

WRITTEN TESTIMONY OF SARAH CHASIS*
SENIOR ATTORNEY AND DIRECTOR OF OCEAN INITIATIVE
NATURAL RESOURCES DEFENSE COUNCIL

HEARING ON
PLANNING FOR A CHANGING CLIMATE
AND ITS IMPACTS: STATE AND FEDERAL EFFORTS AND NEEDS

BEFORE THE
COMMITTEE ON NATURAL RESOURCES
SUBCOMMITTEE ON WILDLIFE, COASTS, AND OCEANS
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I. Introduction**

Madame Chair and distinguished members of this Subcommittee, thank you for this invitation to testify on what we see as the expected need for Federal and state agencies to ramp up efforts to plan for global warming and its impacts. We believe that an essential element of this planning must be on improving the resilience of our natural systems and their ability to withstand the ongoing and expected impacts of global warming and ocean acidification. My testimony is presented on behalf of NRDC, a national environmental organization with over a million members and online activists, dedicated to the protection of the earth – its people, plants and animals and the natural systems on which all life depends.

Global warming is contributing to higher ocean temperatures, more extreme weather events, and rising sea levels. We are already starting to see its effects. For example, average surface water temperatures have increased about a degree Fahrenheit in the California Current off the west coast (Mendelssohn, 2005), 1.5 to 2 degrees Fahrenheit in the Chesapeake Bay (Austin, 2002) and 3 degrees Fahrenheit in Florida since the 1950s and 1960s (U.S. EPA, 1997). In addition, the higher concentration of CO₂ in the atmosphere is directly altering the chemistry of our oceans, causing the water to become more acidic (Kleypas, et al., 2005). Left unchecked, all of these changes will have a profound impact on coastal and marine ecosystems including:

*Roberta Elias, Ocean Advocate, NRDC and Lisa Suatoni, Ocean Scientist, NRDC helped prepare this testimony.

** This testimony is largely drawn from the guide *Preparing for a Sea Change in Florida: A Strategy to Cope with the Impacts of Global Warming on the State's Coastal and Ocean Systems*, released in May 2008 by the Florida Coastal and Ocean Coalition, of which NRDC is a member. Patty Glick (NWF) was the primary author of the guide. Groups that are part of the Florida Coastal and Ocean coalition, in addition to NRDC, include the National Wildlife Federation, Environmental Defense Fund, Ocean Conservancy, Surfrider, Gulf Restoration Network, Coastal Conservation Association/Sea Turtle Survival League and Reef Relief. The guide can be found at:
http://www.flcoastalandocean.org/Climate_Change_Guide_for_Florida_Preparing_for_a_Sea_Change.pdf.

- *Rising sea levels will increase erosion of beaches, cause saltwater intrusion into water supplies, inundate coastal marshes and other important habitats, and make coastal property more vulnerable to storm surges.*
- *More-extreme weather events, including intense rainfall, floods, droughts, and tropical storms, will alter freshwater flows into estuaries and lagoons, exacerbate polluted runoff and water supply problems, and damage coastal habitats and property. An increase in wave height over the past 50 years has already been measured in the Northeast (Wolf et al., 2002) and the Pacific northwest (Allen et al., 2006)*
- *Higher ocean temperatures will cause extensive coral bleaching, enhance marine diseases, alter species' ranges and population abundances, and stress many fisheries. For example, unusually warm winters have resulted in lobster disease outbreaks in Long Island Sound (Glen and Pugh, 2006) as well as the northward spread of an oyster parasite, referred to as 'dermo', from southern U.S. to areas north of Delaware Bay (Ford and Smolowitz, 2007). This disease has resulted in massive mortalities of the northeastern oysters in recent years.*
- *Changes in local and regional circulation patterns may occur causing changes in productivity. For example, recent changes in the timing and duration of upwelling along the Pacific coast – which are believed to be related to changes in wind patterns from continental warming – have triggered sea bird colony die-offs and dead zones along the west coast of the United States over the past few years (Chan et al., 2008).*
- *Increased ocean acidity will profoundly affect many forms of marine life, particularly those with carbonate shells or other exterior structures, such as tropical and cold water corals. This change in pH will directly affect many organisms at the base of marine food chains as well as organisms that provide critical habitat for other forms of marine life. Increased acidity may also have direct physiological effects on vulnerable juvenile stages of other types of marine organisms, such as fish and squid. Recent research shows corrosive waters are now being upwelled onto the continental shelf off the west coast of the United States due to ocean acidification (Feely et al., 2008). There is significant concern of what impacts this could have on coastal resources and ecosystems.*

While it may seem daunting, state and federal agencies must confront these problems. This work will require concerted efforts on two important fronts: minimizing global warming by reducing greenhouse gas emissions and preparing for related changes, many of which are already underway.

