Workshop on sardine and anchovy fluctuations

By Shin-ichi Ito, Michio J. Kishi, Bernard A. Megrey, Kenneth A. Rose and Francisco E. Werner

A workshop on "Global comparison of sardine, anchovy and other small pelagics: Building towards a multi-species model" was held in Tokyo, Japan, from November 14-17, 2005. Support for the workshop was provided by the Japanese Fisheries Research Agency (FRA, http://ss.myg.affrc.go.jp), PICES (http://www.pices.int), Global Ocean Ecosystem Dynamics (GLOBEC, http://www.globec.org), the Asia Pacific Network for Global Change Research (APN, http://www.apn-gcr.org/en/indexe.html), Scientific Capacity Building/ Enhancement for Sustainable Development in Developing Countries Program (CAPaBLE, http://www.apn-gcr.org/en/activity/capable.html) and the Inter American Institute for Global Change Research (IAI, http://www.iai.int/), enabling participation by 22 attendees from Chile, China, India, France, Japan, Mexico, Pakistan, the Philippines, South Africa, the United Kingdom, and the United States of America (see photo below). The workshop's agenda and other preparatory material are available on http://www.myg.affrc.go.jp/kaiyo/sardine-anchovy/index-sardine-anchovy.html.

The goal of the workshop was to explore ways to extend an existing marine food-web and fisheries model to ecosystems containing sardine and anchovy. Together with long-term ecosystem-specific oceanographic and fisheries data sets, our aim was to:

- Understand the propagation of climate change effects up the marine food-web;
- Quantify its effects on energy cycling and fish growth and production in distinct geographic regions that support important sardine and anchovy populations;
- Explain synchronous and asynchronous patterns of abundance trends; and
- Explore how to best integrate these results into the decision making process by fisheries/resource managers and policy makers.

Over the past century, global fluctuations in the populations of sardines and anchovies have been documented (Fig. 1). The amplitude of fluctuations can be high, and inter-annual and longer-term fluctuations contribute significantly to the total variability of the world's fish harvest. Additionally, the fluctuations appear to be at times asynchronous across species within specific regions, as well as synchronous within species at larger (basin) scales. For example, sardine populations exhibit synchrony over a large part of the Pacific (Humboldt Current, California Current, and Kuroshio Current areas). On the other hand, sardines do not show any apparent systematic synchrony between the Pacific and Atlantic Oceans. The local out-of-phase asynchrony between sardine and anchovy may result from differences in species life-histories, as well as from bottom-up processes driven by climate shifts. The in-phase synchrony of sardine populations within the Pacific also suggests a bottom-up, climate-driven component. The possibility of climate-induced variability in sardine and anchovy population

Workshop attendees left to right. Back row: Yasuhiro Yamanaka (Japan), Luis Cubillos (Chile), Carl van der Lingen (South Africa), Vera Agostini (U.S.A.), Taketo Hashioka (Japan), Bernard Megrey (U.S.A.), Michio Kishi (Japan), Manuel Barange (GLOBEC IPO), Francisco Werner (U.S.A.), Kenneth Rose (U.S.A.). Middle row: Yasuko Kamezawa (Japan), Yunne Shin (France), Shin-ichi Ito (Japan), Larry Jacobson (U.S.A.), Roehlano Briones (Philippines), Alan Koropitan (Japan), Salvador Lluch-Cota (Mexico). Front row: Akinori Takasuka (Japan), Wei Hao (China), Goh Onizuka (Japan), Francisco Chavez (U.S.A.), Kawser Ahmed (Bangladesh), Pratap Mohanty (India), and Shigeo Hayase (Japan).

