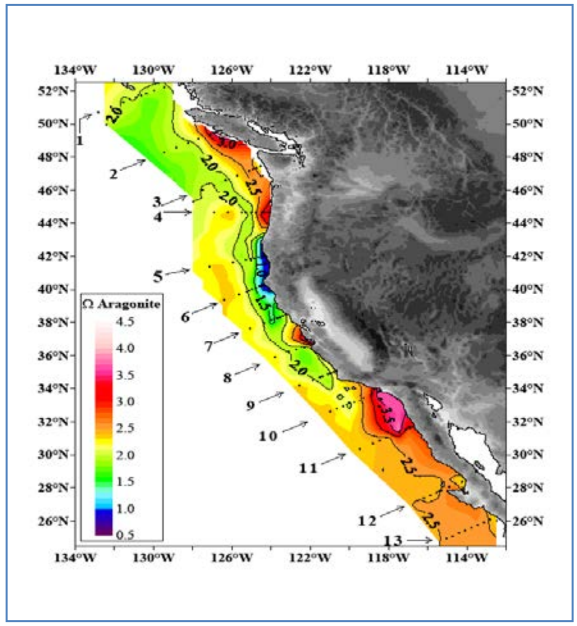
Climate Change and Ocean Acidification

Management Issue

Climate change is predicted to affect physical oceanographic and biogeochemical processes within the Olympic Coast National Marine Sanctuary (OCNMS or Sanctuary) and is being regarded as a cross cutting theme for the Sanctuary's monitoring and research programs. Further, ocean acidification is likely to change aragonite and calcite saturation horizons thereby impacting a wide array of calcareous organisms.

Description

Global climate change is projected to alter physical parameters such water temperature and coastal upwelling, while impacting longer term climatic patterns such as the Pacific Decadal or El Niño Southern Oscillations. It is important to gain deeper understanding of the coastal ocean processes in the Sanctuary to realize the implications of climate change on the sanctuary's living resources and to position the OCNMS to serve as a sentinel site.



Ocean pH at Tatoosh Island (within OCNMS) as a function of date and time (2000 to 2007).
Image Credit: Wooton et al. 2008.

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. It is further estimated that 1/3 of all anthropogenic CO_2 was 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 the carbonate ion (CO_3^{2-}). Carbonate ions are utilized by organisms to form 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 is now reported to shoal up along the West Coast at shallow depths potentially impacting benthic communities and reduced pH has been reported in the intertidal within 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 egg production in urchins, reduced sperm motility in fish and reduced thermo tolerance in crabs.).

Questions and Information Needs

1) 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?

2) Is there a change in ecological community structure dominated by in influx of warmer water or invasive species?

3) How is ocean acidification affecting aragonite and calcite saturation horizons and what impacts are observed among benthic and intertidal population dynamics and community structures?

4) To what extent is upwelling intensity affected by climate change and are any observed changes linked to hypoxia and harmful algae blooms.

Scientific Approach and Actions

- Continuous data logging instruments include surface current meters, fluorometers, conductivity-temperature sensors and thermistors
- Measuring carbon cycle parameters such as dissolved inorganic carbon (DIC), alkalinity, pH and pCO_2
- Integrate introduced species monitoring components to all current sanctuary monitoring programs which includes screening for introduced species
- Conduct ROV and/or submersible video surveys to quantify deep benthic community distribution and abundance patterns
- Develop, partner and implement citizen science monitoring programs

Key Partners and Information Sources

NOAA Pacific Marine Environmental Laboratory, NOAA National Centers for Coastal Ocean Science, Northwest Regional Ocean Observing System (NANOOS), Marine Conservation Biology Institute (MCBI), University of Washington, Olympic Region Harmful Algal Bloom consortium (ORHAB), Ecology and Oceanography of Harmful Algal Blooms (ECOHAB), University of Washington, Oregon State University, NOAA Northwest Fisheries Science Center, the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO), NOAA National Centers of Coastal Ocean Science, NOAA Northwest Fisheries Science Center, NOAA Fisheries Northwest Regional Office, NOAA Fisheries Office of Habitat Conservation, Pacific Fishery Management Council, U.S. Geological Survey, Washington State Department of Fish and Wildlife, Olympic Coast Intergovernmental Policy Council, Washington State University, Western Washington University, and Moss Landing Marine Laboratory, State of Washington, Northwest Indian Fisheries Commission

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 such as deep coral, 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 upwelling fronts, sea surface temperatures, current systems, and mesoscale eddies as well as CO_2 concentrations and pH values, as well as living and cultural resources vulnerable to climate change

Planned Use of Products and Actions

- Use habitat maps and natural resource overlays as baseline data to assess environmental impacts of climate change, and incorporate these data into ecological based management plans
- Develop habitat suitability models which 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.

Program References

OCNMS Management Plan

- Management Plan Review 2009 - *Priority Topics C & E*
- http://olympiccoast.noaa.gov/protection/mpr/mpr_prioritytopics.html

OCNMS Condition Report

- Questions 1,2,3,4,5,8,9,11,14

Other Documents

- OCNMS Science Framework, 2003 (*http://olympiccoast.noaa.gov/research/interested/welcome.html)*