First and foremost, the nation must work to lessen the impact of global warming by reducing the pollution causing it. However, impacts are already occurring and will continue to occur even if emissions are capped (though at less dramatic levels than under a business as usual scenario). Because of this reality and because of the already degraded state of our ocean and coastal resources, federal and state agencies must adjust their management and conservation strategies to maximize resilience and to promote the ability of coastal and marine resources to adapt to ongoing and projected impacts.

There are a number of actions that coastal state and federal agencies can and should take to cope with the significant challenges posed by rising sea levels, more-extreme storm events, higher ocean temperatures, and acidification of ocean waters. Some of the recommended actions are summarized below and discussed in more detail later in this testimony.

Rising Seas

To prepare for sea-level rise, coastal states and the federal government must take steps to implement ecologically and economically sound adaptive policies and strategies that discourage

development in vulnerable areas and support efforts to site structures farther landward of eroding shorelines. This is essential not only to help reduce serious risks to human safety, but also to ensure the preservation of beaches, dunes, and other natural coastal habitats that are so important to coastal economies and quality of life.

Extreme Weather Events

To deal with extreme weather events, such as heavy downpours and droughts, coastal states and federal agencies must emphasize the protection and restoration of shoreline and streamside riparian vegetation and wetlands, upgrade stormwater management to take account of more frequent and heavier rainfall events, and increase water use efficiency and opportunities for beneficial reuse.

Higher Ocean Temperatures

To reduce the impacts of higher ocean temperatures, coastal states and the federal government must work across sectors and agencies to protect and restore coastal and marine ecosystems in order to enhance their ability to withstand the additional stresses accompanying global warming.

Ocean Acidification

To address acidification, coastal states and the federal government must be leaders in efforts to minimize global warming through significant reductions in greenhouse gas emissions, in addition to restoring the health and resilience of marine ecosystems, particularly coral reefs. Because ocean acidification is an emerging issue, directed research and monitoring funds should be made available as soon as possible. Knowledge gained about the effects of ocean acidification at varying carbon dioxide concentrations should be used to inform any carbon cap set by Congress.

By implementing these and the other recommendations, coastal states and the federal government can help ensure that the economic opportunities, ecological benefits, and outdoor traditions that coastal and ocean resources provide will endure for generations to come. Given that the major threats to our oceans and coasts stem from activities pursued on land, along the coasts, and in the water, this shift in perspective will require a legislative directive to all agencies, not just those specifically charged with marine and coastal mandates, to pursue their responsibilities in a manner consistent with the protection, maintenance, and restoration of the health and productivity of coastal and marine ecosystem and resources

Each of these impacts associated with increased atmospheric concentrations of greenhouse gases – sea level rise, extreme weather events, higher ocean temperatures, and increased ocean acidification – is discussed further below as well as state and federal strategies both to minimize these impacts and to improve the ability of natural systems and resources to adapt to related changes in conditions

II. Confronting the Impacts of Sea Level Rise

Global warming is causing sea levels to rise due to a combination of thermal expansion of the oceans and rapidly melting glaciers and ice sheets. The average global (eustatic) sea level rose about 6.7 inches over the 20th century. This was 10-times faster than the average rate of sea-level rise during the preceding 3,000 years (IPCC, 2007). In the coming decades, the rate of sea-level rise is expected to accelerate. The most recent estimates from the 2007 IPCC assessment show an additional 7 to 23 inch rise in global average sea level by the 2090s (IPCC, 2007). However, scientists are becoming increasingly concerned that the rate of global sea-level rise in the coming decades and beyond will be even greater than these projections, as several new studies have determined that the ice sheets of Greenland and parts of Antarctica are melting much more

rapidly than previously estimated (Otto-Bliesner, et al, 2006; Overpeck, et al., 2006; Rignot and Kanagaratnam, 2006). According to Dr. James Hansen, Director of NASA's Goddard Institute for Space Studies, if greenhouse gas emissions continue to increase on a "business-as-usual" trajectory, we could ultimately see a disintegration of the West Antarctica ice sheets. This has the potential to yield "a sea-level rise on the order of 5 meters this century" (Hansen, 2007).

