Gray's Reef National Marine Sanctuary

Climate Change and Ocean Acidification

Management Issue

Climate change is predicted to affect physical oceanographic and biogeochemical processes within the Gray's Reef National Marine Sanctuary (GRNMS) and is being regarded as a cross cutting theme for the sanctuary's monitoring and research programs. Climate change is having significant effects on sea temperature, pH, sea level, and currents potentially increasing storm intensity, flooding and droughts. Sea level rise can cause coastal erosion, wetland loss, alteration of species assemblages and distributions, impacts on infrastructure flooding and island re-sizing, and can have groundwater implications – all of which can potentially affect the resources of GRNMS.

NOAA divers install the seafloor observatory that collects continuous pCO2, pH, and temperature data. Photo Credit NOAA

Description

Over the next century, climate change is projected to profoundly impact coastal and marine ecosystems. It is important to gain deeper understanding of the coastal ocean processes acting on the sanctuary to realize the implications of climate change on the sanctuary's living resources and to position GRNMS to serve as a sentinel site. Scientists are currently monitoring chemical and physical oceanographic parameters as well as studying the benthic and pelagic communities for signs of degradation related to climate change.

The concentration of atmospheric carbon dioxide (CO_2) has risen approximately 35% since the industrial revolution, and is causing climate change and ocean acidification. Atmospheric CO_2 is at its highest levels in the past 400,000 years and the rate of increase is ~100 times faster than any other event in this same time frame. At GRNMS, atmospheric CO_2 has been increasing at a rate of 0.78% per year and seawater pCO_2 has increased at 2.7% per year. It is further estimated that 1/3 of all anthropogenic CO_2 has been taken up by the oceans and has reduced the pH of seawater by 0.1 pH units, i.e., a 30% increase in the hydrogen ion concentration.

Increased pCO_2 in seawater changes the carbonate buffering system of seawater and reduces the concentration of carbonate ions (CO_3^{2-}). Carbonate ions are utilized by organisms to form skeletons and protective structures of calcium carbonate ($CaCO_3$) such as shells or plates. These organisms include corals, echinoderms, mollusks, crustaceans, phytoplankton and macroalgae, which synthesize $CaCO_3$ by a variety of mechanisms in the form of aragonite or calcite. Increased pCO_2 also affects saturation horizons, i.e., water depths at which calcite and/or aragonite begin to dissolve. Acidified seawater can potentially impact benthic communities in the Sanctuary. Additionally, increased pCO_2 can produce a physiological state known as hypercapnia, which among other things can have negative effect on growth in bivalves, reduced sperm motility in fish and reduced thermal tolerance in crabs.

Questions and Information Needs

1) What habitats are most at risk from changing climate?

2) How are the abundance, distribution and diversity of living resources throughout sanctuary habitats affected by global climate change, and at what temporal and spatial scales do they occur?

3) How could/are warmer ocean temperatures change/changing the ecological community structure?

4) How will ocean acidification impact the sanctuary and what affect will it have on various species?

5) Can acoustics monitored over time be utilized to determine the impact of climate change on the sanctuary?

Scientific Approach and Actions

- Measuring carbon cycle parameters such as dissolved inorganic carbon (DIC), alkalinity, pH and pCO_2 to determine rates of change
- Develop a climate change site scenario to identify climate change drivers and regional impacts
- Logging data continuously by instruments such as surface current meters, fluorometers, and water quality parameters will provide a means to understand how conditions within the Sanctuary vary over different time scales as well as how these patterns relate to regional oceanographic dynamics
- Create an atmospheric and oceanographic climatology report to provide a summary of how the conditions within the sanctuary vary seasonally; this would provide a basis for understanding interannual variation
- Conduct characterization surveys to quantify benthic community distribution and abundance patterns
- Develop, partner and implement citizen science monitoring programs
- Develop an acoustic array monitoring sounds at the Sanctuary to compare changes over time

NDBC buoy #41008 located inside the sanctuary. Photo Credit: NOAA

Key Partners and Information Sources

Team Ocean Divers; Reef Environmental Education Foundation; University of Georgia; Georgia Southern University; National Centers for Coastal Ocean Science; Skidaway Institute of Oceanography; Georgia Department of Natural Resources; NOAA Office of Law Enforcement; Fishing clubs/associations; USCG Auxiliary; South Carolina Department of Natural Resources; NMFS Beaufort Lab; NOAA National Data Buoy Center; NOAA Pacific Marine Environmental Laboratory; NOAA Atlantic Oceanographic and Meteorological Laboratory

Sanctuary Resources Available

- Two research vessels complete with Captain and crew
- Staff to support field operations including science divers
- Habitat maps and bathymetry files
- Annual monitoring data of benthic and fish communities
- NDBC buoy located within the boundaries of GRNMS measuring atmospheric, oceanographic, and ocean acidification-related data (pH, CO_2, and noise)

Resource Needs

- Financial support
- Partnerships for: grant application, project design, data collection and analysis, reporting, and monitoring

Management Support Products

- Evaluation matrix on the effects of climate change on community structure and the population dynamics of individual species as well as immigrants from warmer water
- Map abundance and distribution of critical species, as well as their temporal patterns of expanding or contracting ranges of distribution in response to climate change
- Associated GIS layers can map physical oceanographic features such as sea surface temperatures, current systems, and mesoscale eddies, CO_2 concentrations and pH values. GIS layers can also include living resources vulnerable to climate change.
- Education and outreach products to inform the general public about research area issues and research results

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Planned Use of Products and Actions

- Use climatology to understand variations in local oceanography driven by climate change
- Reduce stressors on sensitive communities susceptible to climate change
- Use habitat maps and natural resource overlays as baseline data to assess environmental impacts of climate change, and incorporate these data into ecosystem based management plans
- Develop habitat suitability models that incorporate parameters such as aragonite or calcite saturation horizons
- Develop web based systems to display geographically explicit data and images and use maps as communication tools with general public for education and outreach
- Use regional scientific data to assess the impacts of climate change.
- Develop education and outreach products to inform general public about research area issues and research results

Program References

GRNMS Management Plan
Objective SR2: Activity SR2A and Activity SR2B

2008 GRNMS Condition Report and 2012 Addendum

- Question 1: Are specific or multiple stressors, including changing oceanographic and atmospheric conditions, affecting water quality?
- Question 5: What are the abundance and distribution of major habitat types and how are they changing?
- Question 6: What is the condition of biologically structured habitats and how is it changing?
- Question 8: What are the levels of human activities that may influence habitat quality and how are they changing?
- Question 9: What is the status of biodiversity and how is it changing?
- Question 12: What is the status of key species and how is it changing?
- Question 13: What is the condition or health of key species and how is it changing?
- Question 14: What are the levels of human activities that may influence living resource quality and how are they changing?