fluctuations was previously discussed at the symposium entitled "Long-term variability of pelagic fish populations and their environment" that was held in Japan in 1989.
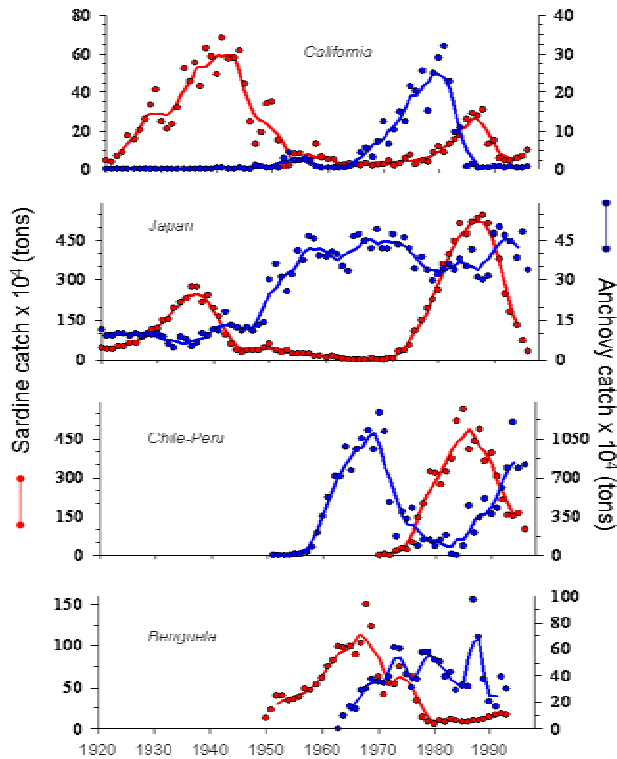

Fig. 1   Sardine and anchovy catch at three sites in the Pacific and in the Benguela region from 1920 to 1996 (courtesy of S. Lluch-Cota).

Since the 1989 symposium, our ability to model marine ecosystems and their response to physical forcing has evolved rapidly. For example, the PICES CCCC MODEL Task Team has built a community ecosystem model called the "North Pacific Ecosystem Model for Understanding Regional Oceanography (NEMURO)", and coupled the NEMURO model to a bioenergetics-based population dynamics model of fish (see PICES Scientific Report No. 20, 2002). The coupled model, called NEMURO.FISH, has been used to examine the responses of Pacific herring (*Clupea pallasii*) and Pacific saury (*Cololabis saira*) to decadal variations in climatic conditions (focusing on the 1950-2000 time period). At the November 2005 workshop in Tokyo, we reviewed recent data and modeling approaches that could help explain the annual and inter-decadal variability of sardine and anchovy populations. We also outlined a common multi-species, spatially-explicit modeling approach, which is an extension to the NEMURO.FISH model, to study the synchrony and asynchrony of sardine and anchovy populations. Workshop attendees outlined a comparative approach designed to study the effects of the climate change on sardine and anchovy population dynamics by focusing on the populations located in the key geographic areas

accompanied by supporting data for model comparison, calibration and validation.

The work-plan for the group in the coming months will focus on addressing the question "How much can bottom-up food-web dynamics explain sardine and anchovy growth and relative abundance between warm and cold regimes in the different ecosystems?" Specific tasks and objectives include:

- Initiate a review paper (as an update to the 1989 symposium) on the processes that affect sardine and anchovy populations, including comparisons among ecosystems where possible;
- Develop bioenergetics growth models for sardine and anchovy with sufficient detail to capture important differences in the feeding behavior and energetics between species;
- Update and synthesize sardine and anchovy weight-at-age data from a variety of ecosystems and identify candidate data sets for calibration of the NEMURO.FISH model and its envisioned extension to multiple species;
- Apply the NEMURO.FISH model, updated for sardines and anchovies, as a box (point) model using predicted prey from an uncoupled spatially-explicit NEMURO lower trophic model. The analysis would examine sardine and anchovy growth responses (*i.e.*, weight-at-age) to geographic variation in physical factors (*e.g.*, temperature) as well as prey dynamics and abundance;
- Extend NEMURO.FISH to a 2-dimensional model that simulates sardine and anchovy population dynamics, with potential application to a variety of geographic locations with contrasting lower trophic level and fish dynamics;
- Analyze existing field data from different locations to quantify and compare the contraction and expansion response of sardine and anchovy populations to environmental and biomass conditions;
- Consider the need to incorporate parameters and/or outputs of bio-economic models in future developments regarding NEMURO.FISH to capture the impact of top-down (human) approaches in generating or enhancing the cyclic behavior of pelagic fish populations.

Future communications among the workshop participants will occur mainly via e-mail, with a possible meeting of a subset of the participants in April 2006 in Honolulu, before the PICES/GLOBEC Symposium on "Climate variability and ecosystem impacts on the North Pacific: A basin-scale synthesis". Presentations of the resulting efforts are planned at a sardine-anchovy dynamics session (topic session on "Modeling and historical data analysis of pelagic fish, with special focus on sardine and anchovy") at PICES XV in Yokohama, Japan, in October 2006.

[*Article submitted by the workshop co-convenors.*]