Sea-level rise will increase beach erosion and associated shoreline recession and have a profound impact on beaches, the beach using public, and the tourism industry. Beaches are important economic engines. According to the Department of Commerce, travel and tourism is the Nation's largest employer and the second largest contributor to the gross domestic product – contributing over \$700 billion annually. Beaches are the leading tourist destination (U.S. Dpt. Commerce (NOAA), 2006). Beyond tourism-related revenues and employment, healthy beach/dune systems protect upland property from storm damage. Average damage from hurricanes is \$5.1 billion and 20 deaths per year (U.S. Dpt. Commerce (NOAA), 2006). Finally, beaches provide critical habitat for endangered sea turtles, shorebirds, invertebrates, forage fish, and other species.

Many of the federal and state procedures for planning and assessing conditions for coastal and shoreline development fail to incorporate effects of sea-level rise, global warming, and future development associated with a rapidly growing human population. Now is the time for coastal states and relevant federal agencies to develop a comprehensive strategy to confront sea-level rise in a way that reduces the risks to communities by discouraging building in vulnerable areas, and increase the resiliency and protection of coastal habitats by a) steering away from structural armoring of shorelines; b) avoiding beach re-nourishment projects where especially harmful for ecosystems; and c) restoring and protecting natural buffers.

Many coastal management and coastal development policies currently do not pro-actively take sea-level rise into consideration. Worse yet, the government continues to subsidize high risk coastal development. Defying long term planning needs in the face of global warming by allowing and encouraging high risk development is a serious mistake in terms of the economy, the health of natural systems and resources, and human safety.

Similarly, many federal agencies have thus far failed to incorporate effects of accelerating sea-level rise and reasonably foreseeable effects of global warming into their procedures, such as incorporating likely future conditions into mapping of floodplains, storm surge zones, or flood elevations affected by increasing impervious development in watersheds in the Federal Emergency Management Agency's (FEMA) National Flood Insurance Program (NFIP) and the planning of flood damage reduction projects by the Army Corps of Engineers (ACE). Current procedures are based almost entirely on looking backwards at past records only, rather than incorporating current climate science.

States and the federal government must take steps to implement ecologically and economically sound adaptation policies and strategies that discourage development in vulnerable areas and support efforts to site structures farther landward of eroding shorelines. This is essential not only to help reduce serious risks to human safety and the well-being of communities, but also to ensure the preservation of beaches, dunes, and other natural coastal habitats that are so important to our economy and quality of life.

Examples of State actions to deal with rising seas:

- *The states should consider sea-level rise in their plans for land use, open space, wetland protection, public infrastructure siting and maintenance, and other relevant activities.*

- *The states should assess, restrict, and/or reduce state funding, tax breaks, and other incentives for private development in coastal areas at high risk from erosion and storm surges.*
- *States should consider the adequacy of existing coastal setbacks and post-storm redevelopment policies in light of projected sea-level rise scenarios and develop, assess, and implement a suite of planning tools and global warming adaptation strategies to maximize opportunities to protect the beach/dune system, coastal wetlands, and other coastal resources in an era of rising seas. These tools should include strategies to encourage the landward siting and relocation of structures and public facilities in areas adjacent to receding shorelines through acquisition, transfer of development rights, stronger setbacks, and tax incentives.*
- *States should develop wetland conservation and restoration plans that promote designation of wetland migration corridors for wetland migration as sea levels rise, thereby protecting the valuable benefits they provide by buffering coasts against storms and erosion, improving water quality, and supporting fish and wildlife.*
- *Incentives should be provided to local governments and private organizations to acquire and manage ecologically important coastal lands, including upland buffers in vulnerable areas. Acquisition efforts should be strategically targeted in order to protect coastal resources, reduce insured risk, and reduce the impacts of global warming on both ecosystems and communities.*

Examples of Federal actions to deal with rising seas:

