Alaska & Pacific West Regions
Pacific Ocean Education Team

National Park Service
U.S. Department of the Interior

Pacific Ocean Newsletter

Sea Level Rise and Coastal Parks

Rachael Carson's book "The Sea Around Us" was a call to action for ocean conservation, but the title of her book is a metaphor for what is unfolding today on global climate change. For coastal environments, one of the largest challenges is linked to sea level rise (SLR), the effects of which are magnified by potential increases in storm frequency and intensity, erosion, and flooding. The physics of SLR includes two primary processes: thermal expansion of warming ocean waters and water mass added to the oceans from melted glaciers, particularly from Antarctica and Greenland. SLR is occurring *now* and being measured throughout the Pacific. At Golden Gate NRA located at the mouth of San Francisco Bay, one of the oldest tidal gauges in the US (established in 1854), measured an 8 inch rise in SLR per 100 years. The rise of water along the coast is more than simple inundation, called the "bathtub model", but instead, is a complicated interaction of several factors such as vertical land movement, wave-driven processes, and storm surge. The ocean is not level but instead is full of subtle mountains and valleys formed by prevailing wind patterns, oceanic currents, density variability, gravitational differences and tectonics. Globally, Figure 1 depicts a mosaic of sea level changes between 1993-2008. Planning for the potential effects at the scale of a park, though, requires understanding how global SLR is translated into storm events when waves, tides and runoff combine into extreme coastal conditions. These extreme events are when park coastal resources are most at risk.

El Niño events provide insights into potential damages to park resources. During the 1998 El Niño, infrastructure including parking lots, docks and roads were damaged in several coastal parks; wildlife habitat where species rest, feed, and breed was inaccessible or washed away, including Critical Habitat for federally listed species such as western snowy plovers; cliffs and dunes were scoured and had to be stabilized at many coastal parks; rare fossils were uncovered by erosion; and wetlands were inundated and altered.

Furthermore, changes in coastal geomorphology in estuaries may provide enhanced opportunities for the spread of invasive, non-native aquatic species and discharge of pollutants. Changes in shoreline will also affect tens of thousands of seabirds and pinnipeds that depend on the intertidal and supratidal areas for breeding and resting habitat in the parks; although

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Fun with Coral Reefs and Climate Change Education

Design a reef!
Identify that coral!
Learn from a Samoan chief!
Teach your friends how cars kill fish?

Games, animations, videos and colorful graphics make learning fun for students while also connecting them to Hawaiian, Samoan, and Chamorro (Guam) cultures. All of this and more can be found on a multifaceted coral reef and climate change web-based program including teacher-tested curriculum materials that meet educational standards. The program highlights coral reefs in a changing climate and, specifically, the coral reef resources of Pacific island national parks.

Content for this dynamic educational program was developed by the University of Maryland Center for Environmental Science (UMCES) working closely with island teachers, NPS marine scientists, and the Pacific Island Network Inventory and Monitoring Program (PACN). Students use coral reef photos and follow coral reef monitoring procedures similar to actual PACN methods to learn how the health of reefs is tracked. The program is highlighted by a geographically appropriate reef food web game, animations of climate change, a coral identification game, an interactive land-sea connection activity, and much more. Traditional ecological knowledge forms an important part of the message through the telling of island legends, videos, and a personal account of changes to the reefs by a local chief.

An important part of the project is week-long teacher workshops in Hawaii (2011), on Guam (2012), and in American Samoa (2013) conducted by UMCES education experts to instruct teachers about coral reefs in a changing climate, and to provide guidance on using the curriculum materials in the classroom. The program is accessible on the Teach Ocean Science website (http://www.teachoceanscience.net/teaching_resources/education_modules/coral_reefs_and_climate_change/get_started/), on CD by request from corbett_nash@nps.gov, or printed for classrooms lacking computers and internet access.

Visit the website and have some coral reef fun yourself!

Students and teachers in Guam taking part in training conducted by University of Maryland, Center for Environmental Science in partnership with the NPS.

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beneficial opportunities may also arise with created habitat. Current trends in sea level and storm intensity/frequency suggest that the vulnerability of resources on the US West Coast will increase dramatically in the coming decades. Yet, there is currently no comprehensive, physics-based approach for making vulnerability assessments in this region.

The United States Geological Survey (USGS), in partnership with the NPS, and other agencies and institutions have developed a sophisticated, process-based numerical modeling system for predicting the impact of severe winter storms due to climate change, known as CoSMoS (Coastal Storm Modeling System). USGS is a leader in the development of modeling systems for forecasting the impact of SLR and has developed models in several locations in the Pacific. The modeling system utilizes the latest Global Climate Models (GCMs) to drive global wave and tide models linked with local physical process models (i.e., wave, water level, sediment transport, and morphological change) of the coastline to make highly detailed predictions of local susceptibility to flooding, inundation, beach erosion, and cliff failure during powerful storm events. Spatial data required to run the models include LiDAR coastal data, high resolution bathymetry and topography. These data were not part of the initial inventory of resources under the NPS Inventory and Monitoring Program; however, some data layers are now being acquired along coastal parks such as War in the Pacific NHP, Channel Islands NP and Golden Gate NRA.

USGS focuses on future plausible severe winter-storm scenarios but also tests the models by modeling coastal-hazard hindcasts of past historical winter storms. The coastal-hazards model design simulates the impact of storms under various sea level rise and climate-change scenarios. The objective of the modeling system is to provide the most scientifically robust information for managers to identify coastal areas at risk and plan in advance to protect sections of coast that may be vulnerable to severe storms.

