Workshop on "*Climate Impact on Ecosystem Dynamics of Marginal Seas*"

by Yasunori Sakurai and Christian Möllman

Marginal and semi-enclosed seas contribute a substantial share to the world fisheries catch and hence are significantly impacted by human exploitation. Additionally, these areas are increasingly affected by climate variability and change. However, whereas our knowledge on the ecological functioning of ecosystems for particular marginal and semi-enclosed seas has progressed considerably, a synthesis of results derived by GLOBEC regional efforts is still missing. Consequently, a 1-day workshop held on June 23 at the 2009 GLOBEC Open Science Meeting in Victoria, Canada, sought to compare climatic influences on marginal and semi-enclosed seas on a global scale. The geographic scope of this workshop was on traditional GLOBEC study areas such as the Barents Sea, North Sea, Mediterranean, Baltic Sea, Black Sea, East China Sea, Yellow Sea, Okhotsk Sea, Japan Sea, Georges Bank, Bering Sea, Gulf of Alaska, and Scotia Sea (or other Southern Ocean regions). Particularly rewarding periods for cooperative studies are the late 1980s and 1990s, when dramatic changes were observed in the North Pacific as well as in the North Atlantic in association with changes in climatic indices, such as the North Atlantic Oscillation (NAO), Arctic Oscillation (AO) and Pacific Decadal Oscillation (PDO). In total 14 very diverse studies from 11 different areas were presented during the workshop, focused mainly on higher trophic levels, particularly on zooplankton and fish.

Two studies compared climate influences over a range of geographical systems. The response of plankton trophic levels to climate forcing was explored in five European shelf seas: the northwestern Mediterranean, Adriatic, North, Baltic, and Black Seas. The study revealed coherent, synchronized climate-related changes in plankton during the late 1980s (Fig. 1). Similar climate-related changes were reported for several Northern Hemisphere systems, namely the Japan/East Sea, Kuroshio and Oyashio ecosystems, California Current and Iberian Upwelling systems, as well as the North, Baltic and Mediterranean Seas. In spite of the very diverse structure of these different systems, all of them exhibited strong synchronous reactions suggesting large-scale atmospheric teleconnections.

A system-specific synthesis reviewing both the influence of climate and overfishing was presented for the central Baltic pelagic ecosystem. This system, which is characterized by a simple trophic structure and only a few dominant fish species, exhibited both ecosystem regime shifts and trophic cascades. A conceptual model synthesizing the different pathways of change into a holistic understanding of ecosystem functioning has been developed as a basis for reliable ecosystem-based management (Fig. 2).

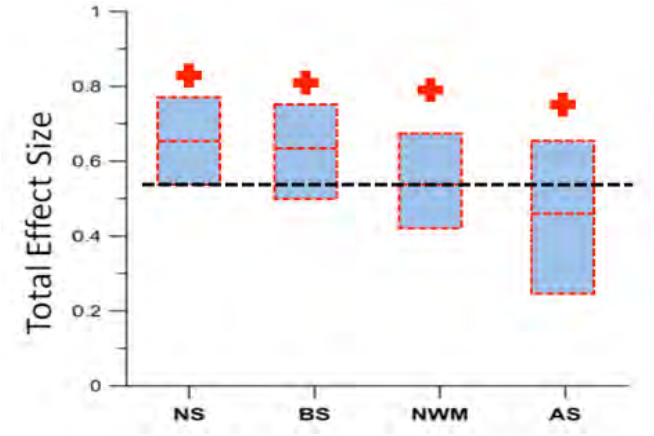

Fig. 1 Response of plankton to climatic conditions in European shelf seas (1970–2005): North Sea (NS), Baltic Sea (BS), northwestern Mediterranean Sea (NWM) and Adriatic Sea (AS). For each ecosystem at least a 25-year period was tested. Boxes illustrate the variability in the strength of the relationship between plankton and climate, and encompass the first and third quartiles of the distribution. The figure further shows a higher sensitivity in northern ecosystems (NS and BS). However, when considering only threshold climate values, no differences were observed in the plankton response regardless of the geographic locations of the ecosystems investigated. The horizontal line indicates the mean value of the total effect size.