- *Congress should amend the Coastal Zone Management Act (CZMA) to require relevant state agencies to consider sea-level rise in coastal management programs in order to qualify for federal funding assistance.*
- *Congress should establish policies to restrict federal flood insurance (via NFIP) for new construction and rebuilding in high hazard coastal areas.*
- *Congress should also provide increased funding and technical support for hazard mitigation by states, communities, and building owners through floodplain management; establishment of greenways, open space, and building setbacks; and use of voluntary buyouts and relocations of high risk properties, higher building elevations, flood proofing, and other techniques.*
- *Congress should replace economic incentives for private development in high risk coastal areas with incentives to relocate and build in other areas and invest in coastal land conservation, such as by allowing tax exempt financing for acquisition of properties in hazard areas.*
- *Congress should resist efforts to exempt areas or roll back protections for coastal barriers that are included in Coastal Barrier Resources Act (CBRA). Coastal barriers designated under the act are ineligible for direct or indirect federal financial assistance that might support development.*

III. Confronting the Impacts of Severe Weather

Global warming is disrupting the planet's climate system, causing widespread changes in regional temperatures, precipitation, and wind patterns (IPCC 2007). In particular, these changes are manifesting themselves as an increase in the frequency and intensity of "extreme" weather events like heat waves, droughts, floods, and severe storms. According to the IPCC, since 1950, the number of heat waves has increased around the world, as has the extent of regions affected by droughts due to warmer conditions and increased evaporation (IPCC 2007). Global warming is also contributing to an increase in the frequency and number of very heavy precipitation events

and flooding in many areas, a trend that is attributed to higher levels of moisture in the atmosphere (Diffenbaugh, 2005; Groisman, 2004; Trenberth 2003). Several studies have also found a correlation between warmer average ocean temperatures associated with global warming and an increase in the intensity of tropical storms and hurricanes (Trenberth, 2007; Webster, et al., 2005; Emanuel, 2005).

Based on this evidence, a number of scientists believe that the trend toward more-intense storms will continue in the coming decades as our oceans warm further (Trenberth, 2007; Oouchi, et al., 2006; Knutson and Tuleya, 2004; Walsh, Nguyen, and McGregor, 2004). However, there are many factors that contribute to both the frequency and intensity of hurricanes, and some uncertainty remains about how these storms will be affected by global warming in the future (Pielke, et al., 2005). Regardless of whether or not global warming will have a direct impact on hurricane frequency and intensity, there is little question that these storms will become more destructive in the future due to a combination of increased coastal development as well as higher storm surges exacerbated by sea-level rise (Anthes, et al., 2006).

A general trend toward heavier rainfall events (whether or not associated with tropical storms) will likely contribute to a decline in coastal water quality due to enhanced stormwater runoff. This is a problem that has already been exacerbated by the destruction of wetlands, forests, and other natural buffers (which help store water and trap pollutants and sediments) and expansion of impervious surfaces associated with urban development and roads.

One of the potential impacts of additional precipitation, resulting in additional runoff, is an increase in the duration and/or extent of coastal hypoxia and anoxia events caused by eutrophication (excess nitrogen and other nutrients in coastal waters from sources such as agricultural fertilizers, sewage discharges, and septic tanks) (Justic, Rabalais, and Turner, 2003). This nutrient loading leads to excessive algae growth that contributes to a depletion of oxygen in affected waters, a condition called hypoxia. Similarly, anoxia is a condition in which all oxygen is depleted, which can lead to “dead zones” – areas in which most marine organisms cannot survive (Joyce, 2000).

While neither hypoxia nor anoxia are new phenomena, their prevalence has become much more widespread in recent decades, which scientists attribute in part to heavier precipitation flushes triggered by global warming, causing increased nutrient runoff (Boesch, 2007; Dybas, 2005; Kennedy, et al., 2002). In addition to eutrophication, heavy runoff exacerbates hypoxic and anoxic conditions by decreasing water mixing in estuaries, as less dense fresher water rides over the top of the denser saltier water, inhibiting the replenishment of oxygen to deep waters.

