Greater Farallones National Marine Sanctuary

Climate Impacts to Intertidal and Subtidal Habitats

Management Issue

Climate change continues to pose a serious threat to the health and resilience of coastal rocky habitats along the California coast. Extreme heat events are expected to increase, which leads to increased mass mortality events. Extreme precipitation events are expected to cause greater fluctuations in salinity. Decreased pH may impede the ability of calcifying organisms to build calcium carbonate shells, resulting in the dissolution of existing shells. Increased storm activity suggests that intertidal organisms will experience more frequent and more intense physical forces due to wave action, i.e. increased "storminess." Climate change has caused carbon dioxide (CO_2) levels and acidification of the ocean's waters to increase at an alarming rate, posing a serious threat to the health of ocean ecosystems. Oil pollution and physical impacts, such as anchoring will compound the impacts from climate change. In order to develop adaptive management actions that will help reduce the severity of impacts from climate change to the rocky intertidal and subtidal habitats of Greater Farallones National Marine Sanctuary (GFNMS or sanctuary) and the northern portion of Monterey Bay National Marine Sanctuary (sanctuary), data from existing long-term monitoring programs must be analyzed with respect to these major climate stressors and current research gaps must be filled.

Description

The ocean plays a critical role in maintaining and balancing the amount of CO_2 within Earth's atmosphere. Ocean acidification poses a serious threat to the health of the oceans habitats. As concentrations of CO_2 increase in the ocean, a decrease in the calcium carbonate saturation state occurs leading to less calcium carbonate ($CaCO_3$) production in some marine organisms. Reduction in shell-forming animals and algae containing $CaCO_3$ can ultimately lead to shifts in ecosystem structure and dynamics, altering biological production and marine food webs. Locally, affected species include abalone, urchins, barnacles, mussels, and some algae. Chemical and physical disruptions, compounds these impacts and reduce resiliency in habitats to cope with accelerated climate change impacts. A decline in these organisms will cause declines in seabirds, shorebirds, and marine mammals that forage on these species, as well as disrupt sport and commercial seafood harvests. Healthy intertidal and subtidal ecosystems can reduce the impacts of wave energy and provides shading and cooling, which reduces desiccation of organisms and enhancing resilience to climate changes. It is important for sanctuary management to understand the status of our rocky intertidal and subtidal reefs on local and regional scales, in order to provide fully informed restoration and mitigation protection measures, design appropriate restoration projects, keeping in mind the rise in sea level, the potential decrease in some invertebrate organisms, and increase in other marine organisms.

Abalone, sea urchins and kelp are severely impacted by climate change because of increased temperature, increased storms, and increased ocean acidification. Photo credit: C. King, MBNMS

Questions and Information Needs

1) What are the predictions of impacts to intertidal and subtidal rocky reefs from ocean acidification, increased storminess, and sea level rise and can we modify shorelines to accommodate shifting intertidal habitats in response to sea level rise?
2) Are we currently seeing changes in distribution, abundance or diversity of intertidal and subtidal organisms?
3) To what extent are intertidal and subtidal invertebrates weakened due to reduced ability to calcify? Are rocky intertidal invertebrates more vulnerable to predations from foraging shorebirds and seabirds? What are the past and current levels of predation from shorebirds on rocky intertidal invertebrates? How have these rates changed over time?
4) How do the densities and percent coverage of calcifying ($CaCO_3$ containing) organisms at the Farallon Islands compare to other areas, e.g. nearby mainland, northern and southern island habitats?
5) How do changes in pH levels affect growth and reproduction in calcifying species?
6) What are the socio-economic impacts of changes in extraction or disturbance regulations of calcifying rocky intertidal species? Are there physical, e.g. trampling, anchoring, extraction or pollution impacts?
7) What are additional monitoring parameters that specifically assess ocean acidification and that can be incorporated into existing long-term monitoring programs?
8) How are invasive species impacting intertidal and subtidal habitats and are the rates of occurrence increasing with climate change?

Scientific Approach and Actions

- Catalogue intertidal and subtidal calcifying organisms and determine appropriate species for long-term study
- Review intertidal and subtidal species inventories and identify introduced species and calcifying species
- Continue to collect monitoring data to identify linkages between introduced species, ocean acidification, sea level rise and accretion of habitat, and storminess
- Investigate restoration actions
- Implement monitoring programs targeting influences from global climate change
- Compare GFNMS's 21-year rocky intertidal data with partner data sets from other rocky intertidal areas
- Integrate current web enabled databases for rocky intertidal and subtidal habitats, e.g. PISCO, Reef Check, to specifically analyze density and distribution changes of organisms potentially disrupted by ocean acidification

Key Partners and Information Sources

NOAA's Pacific Marine Environmental Laboratory, NCCOS, University of California, Bodega Marine Laboratory, National Park Service; Partnership for Interdisciplinary Studies of Coastal Ocean (PISCO); Reef Check, Multi-Agency Rocky Intertidal Network; United States Fish and Wildlife Service; Point Blue Conservation Science; University of Washington, Humboldt State University; Stanford University, Hopkins Marine Station, West Coast Region LiMPETS, Tenera Inc; Sonoma State University; San Francisco State University; California Ocean Protection Council; and Ocean Science Trust Monitoring Enterprise

Management Support Products

- Interpretive, web enabled maps on SIMoN MPA Monitoring map and CeNCOOS platforms, to better track species, abundance and distribution, and comparisons to historic data
- Provide habitat characterization with substrate and intertidal characteristics and quantification
- Web enabled biological database to track trends, distributional changes, biodiversity, density and percent cover of calcifying organisms
- Link CeNCOOS database of monthly average sea surface temperature, salinity, pH, alkalinity, wind stress, and upwelling index, within defined areas and increase fine-scale monitoring relative to waters near the state's MPA's and sanctuary rocky intertidal areas
- Trend analysis of organisms potentially disrupted by ocean acidification
- Maps and web enabled biological database showing spatial change of affected intertidal organisms
- Document prescribing adaptive management actions, predicted results, and reviews the socio-economic impacts of changes in the extraction or disturbance regulations of calcifying rocky intertidal and subtidal species

Planned Use of Products and Actions

- Disseminate information on ocean acidification and develop recommendations for minimizing CO_2 inputs
- Inform stakeholder community how calcifying species are affected by ocean acidification
- Develop adaptive management and restoration actions to help alleviate the consequences of climate change impacts
- Compare the health of organisms impacted from climate change found at mainland and Farallon Island intertidal and subtidal areas and determine if additional protection for mainland sites is warranted
- Develop recommendations for restoration or mitigation projects as compensation from anthropogenic damages
- Develop adaptive management actions to adjust management zones, boundaries and regulations

Program References

GFNMS Management Plan (2014)
STRATEGY FA-1: Develop an ecosystem characterization of the sanctuary
STRATEGY CS-4: Develop and implement sanctuary ecosystem assessment and monitoring programs
STRATEGY CS-5: Complete characterization of sanctuary biological and physical features
STRATEGY IS-3: Develop a monitoring program to detect and monitor introduced species

GFNMS Condition Report (2010) – Questions 1, 4-9, 11-14

- What are the status and trends of human activities that may influence water quality, habitats, and living resources, including invasive species, biologically structured habitats, key and foundation species

Climate Action Plan Strategies (2016) – H-4-6, HD-1, IS-3 and 4, SN-5

- Restore and protect intertidal and subtidal invertebrates and algae to enhance habitat growth with sea level rise and increased storminess, reduce trampling impacts, early detection and removal of invasive species