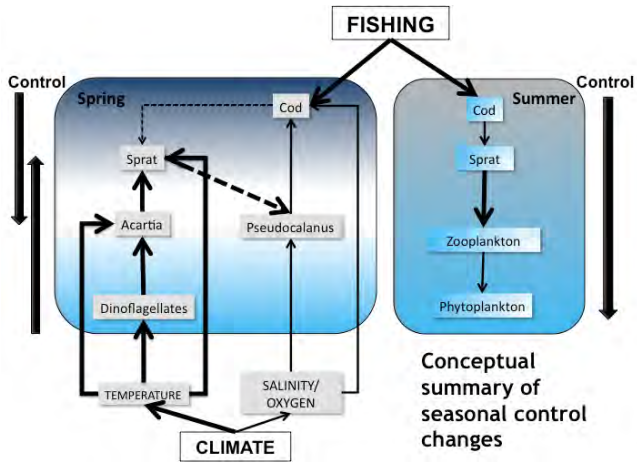

Fig. 2 Conceptual diagramme of the different seasonally varying effects of climate and fishing on the Central Baltic ecosystem (courtesy of C. Möllmann).

Research focusing on zooplankton dynamics in the northwestern Pacific marginal seas and in the Balearic Sea (western Mediterranean) indicated an increase in biomass

with climate warming. For the Yellow and East China Seas, a study on *Calanus sinicus*, a key species functionally equivalent to *C. finmarchicus* in the North Atlantic, was presented. Based on data from the last 10 years, the seasonal and regional variations in population distribution, biomass, reproduction and recruitment were studied in relation to the temperature, food supply, cold water mass, fronts and lipid reserves.

Several studies demonstrated climate influences on commercially important fish species. One example was the long-term climate effect on growth and survival of Japanese chum salmon in the Okhotsk Sea. The condition of this stock improved because of less sea ice cover area in winter and higher SST in summer and autumn. The effect of climate on Baltic cod, sprat and herring has been reported. Furthermore, the combined effect of climate and the fishery triggering a shift in the hake population of the northwestern Mediterranean, has been found for the early 1980s.

Finally, a number of presentations dealt with diverse themes, such as the effect of the increased abundance of jellyfish and invasive species on ecosystems in the Mediterranean, climate effects on the Gulf of California, dynamics and functional role of heterotrophic flagellates during the spring diatom bloom in the central part of the Yellow Sea, and the dynamics of chlorophyll-*a* concentration due to climate change and its possible impact on *Sardinella lemuru* at Bali Strait, Indonesia.

In summary, a recurring theme of the workshop was climate-related trends in upper trophic level dynamics of the investigated marginal and semi-enclosed seas. An obvious pattern was regime shifts in ecosystem structure and function which occurred in the late 1980s/early 1990s. Workshop discussions centered around this issue, and large-scale atmospheric teleconnections in the Northern Hemisphere were hypothesized to be responsible for this phenomenon, which has to be discussed with climatologists. In general, workshop participants felt that more synthesis efforts are needed for a comprehensive understanding of the dynamics of these systems, especially considering the interplay between climate and exploitation effects. Further analyses should explicitly include additional expertise from systems not represented at this workshop, *e.g*., the Black and Barents Seas.

To facilitate the intended large-scale comparison of marginal and semi-enclosed ecosystems, GLOBEC has agreed to fund a small follow-up workshop next autumn in which these analyses will be initiated, potentially leading to a synthesis article in a peer-reviewed journal.

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Erratum

A reference to Figure 2 was missing in the PICES Press article on the PICES/ESSAS Workshop on "*Marine Ecosystem Model Inter-Comparisons*" by Bernard A. Megrey, Masahiko Fujii and Shin-ichi Ito, 2009, Vol. 17, No. 1. Credit should be given to Stow *et al.*, 2009, *J. Marine Systems* 76(1-2), 4–15. The source for the figure can also be found on-line at http://www.pices.int/publications/pices_press/volume17/v17_n1/pp_20_21_2008%20Model%20intercomparisons_f.pdf.