Examples of State actions to deal with the impacts of more severe weather:

- *Coastal states should upgrade stormwater regulations, taking the likelihood of more frequent heavy rainfall events into consideration. Emphasis should be placed on natural buffers and requiring adequate long-term capacity and infrastructure for stormwater and sewage. Policies should also focus on implementing Low Impact Development (LID) methods, both for new developments and retrofits in existing developed areas.*
- *States should enhance protection and restoration of wetlands and riparian floodplains to help remove nutrients and reduce eutrophication, hypoxia, and anoxia.*
- *State water managers should: move away from relying on historic trends to determine future water availability; place significantly greater emphasis on reducing demand (for instance by increasing efficiency in water delivery and water use); and fund strategies to make better use of reclaimed water (for instance through decentralized LID approaches).*

Examples of Federal actions to address the impacts of more severe weather:

- *Congress should require all federal resource-related agencies to incorporate modern climate and sea-level rise projections into their resource planning procedures and programs.*
- *To reduce eutrophication (and other pollution) associated with heavier rainfall events and runoff, U.S. EPA should revise its stormwater management rules under the Clean Water Act to discourage development in or near coastal and stream riparian buffers, wetlands, and other sensitive areas.*
- *States should be encouraged to develop and implement long-term regional water management plans that incorporate global warming and take a more coordinated approach to water management, including water conservation and reuse, in order to meet the needs of people and the fish and wildlife they depend on for food, jobs, and recreation.*

III. Confronting the Impacts of Higher Ocean Water Temperatures

Average sea surface temperatures have increased over the latter half of the 20th century, providing another important indication of global warming (IPCC 2007; AchutaRao, et al., 2007). On average, the temperature of the upper 300 meters of the world's oceans has risen about 0.56 degrees Fahrenheit since the 1950s, a trend that scientists have determined is a direct result of human activities (NOAA, 2000; Santer, et al., 2006). The increase has been even greater in the tropical Atlantic region, where the average sea surface temperature has risen 1 degree Fahrenheit over the past three decades (Barnett, Pierce, and Schnur, 2001).

If global warming pollution continues unabated, average ocean temperatures are projected to rise by an additional 2.7 to 5.4 degrees Fahrenheit before the end of the century, with potentially devastating consequences for coastal and marine ecosystems (IPCC 2007). The primary impacts of rising sea-surface temperatures include coral bleaching, exacerbation of marine diseases, and significant shifts in the ranges and population abundances of fish and other marine species.

Lessening the impacts of higher ocean temperatures due to global warming will require strategies that increase the overall resilience of ecosystems. It will be necessary to reduce the negative impacts of a broad range of human-induced stressors on coastal and marine ecosystems in an effort to help these systems resist and/or recover from disturbances such as coral bleaching, disease outbreaks, or anoxia events (Grimsditch and Salm, 2005). Placing significantly greater emphasis on habitat protection and ecosystem-based management (EBM) approaches to managing fisheries, coral reefs, and other coastal and ocean resources will improve the likelihood that these systems and resources will be able to withstand the multitude of stressors affecting them, including global warming and ocean acidification.

This shift in management will require a broad directive to federal agencies and encouragement to state agencies to pursue their responsibilities, whether pursued under marine or non-marine mandates, in a manner consistent with the protection, maintenance, and restoration of the health and function of marine and coastal ecosystems and resources. In terms of activities pursued under marine and conservation related mandates, fish and wildlife managers and other relevant decision makers should focus on protecting the diversity of species across their spatial range, as well as protecting and restoring the habitat they depend upon (Worm, 2006; Nyström and Folke, 2001). For example, a focus on diversity would lead fish and wildlife managers to protect and restore algae-grazing fish and invertebrates known to limit the overgrowth of harmful, opportunistic algae on coral reefs, as a way of improving overall coral resilience (Nyström, Folke, and Moberg, 2000).

Examples of State actions to address the impacts of warmer ocean waters:

- *States should adopt and implement policies directed to the protection, maintenance and restoration of healthy coastal and ocean ecosystems and resources.*
- *States should strengthen programs that support biological diversity among fish and wildlife species.*
- *States should prioritize the rebuilding of depleted coastal and ocean fish populations since depleted populations will have a harder time dealing with additional stresses posed by global warming and warming waters.*
- *States with coral reefs should expand research and monitoring of coral reef ecosystems, including ongoing assessments of factors such as water temperatures and coral bleaching, incidence and range of coral diseases, damage and recovery from storms, and assessment of water quality, including the calcium carbonate saturation state and its effects on reefs over time.*

Examples of Federal actions to address the impacts of warmer ocean waters:

