Climate Change Issue Profile: SEA LEVEL RISE

Climate Change and Sea Level Rise:
What can marine protected areas do to lessen impacts?

Introduction

Rising sea levels accompanied by strong storm surges put coastal communities at risk (credit: NOAA National Weather Service Forecast Office – Tallahassee, FL)

Sea level rise is a major climate change impact that is already being experienced in parts of the United States, including many marine protected areas (MPAs) along the coast. MPAs can play an important role in addressing the impacts of climate change and building community resilience. As special places with long term protection, many MPAs provide the infrastructure to focus research and monitoring efforts of climate trends, provide protection against non-climate stressors, and effectively engage the community through public education programs, advisory groups, and onsite staff. Familiar examples of MPAs include national parks, national wildlife refuges, national marine sanctuaries, national estuarine research reserves, and state or tribal fish and wildlife areas. While MPAs have legal authority to provide lasting protection and minimize some local disturbances (e.g., fishing, bottom disturbance, vessel discharge, and development), they remain vulnerable to large scale disturbances originating outside their boundaries, particularly those associated with climate change (e.g., sea level rise, warming sea surface temperature, ocean acidification, magnitude and frequency of storms, storm surge).

In areas where there is a high confidence that sea level rise will occur and the impacts will be significant, many MPAs are taking proactive actions in order to lessen future impacts of rising seas and storm surges that reach further inland. Responding to rising seas can take three different approaches: (1) Non-Intervention (e.g., letting nature take its course); (2) Persistence (e.g., resisting change through actions); or (3) Directed Transformation (e.g., assessing vulnerability and take appropriate actions where necessary). A combination of actions presented here (persistence and directed transformation) are examples of the types of management actions other MPAs facing similar challenges may wish to consider.

What do we mean by "sea level"?

Sea level is generally referred to as Mean Sea Level (MSL), an average of the ocean level from which heights such as elevations may be measured. A common and straightforward MSL standard is the midpoint between mean low and mean high tide at a particular location. MSL is measured in relation to a known elevation (i.e., datum) on the land. Hence a change in MSL can result from a real change in sea level (referred to as "absolute" sea level change) or from a change in the height of the land on which the tide gauge operates (referred to as "relative" sea level change).

How is sea level measured?

Tide gauges (Figure 1) have measured sea level relative to a known elevation of the local land surface (e.g., vertical datum) for over a century. Assessing tide-gauge data can be complicated because the local land surface from which sea level is measured does not maintain constant elevation due to factors such as subsidence and erosion. Beach erosion, wetland loss and other coastal problems may be attributed to rising sea levels when they are in fact caused by human activities such as construction of jetties that interfere with the normal movement of sand along the shoreline. Because of the difficulty of assessing an actual rise in sea level versus a change in land elevation, sea level is measured against satellite altimetry (highly accurate radar measurements) as well.

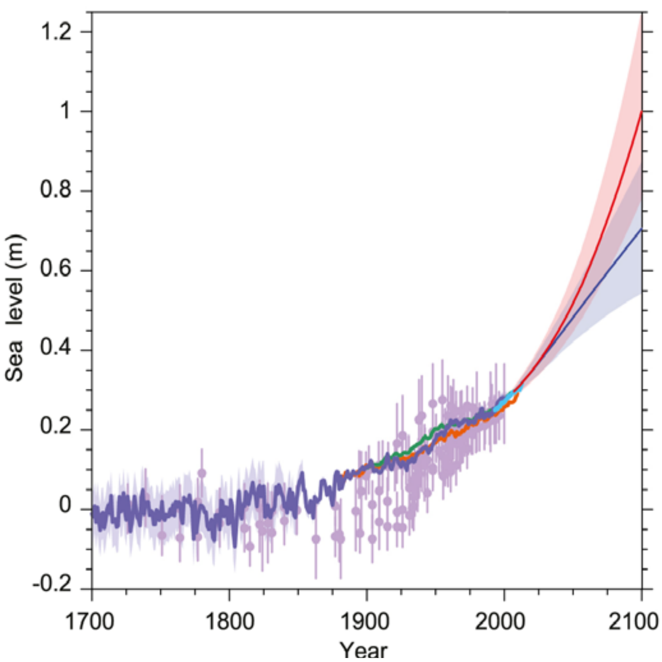
What can cause sea level to rise?

