Forecast fish and marine mammal population responses to ocean acidification in the North Pacific Ocean and Bering Sea

An ocean acidification research plan for the Alaska Fisheries Science Center

Background - Approximately 30-50% of global anthropogenic CO_2 emissions are absorbed by the world's oceans (Feely et al. 2004, Sabine et al. 2004). Increased CO_2 uptake by the oceans is expected to reduce surface ocean pH by 0.3 – 0.5 units over the next century, which would be the largest change in pH to occur in the last 20-200 million years (Feely et al. 2004). Ocean acidification reduces the calcium carbonate ($CaCO_3$) saturation point. Dramatic reductions in calcium carbonate saturation have been observed in the North Pacific since the industrial revolution (Feely et al. 2004).

Ocean acidification likely will impact the ability of marine calcifiers, such as corals and mollusks, to make shells and skeletons from calcium carbonate. This will occur principally because of a reduction in the availability of the chemical constituents needed for calcified shells and plates. In addition, ocean acidification may elicit broad physiological responses from non-calcifying organisms through less obvious pathways. For example, changes in ocean pH may affect the availability of nutrients to phytoplankton, the bioavailability of marine toxins to bacteria and phytoplankton, and internal CO_2 concentrations of marine animals (UK Royal Society 2005). Ocean acidification may indirectly affect fish and marine mammal species through reduced abundance of marine calcifiers at the base of the food web. Changes in ocean pH also may affect reproductive success of commercially important species by reducing demersal egg adhesion or the fertilization success of eggs broadcast into the ocean. Coldwater corals provide shelter for structure-oriented species such as rockfish. The numerous pathways for effects (both direct and indirect) imply that ocean acidification may have important impacts on many marine species.

Alaska Fisheries Science Center (AFSC) Research Program – The AFSC is responsible for scientific research to support conservation and management of fisheries and marine mammals in the U.S. Exclusive Economic Zone off Alaska. The AFSC, as part of its integrated ecosystem approach to studying living marine resources from the North Pacific Ocean and Bering Sea, plans research in four areas to address the threat of ocean acidification:

- Conduct research targeted at understanding species-specific physiological responses to ocean acidification.
- Develop models to forecast the population, community and ecosystem impacts of the physiological responses.
- Develop scenarios to forecast socio-economic consequences of these impacts.
- Collaborate with NOAA's Pacific Marine Environmental Laboratory to monitor ocean pH using AFSC's NOAA and chartered shiptime.

Species-specific physiological response – Ocean acidification may have both direct and indirect impacts on fish, shellfish, coldwater corals and marine mammals off Alaska. The AFSC will study ocean acidification effects on commercially important calcareous species (shellfish), living structure (corals), and fish and shellfish species (e.g., reduced egg adhesion and subsequent reproductive success). The AFSC also will study the effect of ocean acidification on ecologically important calcifiers that are prey of marine mammals and commercially important fish and shellfish.

Ecosystem forecasting – The AFSC has a well-developed single species and ecosystem modeling capability. This capability will be applied to forecast potential effects of ocean acidification (scenarios) and integrate studies of species-specific physiological response. The Center will model both single species and ecosystem or emergent effects.

Socio-economic consequences - Output from single-species and ecosystem models will be used as input by AFSC economists to forecast changes in value of Alaska fisheries, which currently comprise over 40% of US landings. The scenarios developed by the ecosystem models will also be used by AFSC socio-economists to predict impacts on coastal communities and subsistence harvest by Native Alaskans.

Support long-term monitoring & research on emergent properties – The AFSC has a long history of collaboration with the Pacific Marine Environmental Laboratory (PMEL). PMEL plans to conduct long-term monitoring of ocean acidification in the North Pacific Ocean and Bering Sea. The AFSC will collaborate with PMEL in this research. AFSC will supply additional sampling platforms for ocean acidification measurement (AFSC fisheries and marine mammal surveys) and will jointly conduct research on physical – biological interactions affected by the changing pH of the ocean.

References

Feely, R.A. et al. 2004. Impact of anthropogenic CO_2 on the $CaCO_3$ system in the oceans. Science 305:362-366.

Sabine, C.L. et al. 2004. The oceanic sink for anthropogenic CO_2. Science 305:367-371.

UK Royal Society. 2005. Ocean acidification due to increasing atmospheric carbon dioxide.