2010 Sendai Zooplankton Workshop

by William Peterson and Kazuaki Tadokoro

The goal of a workshop, co-convened by the authors of this article immediately prior (April 25, 2010) to the International Symposium on "*Climate change effects on fish and fisheries*" in Sendai, Japan, was to provide an opportunity for those keenly interested in "*how data on zooplankton and krill can be used to better understand and forecast the impacts of climate change on fisheries*" to discuss the topic in an informal workshop atmosphere. Contributions were requested which demonstrated explicitly how information on copepods and euphausiids might lead to a better understanding of the linkages between physics and fish. We worked hard to invite people, but in the end we received only 8 abstracts, and thus decided to have a half-day workshop. When the happy day arrived, we did not know what to expect in terms of participation, and we were delighted and very pleased to find the room filled to its capacity, with more than 50 people in attendance. This is evidence of great interest in learning more about mechanistic linkages between physics through the zooplankton to fish.

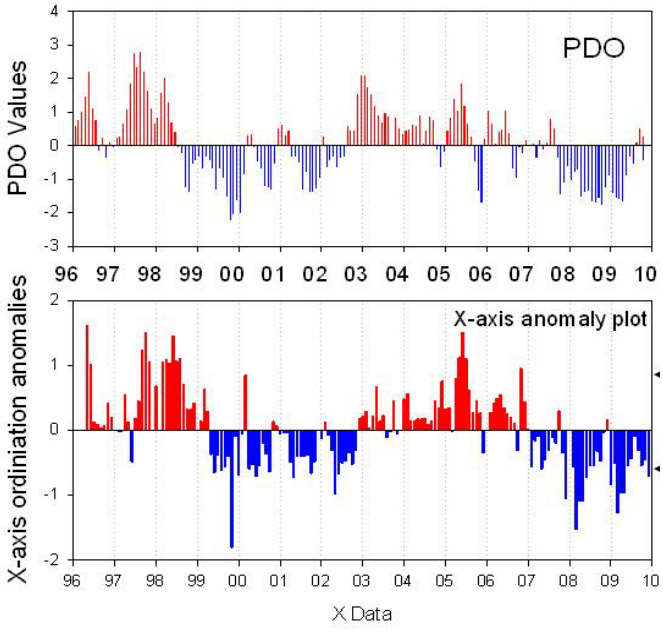

Fig. 1 PDO (upper panel) and monthly anomalies of the x-axis scores of a NMDS of copepod community structure (lower panel).

The meeting was opened by William (Bill) Peterson (NOAA Fisheries, U.S.A.), who presented an overview of some mechanisms that link physical forcing with zooplankton and fisheries response in the North Pacific. As one of the examples, he demonstrated a link between the Pacific Decadal Oscillation (PDO) and the copepod community structure (Fig. 1). The positive (negative) phase of the PDO results in the advection of warm (cold) water to the coast in the northern California Current. As a consequence, "warm" and "cold" water copepod species and communities dominate coastal waters; changes in community structure lag changes in the PDO by a few months.

Ryan Rykaczewski (Princeton Geophysical Fluid Dynamics Laboratory, U.S.A.) gave a Pacific basin-scale perspective on how the Kuroshio and California currents might be linked. He examined basin-wide variability in the depth of the nutricline across the mid-latitude North Pacific using a global, earth system model and found that variability in the depth of wintertime convection in the western North Pacific stimulates anomalies in the vertical distribution of nitrate, and that these anomalies propagate from west to east with the North Pacific Current, with a transit time on the scale of decades.

Bill Peterson discussed his two favorite hypotheses: (1) lipids and cold water copepod species, and (2) source water which feeds the northern California Current, and how these two are linked with salmon survival.

Jay Peterson (Hatfield Marine Science Center, U.S.A.) showed that there have been chronic changes in the upwelling ecosystem off Newport over the last 40 years. First, there has been an increase in the number of copepod species routinely found along the coast (0.11 species per year); second, an intensification of oxygen-depleted bottom waters on the shelf; and third, a deepening in the depth from which water upwells.

Tracy Shaw (Hatfield Marine Science Center) discussed relationships between timing and strength of upwelling and euphausiid spawning. She showed that *Euphausia pacifica* spawning is strongly associated with the timing of the onset of upwelling, but not with upwelling strength. *Thysanoessa spinifera*, on the other hand, spawn prior to and during upwelling and seem to be more strongly affected by water temperature. Future changes in the timing of the spring transition are likely to affect *E. pacifica* spawning behavior. A warmer ocean will likely lead to a decrease in *T. spinifera* abundance and spawning. Both scenarios will affect the availability of euphausiids as a food source for higher trophic level predators.

Motomitsu Takahashi (Nagasaki National Fisheries Research Institute, Japan), presented his work carried out during a short visit at the Peterson's laboratory. He looked at otoliths of late-larval and juvenile northern anchovy and Pacific sardine collected off Oregon in the summer of 2005, an unusual year in which upwelling began very late, in mid-July. The results suggested that the fish responded quickly to the intensification of upwelling after mid-July due