Figure 1. Tide gauge station (credit: NOAA Climate Observation Program)

The two main factors that can cause sea level to rise are (1) thermal expansion of ocean water due to increased sea surface temperature; and (2) input of water from the land such as ice caps in the southern hemisphere, melting glaciers, and water retained in rivers, aquifers, and lakes. Based on an analysis of aerial photographs over the past century, the National Snow and Ice Data Center has concluded that with very few exceptions, glaciers around the world have been shrinking at unprecedented rates. This potentially adds a significant amount of additional water to the ocean (https://nsidc.org/cryosphere/glaciers/questions/climate.html).

What changes have we seen in sea level?

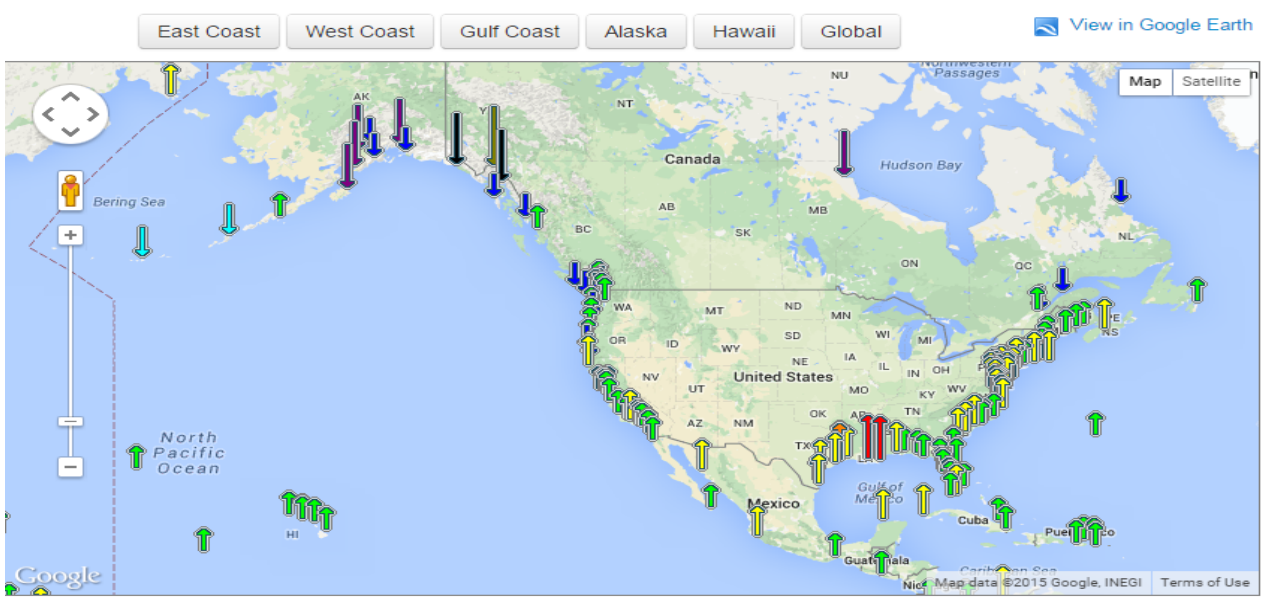
Tide gauges show that global sea level has risen about 7 inches during the 20th century (Figure 2), and recent satellite data show that the rate of sea level rise is accelerating. The NOAA Climate Program Office has a very high confidence (greater than 9 in 10 chances) that global mean sea level (based on mean sea level in 1992) will rise at least another 8 inches (0.2 meters) or more by 2100. Rates of sea level rise vary by location. Sea levels have been rising up to 2 feet per century along the east coast, and as high as 3-4 feet per century along the Gulf of Mexico (Figure 3). A 2012 study undertaken by the Virginia Institute of Marine Science predicts that waters around Norfolk, Virginia, will rise higher, approximately 2 feet (0.62 meters) compared to Charleston, South Carolina, for instance, where sea



