Integration of ecological indicators for the North Pacific with emphasis on the Bering Sea

By Gordon H. Kruse, Diana Evans and James E. Overland

PICES scientists responded to a North Pacific Research Board (NPRB) call for proposals to evaluate the utility of ecosystem indicators to explain processes underlying biological production in the ocean. The principal investigators (Glen Jamieson, Gordon Kruse, Patricia Livingston, James Overland and Ian Perry) have interests in processes associated with physical (*e.g.*, atmospheric forcing, ocean temperature, salinity, sea level, freshwater discharges, transport of planktonic life history stages, sea ice extent and duration, turbulence, and cold pool extent), chemical (*e.g.*, nutrient/micronutrient availability to phytoplankton), and biological (*e.g.*, predation, timing of plankton/zooplankton production, commercial catch composition, and biomass/abundance trends) phenomena and their potential utility as indicators of ecosystem status. The goals of the project were to:

- report on the current understanding of ecosystem indicators in the Bering Sea and Aleutian Islands;
- evaluate the pros and cons of existing indicators; and
- identify the next steps toward developing and/or validating indicators and evaluating their performance (*e.g.*, using hind-casts of indicators and various marine populations).

A final report of the project will be published as a PICES Scientific Report.

The overall approach included:

1. involving the Bering Sea and international communities in developing of a set of operational objectives for the southeast Bering Sea ecosystem;
2. evaluating two existing status reports with a goal of integrating results and streamlining their presentation:
   a. NPFMC. 2005. Appendix C: Ecosystem Considerations for 2006. North Pacific Fishery Management Council, Anchorage, Alaska. (available at: http://access.afsc.noaa.gov/reem/ecoweb/index.cfm)
   b. PICES. 2004. Marine Ecosystems of the North Pacific, PICES Special Publication 1, 280 p. (available at http://www.pices.int/publications/special_publications/NPESR/2005/npesr_2005.aspx);
3. investigating methodologies to monitor system-wide structural changes within the marine ecosystem; and
4. identifying steps to validate indicator performance, improve the monitoring network, and integrate indicators into predictive models.

There was a focus on the southeastern Bering Sea because it represents the center of the Bering Sea/Aleutian Islands large marine ecosystem (LME), one of three LMEs (the other two are the Gulf of Alaska and Arctic Ocean) encompassed by the NPRB research region. Nevertheless, the intent was to provide insights, findings, and recommendations that might be more broadly applicable to the northern North Pacific and adjacent marginal seas, including waters bordering China, Japan, Korea, Russia, Canada, and the United States.

While the main activity involved a workshop of experts (Seattle, June 1–3, 2006) who addressed the challenge of developing indicators and interpreting their utility, the pre-workshop activities included outreach to engage the Bering Sea/Aleutian Island communities in the project. One such meeting was organized in Anchorage on January 25, 2006, at the annual Marine Science in Alaska Symposium, and the other was held on February 8, 2006, in Seattle during a North Pacific Fishery Management Council meeting.

PICES/NPRB workshop convenors and breakout group facilitators (clockwise from left): Glen Jamieson, George Hunt Jr., Sarah Kruse, Gordon Kruse (no relation), Patricia Livingston, James Overland, Nathan Mantua, Franz Mueter, Ian Perry, Anne Hollowed, and Robert O'Boyle.

Beth Fulton was invited to present the Australian experience on the use of ecological indicators.

Ian Perry describing the development of the first PICES Ecosystem Status Report.

Jake Rice was invited to critique ecosystem status reports.

White (working) papers related to the first three elements of the overall approach were written by Gordon Kruse and Diana Evans (*Operational objectives for the Bering Sea*), Patricia Livingston and Andrea Belgrano (*Ecosystem-based management of the oceans*), and Sergei Rodionov (*Analysis of ecological indicators*). These papers can be found on the PICES website at http://www.pices.int/projects/Bering_Indicators/bering.aspx.

The main product of this project will be a PICES Scientific Report, which will include the three working papers, and a summary of workshop discussions and recommendations. As the outcomes of the workshop will be used by NPRB in developing an integrated ecosystem research plan for the Bering Sea, an interim report will be prepared shortly after the workshop so that key findings are available for planning.

Although the issue of dealing with large numbers of potential indicators was not discussed in depth, the workshop had initiated a process for developing a list of indicators for the Bering Sea and the broader Pacific region. The purposes and objectives of indicators in management were discussed, and it was concluded that considerable work on establishing critical issues has been completed. There were excellent presentations by scientists who have used indicators in other regions, including the east coasts of the United States (Jason Link) and Canada (Robert O'Boyle), and the Australian experience (Beth Fulton). Exploration of these topics provided a basis for the credible use of indicators in the North Pacific.

A major theme of the Seattle workshop was to consider how to communicate information about the ecosystem and fisheries. Although it is important to document and interpret a large number of indicators as background material, it is also important to consider the audience and the core information to be presented. For example, it is crucial to focus on a reduced set of key indicators so that the main patterns of change can be elucidated from a myriad of variables. Given the complexity and uncertainty about ecosystem change, a continuing dialog about potential ecosystem/management issues is needed. Discussion around the appropriate use of indictors is a good start, as they provide semi-quantitative information that enhances communication between scientists, managers and the larger community.

Breakout group discussion at the PICES/NPRB workshop.

It was noted that there was already a good match between the operational objectives developed by the North Pacific Fishery Management Council and the indicators reported in the NMFS Ecosystem Considerations Appendix. These include, for instance, onboard observations of discards that are used as a performance measure for an objective to reduce bycatch and waste, and a prohibition of fishing on forage fishes to, in part, address an objective to avoid fishing impacts on seabirds and marine mammals. Unlike most other LME regions where fishing is the main driver of the ecosystem and recovery plans are paramount, issues for the Bering Sea appear to deal more with climate change and resultant ecosystem dynamics and structural responses rather than mitigation of adverse anthropogenic effects. In this region it is important to monitor the state of the system and its response to ongoing climate change. Thus, there is a need to have broad ecosystem indicators that provide the context for the ecosystem state, in addition to management (*e.g.*, fisheries) indicators that have specific reference points and management actions if the thresholds are crossed.