- *Congress should enact climate adaptation legislation to direct Federal and state agencies to develop and implement strategies to maintain and improve the resilience of our natural ecosystems and should provide the scale and consistency of funding to make these efforts successful. If these provisions are included in a package that also establishes a cap and trade system, a portion of the revenues from the auction of carbon allowances should be directed specifically to federal and state adaptation activities. This funding should supplement rather than replace existing agency funding streams and should be isolated from revenue pots that may go to other adaptation activities, including protecting infrastructure. Recent Senate proposals -- including America's Climate Security Act (S 2191) and the Lieberman-Warner Climate Security Act (S 3036) -- contained this type of system. S 2191 would have provided an estimated \$300 to \$950 million in new funding to the Department of Commerce for ocean and coastal management, protection, and restoration in the first year of the program (2012). S 3036 would have provided an estimated \$574 million per year from 2012 to 2030 to the Department of Commerce for this same suite of activities. This scale of additional funding will be necessary in order to address the ongoing and expected, additional strains that global warming and ocean acidification place on our ocean and coastal ecosystems and natural resources.*
- *Adaptation strategies, funded by this new revenue stream, should be coordinated at the federal level through the development and implementation of a Presidential plan and at the state level through the development and implementation of a governor level plan. Plans should be developed with input from all relevant federal/state agencies, scientists (possibly including a science advisory board established by the legislation), and the public. State level plans should be consistent with the national strategy and should receive federal approval, according to set criteria, in order to receive federal funds.*
- *Congress should enact Oceans-21, H.R. 21, which sets out a national policy to protect, maintain and restore marine ecosystem health and calls on the federal government and federal/state partnerships to implement that policy. The healthier ocean and coastal ecosystems are, the better able they will be to withstand the additional stresses associated with global warming and ocean acidification.*
- *NOAA should move expeditiously and effectively to implement the Magnuson-Stevens Reauthorization Act of 2006 in order to meet the deadline for ending overfishing and rebuilding healthy fish populations. The healthier fish populations are, the better able they are to withstand the impacts of global warming and ocean acidification.*

- *Congress should call for and support a National Academy of Sciences study, looking at the implications of global warming and ocean acidification on fisheries management. The study should evaluate management methodologies to mitigate impacts of global warming and ocean acidification on the nation's fisheries resources. Following guidelines recommended in the study, the National Oceanic and Atmospheric Administration (NOAA) should develop specific regional adaptation strategies to enhance adaptive capacity.*

IV. Confronting the Impacts of Ocean Acidification

Since the beginning of the industrial age, the world's oceans have absorbed 530 billion tons of CO₂, or at least one third of the anthropogenic CO₂ (Brewer, 2007; Feely, 2004). This has already reduced the pH of ocean waters by .1 units or, in other words, has increased overall acidity by 30%. This pH change has occurred as a result of CO₂ pumped into the atmosphere mixing with ocean waters to form carbonic acid. Under a business as usual scenario, pH will drop by an additional .3 to .4 pH units (Caldeira and Wickett 2005, Orr et al. 2005). This degree of change has not occurred in the past 20 million years (Feely, 2004).

This lower pH is eroding the basic mineral building blocks for the shells and skeletons of calcareous organisms such as shellfish and corals, as well as a number of important microorganisms that are a foundation for marine food webs (Kuffner and Tihansky, 2008; Orr, et al., 2005). For corals, lower calcification rates ultimately mean weaker, slower-growing reefs (Kleypas, Buddemeier, and Gattuso, 2001). The combination of warmer and more acidic waters means that coral ecosystems are among the most threatened marine/coastal habitats now in the world (Hoegh-Guldberg, 2007). Increased acidity may also have direct physiological effects on vulnerable juvenile stages of other types of marine organisms, such as fish and squid (Portner, 2004).

Examples of State actions to address the impacts of ocean acidification:

- *Coastal States should do their part in adopting a stringent CO₂ reduction goal*
- *States should enhance monitoring of coral reefs, oyster reefs, and valuable shellfish such as scallops for calcification problems.*

Examples of Federal actions to address the impacts of ocean acidification:

- *Congress and the administration must place mandatory limits on CO₂.*
- *Federal agencies should invest in studies to better understand the ecological impacts of ocean acidification, both to inform the establishment of an appropriate carbon cap and adaptation strategies.*
- *Congress should enact climate adaptation legislation and Oceans-21, as articulated above.*

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