USGS has developed separate models for southern and north-central California coastal areas to face the challenges from sea level rise, and changes in storm frequency and intensity. To prepare for these impacts, coastal managers need regional scaled tools so that they can understand how future changes will affect local shorelines, ecosystems, and infrastructure. For north-central California for example, a collaboration between the Gulf of the Farallones National Marine Sanctuary, PRBO Conservation Science, USGS and the National Park Service is producing; 1) maps of infrastructure and ecosystem vulnerabilities to sea level rise and storm hazards at the scale needed for management action, 2) an online, user-driven, science-based decision support tool with interactive maps to apply to adaptation, restoration, and management strategies, and 3) training for managers on the use of the decision support tool and maps (Figure 2 on back page). Similar regional modeling efforts to understand, visualize, and anticipate local coastal climate change impacts have been developed for southern California and are also planned for the Hawaiian Islands.

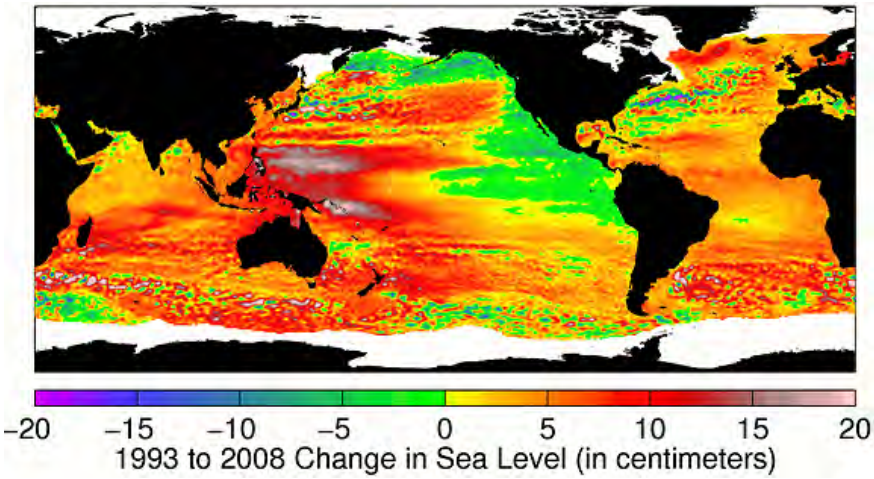

Figure 1. Global change in sea level, 1993 - 2008. Image submitted by Keith Cowing to website http://onorbit.com/node/1946 and downloaded on 7-25-12.

Climate Change Exhibits From Sea to Rising Sea

Many parks are already experiencing the impacts of climate change, and none more so than our coastal parks. As sea level rises or as we experience other changes along the coast, parks continually seek new and innovative ways to interpret this for our visitors. The NPS Climate Change Response Program, Harpers Ferry Design Center, and representatives from 10 parks met in early July for a climate change wayside kick-off meeting. Over the next year this group will develop a series of exhibits that address the climate change impacts to the natural and cultural resources in these parks as well as to the visitor experience. These waysides will be grounded in each park's unique context but will utilize new technology like quick response (QR) codes to connect them to each other. These collaborative exhibits will allow our visitors learning about melting glaciers in Kenai Fjords National Park in Alaska to scan the QR code and discover how this change is affecting sea level rise in Everglades National Park in Florida 5,000 miles away. This year's exhibits focus on parks impacted by sea level rise, while a series of exhibits developed next year will bridge parks that are conducting phenology programs.

Great egret in Everglades National Park.

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The National Park Service cares for the special places saved by the American people so that all may experience our heritage.

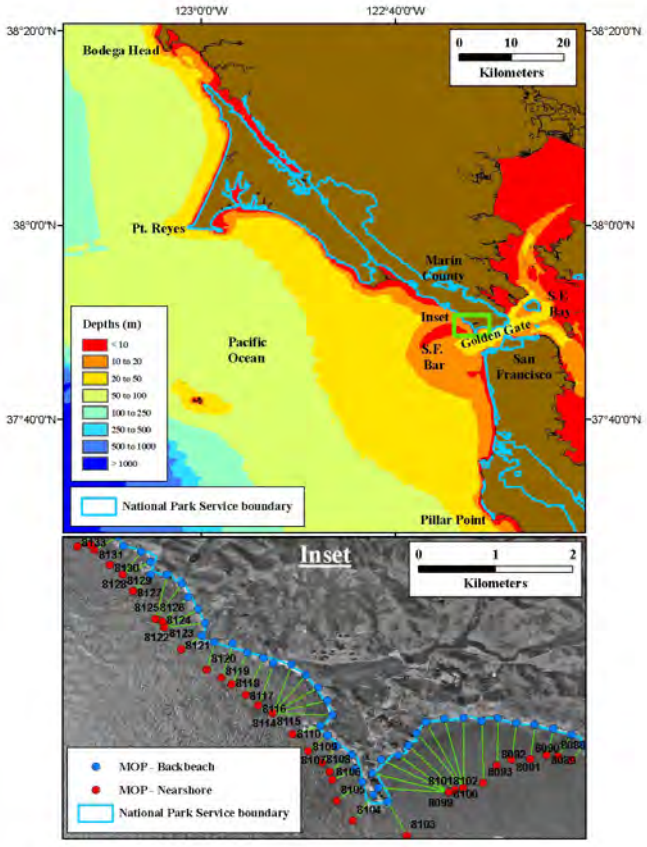

Figure 2. Coastline and bathymetry for north-central California that includes GOGA and PORE. The inset shows an example from the Point Bonita region of the MOnitoring and Prediction (MOP) points that have already been established for the entire study area to serve as a basis for local models. The majority of this shoreline is within the jurisdiction of the National Park Service.