Changes in sea level, past and projected in the future
(credit: Intergovernmental Panel on Climate Change 2013)

level is predicted to rise only about a half a foot (0.15 meters). The Chesapeake Bay area is experiencing both absolute (rising water) and relative (sinking land) sea level changes. Not all areas are experiencing sea level rise. Southeast Alaska, for instance, is experiencing lower sea levels than the changes being measured elsewhere around the United States (Figure 3). The Alaska Center for Climate Assessment and Policy (https://accap.uaf.edu/) has described instances where "absolute" sea level may be rising from nearby melting glaciers and other freshwater input but this is not greater than "relative" sea level due to the fact that plate tectonics is causing the underlying land to rise even faster. In Alaska, geologic processes seem to be outstripping sea level rise.

Sea Level Trends



The map above illustrates regional trends in sea level, with arrows representing the direction and magnitude of change. Click on an arrow to access additional information about that station.

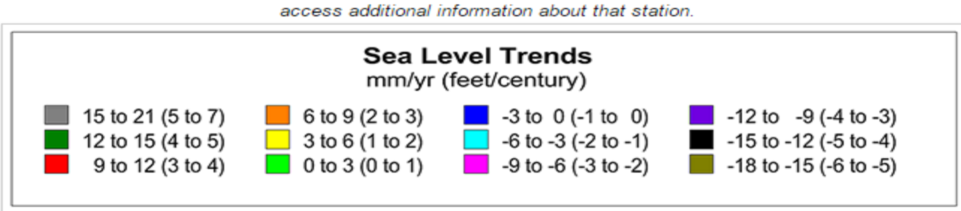


Figure 3. Sea level trends indicating rise or fall and the magnitude of the observed change (credit: NOAA Center for Operational Oceanographic Products and Services)

What are some of the predicted impacts of a rise in sea level?

Figure 4. Coastal road destroyed by overwash. (credit: Amanda Babson and Courtney Schupp, National Park Service)

Sea level rise poses significant risks to valuable infrastructure, development, and wetlands. Submergence and increased coastal flooding along coastal areas (Figure 4) along with saltwater intrusion into surface and groundwater, such as that occurring along the densely populated Florida coast, are evident now. In 2014, NOAA's Office of the Chief Administrative Officer assessed the agency's mission-critical properties and concluded that several along the eastern seaboard are vulnerable and at high-risk. A recent National Park Service report (Peek et al. 2015) identified $40 billion in infrastructure (e.g., buildings, roads, and docks) will be exposed to impacts associated with a 3.2 foot (1 meter) rise in sea level. Some ecological impacts include coastal erosion, with subsequent loss of nesting sea turtle and bird areas (Figure 5), and changes in intertidal areas and inundation of islands and coastal wetlands such as mangroves and saltmarshes. The species that depend upon these ecologically important areas could change and/or disappear. The Florida Climate Institute at the University of Central Florida is assessing how sea level rise in the intertidal zone will increase the time these organisms are fully submerged underwater, leading to an increase in subtidal predators of intertidal oysters and increased competition for space with other invertebrates (http://ucf.floridaclimateinstitute.org/).

What are MPAs doing to reduce projected sea level impacts?

Figure 5. Beach erosion exposes loggerhead sea turtle eggs in a nest at Cape Romain National Wildlife Refuge in South Carolina. (credit: Billy Shaw and U.S. Fish and Wildlife Service, National Wildlife Refuge System)

MPAs around the country are assessing the vulnerability of ocean resources under their purview and developing strategies to plan for and respond to predicted climate change impacts. Many MPAs have begun an effort to integrate adaptation planning, monitoring, mitigation, and climate change education into their management. The Greater Farallones National Marine Sanctuary, for example, along with many of its partners, recently assessed the vulnerability of its marine resources to projected climate change impacts. This assessment will enable managers to respond to, plan, and manage for the projected impacts of climate change to habitats, species, and ecosystem services within the north-central California coast and adjacent Pacific Ocean (http://ecoadapt.org/data/documents/GFNMS_ProjectDescription_updated_6.9.2015.pdf). Other MPAs have also begun to assess their vulnerability and have implemented proactive actions to increase the resilience of their areas to sea level rise.

