change effects at the expense of one part of the ecosystem, the overall thrust of the adaptation plan can still succeed by protecting multiple land uses, ecosystems, and organisms.

C. Measuring the Policy’s Success

The policy specifies that the proposed management plans must include requirements to carry out long term monitoring of environmental indicators to assess their success. Successful outcomes are defined as the whether the adaptation plan achieved the desired effects. The proposed adaptation plans aim to achieve these outcomes, and scientific indicators can measure the success of each corresponding outcome:

Outcome	Indicator
Improved protection of coastal ecosystems	Health of coastal ecosystems like wetlands
Increased protection from sea level rise	Sea level buffer capacity

Coastal ecosystems like wetlands are crucial for buffering sea level rise and absorbing coastal storm impacts (Ozeren *et al.*, 2013). The health of coastal ecosystems can be measured using both biotic factors like grass, benthic, and phytoplankton biodiversity, and abiotic indicators like chlorophyll a, dissolved oxygen, pH, and water clarity. The extent of wetland restoration is another vital adaptation measure of the health of coastal ecosystems because wetlands can protect coasts from severe weather events and sea level rise (Gansler, 2010).

Sea level rise adaptation strategies include dyke construction, coastal dune protection, and beach nourishment. The effectiveness of their protection from sea level rise can be quantified by measuring the distance between the maximum sea level at high tide and the height of the human infrastructure. In other cases, the coastal shoreline gradient can determine the extent of sea level encroachment. By containing language that promotes long-term monitoring, the policy ensures that the adaptation plans not only check progress but also provide the capability to adjust strategies if necessary.

VI. Conclusion

Regardless of the political climate in Washington, urgent legislative action is necessary to address the unprecedented effects of climate change on coastal regions. Adverse environmental threats, including ecosystem degradation, ocean acidification, storm surges, and sea level rise, pose a significant risk to both natural and human communities. Climate change exacerbates these risks and demands prompt attention to ensure the continued protection and welfare of coastal states. The science of climate change has been studied extensively in recent years, and while there are uncertainties in predictive modeling, baseline assumptions, and data availability, a considerable consensus on the inevitability of climate change impacts on coastal states exists in the scientific community (Vermeulen *et al.*, 2013). The cost of these impacts to nature, public infrastructure, private property, and human livelihoods will be greater when communities are unprepared for them. It is essential for coastal states in particular to understand these risks and to move forward in developing appropriate adaptive response plans. The Coastal State Climate Change Planning Act provides a scientifically viable and sorely needed set of financial and technical means to address the problem. Although this piece of legislation is not a comprehensive solution to climate change as no single piece of legislation can tackle so complex or daunting a problem, it takes a confident and vigorous initial step in the direction of coastal resiliency and sustainability.



All things are ready, if our minds be so.
Perish the man whose mind is backward now!

~William Shakespeare, *Henry V*

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