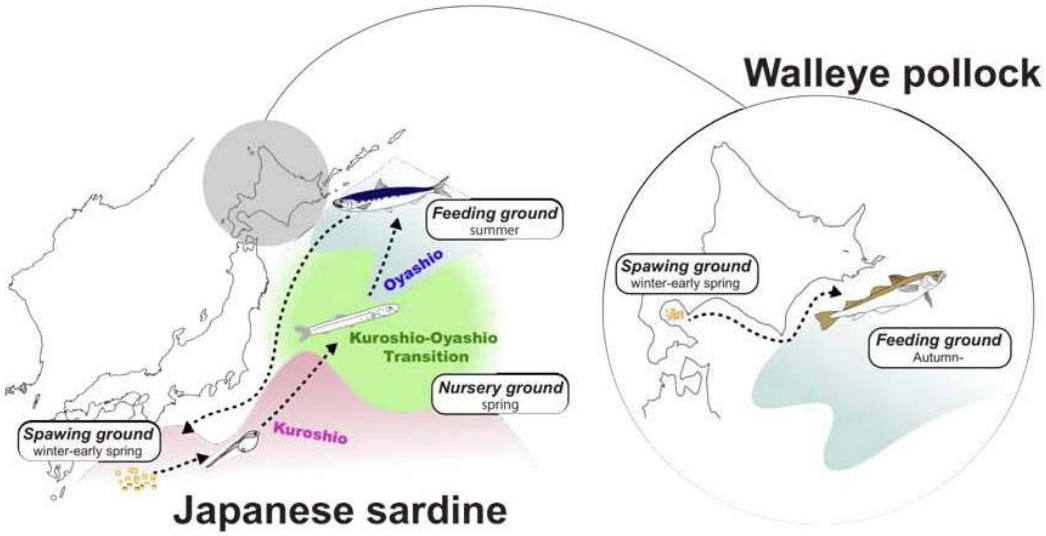

Fig. 2 Overview of the zooplankton from viewpoint of food for fish resources in the western North Pacific.

to the development of a bloom of phytoplankton and a surge in production of cold water copepod species. Increased secondary productivity led quickly to enhance the larval growth rate of northern anchovy.

Kazuaki Tadokoro (Tohoku National Fisheries Research Institute, Japan) provided an overview of the zooplankton from viewpoint of food for fish resources in the western North Pacific (Fig. 2). He reminded us that a great deal of work has been done on the large *Neocalanus* copepod species in the Oyashio-Kuroshio region, with relatively little work on the small copepods species upon which larval and juvenile sardines feed. More research is needed on both food habits of juvenile planktivorous fishes as well as on the zooplankton upon which they feed.

Dr. William (Bill) Peterson (bill.peterson@noaa.gov) is an oceanographer and Senior Scientist with the Northwest Fisheries Science Center, based in Newport, Oregon, at the Hatfield Marine Science Center. Bill is a Team Leader for the "Climate Change and Ocean Productivity" program. One of the core activities of this program is the biweekly oceanographic cruises carried out by his laboratory along the Newport Hydrographic Line, where hydrography, nutrients, chlorophyll, zooplankton and krill are measured. This ongoing activity was initiated in 1996. A key outcome of these monitoring cruises is that the data are now used to forecast successfully the returns of salmon to the Columbia River and coastal rivers of Washington. Bill has been active within PICES since his first meeting (1998), serving on the Executive Committee of the Climate Change and Carrying Capacity (CCCC) Program Implementation Panel, and as Chairman of the CCCC REX (Regional Experiment) Task Team. Now he is a member of the Biological Oceanography Committee and Co-Chairman of Working Group 23 on "Comparative Ecology of Krill in Coastal and Oceanic Waters around the Pacific Rim". Concerning the photo, the presence of the NOAA ship in the background (R/V Bell Shimada) is significant because the entire fleet of NOAA ships based in the Pacific Northwest will be adopting Newport as their new Fleet Headquarters in 2012.

Dr. Kazuaki Tadokoro (den@affrc.go.jp) is a biological oceanographer at the Tohoku National Fisheries Research Institute of the Fisheries Research Agency of Japan. He received his PhD from the University of Tokyo in 1997. Then he worked in the National Research Institute of Far Seas Fisheries, Hokkaido National Fisheries Research Institute, Ocean Research Institute of the University of Tokyo, JAMSTEC, and Hokkaido University. His research interests focus on the influence of the climate change on marine ecosystems of the North Pacific. Kazuaki is also collecting samples for and managing the Odate collection, known as a long-term zooplankton collection at the Tohoku National Fisheries Research Institute.

Mikiko Kuriyama (National Research Institute of Fisheries Science, Japan) reported on long-term variations in copepod community in relation to the climatic change in the Kuroshio waters off southern Japan from 1971 to 2009. She revealed that copepod abundances were high in the early 1970s and after the 1990s, and low in the 1980s. *Paracalanus parvus*, as one of the important prey for the Japanese sardine, was abundant through the study period.

The final talk by Toru Kobari (Kagoshima University, Japan) demonstrated decadal changes in seasonal timing and population age structure of *Eucalanus* in the Oyasiho from a time series initiated in the 1970s. He showed that a decline in copepod abundance originated at the early life stages, and was associated with a shift of atmospheric and oceanographic conditions. Possible biological mechanisms to account for the decline were reduced egg production, lower survival for the portion of the annual cohort with late birth date, and overwintering of the survivors at younger stages.

Each talk was discussed thoroughly, with many questions from the audience. The workshop ended with an open discussion which resulted in the following recommendations: (1) zooplankton time series that are based on either size of copepod taxa, or on species abundance have far greater value than time series of "total biomass" or "volume" of the catch; (2) future workshops on the same topic would be welcomed warmly; and (3) more specialized workshops should be convened whereby zooplankton ecologists with long time series would work with fisheries people from the same region to try harder to relate interannual variations in zooplankton abundance and species composition with variations in some key aspects of pelagic fishes life history – either recruitment or growth.