Examples of MPA Actions:

- To combat loss of marshlands from land subsidence and sea level rise, Blackwater National Wildlife Refuge on Maryland's Eastern Shore has collaborated with the U.S. Army Corps of Engineers to use dredged material obtained from a channel in Chesapeake Bay to spray over open water areas (Figure 6) and raise the level of the marsh, adding resilience against inundation from rising sea levels. The dredged material is stabilized by planting native marsh grasses and plants. A similar project is underway at the Jamaica Bay Unit of Gateway National Recreation Area, National Park Service (New York). (https://www.fbo.gov/index?s=opportunity&mode=form&id=28f1c5dbb8b2989904d40423737abb30&tab=core&_cview=0)

Figure 6. Spraying of dredge spoil to raise elevation of marsh. (Credit: U.S. Army Corps of Engineers)

- In a project to be implemented in late 2015, along the coast of Orange County, California, just east of the busy global shipping facilities at the Port of Los Angeles, Seal Beach National Wildlife Refuge is implementing the "Thin Layer Salt Marsh Augmentation Pilot Project" that will spray 10-12 inches of sediment from a nearby dredging operation over an experimental plot in the marsh. This method for enhancing marshlands has been successful elsewhere, but has not been tested in this area on these marsh grass species (e.g., Cordgrass). http://scc.ca.gov/webmaster/ftp/pdf/sccbb/2014/1410/20141002Board11_Seal_Beach_Sediment_Augmentation.pdf
- With rising sea levels come higher storm surges, increased flooding and erosion of beaches. Alligator River National Wildlife Refuge between Albemarle and Pamlico Sounds in eastern North Carolina has built nearshore oyster reefs to dissipate wave energy from rising sea-levels and storm surge, adding resilience to the refuge's shorelines. Successes/challenges of the project are described at http://www.coastalwildliferefuge.com/pr/pr052410.pdf.
- Assateague Island National Seashore (Maryland and Virginia) is a long barrier island and is very susceptible to sea level rise and storm surge. The NPS has relocated parking lots away from the coast, replaced asphalt with native materials like clay and shells (increasing permeability of water and replacement costs), and elevated infrastructure like the Virginia Visitors Center to lessen its susceptibility to tidal inundation. Some of the focus areas to increase resilience are described at http://www.nps.gov/articles/assateaguelandscape.htm.
- San Francisco Bay National Estuarine Research Reserve (NERR) worked with a diverse team to identify impacts of sea level rise, increased storm surge, and salinity change in the San Francisco Bay. Building on previous efforts along the outer California coast, the "Our Coasts Our Future" project developed decision support tools and data, and provided the technical assistance needed by Bay Area officials working to create restoration and management plans that protect shorelines, property, and infrastructure. More information can be found at: http://www8.nos.noaa.gov/reserves/Doc/PDF/Science/higgason_pr_spr_2014.pdf.

- The ACE Basin NERR (South Carolina) is creating oyster reef-based living shorelines to reduce coastal erosion, build community resiliency, improve water quality, and protect coastal habitats from sea level rise and storm surge impacts. Volunteers are helping prioritize needs, construct the reefs, and monitor the impact. (http://www.nerrs.noaa.gov/Doc/PDF/Science/leffler_overview.pdf)
- In Canaveral National Seashore (Florida), volunteers are constructing a living shoreline by planting native vegetation and restoring oyster reefs to protect Native American shell midden sites from further shoreline erosion. (http://www.nps.gov/seac/tnk/Cana%20B-4%20Final%20%28Front%29-HQ.pdf)
- At the request of the mayor of Homer, Alaska, and other local community leaders, the Kachemack Bay NERR is studying the relationship between coastal uplift and sea level rise for the Kachemack Bay. The study is documenting the rate of biological changes that result from sea level rise, reduced glacial melt water, and coastal uplift and the potential impact to the town of Homer. (http://nerrs.noaa.gov/Doc/PDF/Science/nsc_kachemak.pdf)
- Since 2008 the Hudson River NERR (New York) has helped local stakeholders understand the economic and environmental tradeoffs associated with the different approaches to managing shoreline change. The findings from the economic and environmental tradeoff research are being used to make decisions about community waterfronts, regulatory and land use policies, shore line development, and long-term planning.

Suggested Further Reading

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