2010 Sendai Coupled Climate-to-Fish-to-Fishers Models Workshop

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A 1-day workshop on "*Coupled climate-to-fish-to-fishers models for understanding mechanisms underlying low frequency fluctuations in small pelagic fish and projecting its future*", co-convened by the authors of this article, was held immediately prior (April 25, 2010) to the International Symposium on "*Climate change effects on fish and fisheries*" in Sendai, Japan. Low-frequency variability of abundance of small pelagic fish is one of the most emblematic and best-documented cases of population fluctuations not wholly explained by fishing effort. Over the last 25 years, diverse observations have led to several hypotheses. However, because of limited-duration time series, testing hypotheses has proven extremely difficult with available statistical and empirical tools. As a result, the mechanistic basis for how physical, biogeochemical, and biological factors interact to produce the various patterns of synchronous variability across widely separated systems remains unknown. Identification of these mechanisms is necessary for exploring projections and building scenarios of the amplitude and timing of stock fluctuations and their responses to human interactions (fisheries) and climate change. The workshop was intended to compare state-of-the-art modeling tools and discuss what expertise is necessary to tackle this important scientific and environmental problem.

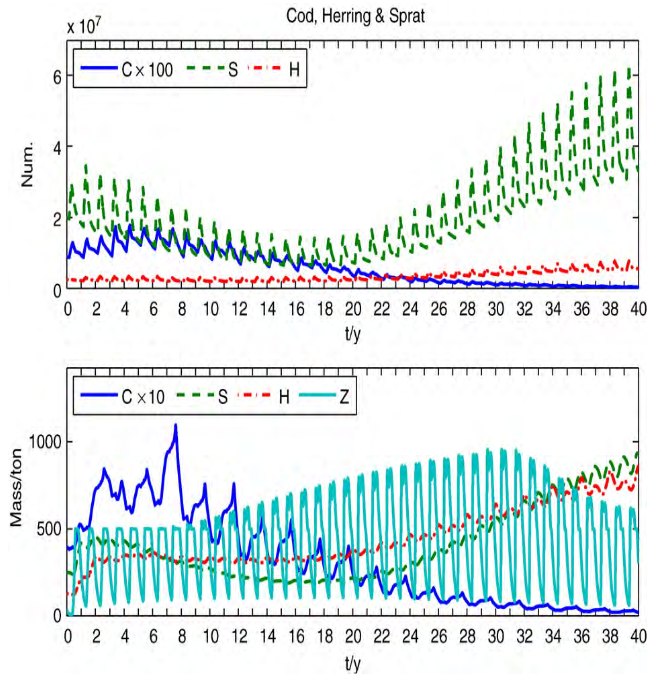

Fig. 1 The variation of total abundance of cod, sprat, and herring (upper, per km^3) and the variations of the total biomass of cod, sprat, herring, and zooplankton (lower, per km^3) derived from hindcast by Fennel's NPZDF model (W. Fennel, Journal of Marine Systems, 2010, 81, 184–195).

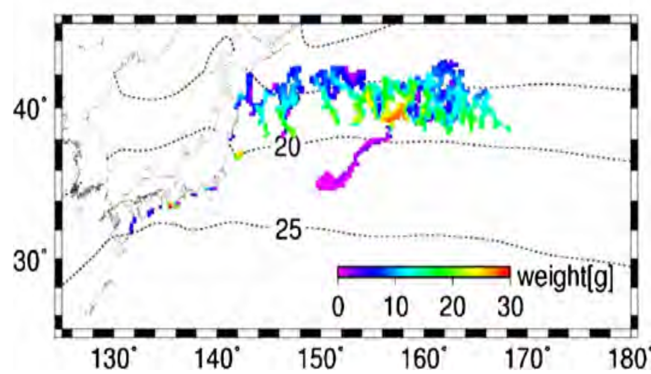

Fig. 2 Seasonally mean spatial weight distributions of Japanese sardine (0-year-old) in autumn simulated by a super-IBM model. The contours show climatological seasonal sea surface temperature from the World Ocean Atlas 2005 (Okunishi et al., Ecological Modelling, 2009, 220, 462–479).

The workshop, attended by about 50 scientists, started with an opening address by the convenors. Six oral presentations were given. Ryan Rykaczewski used bioenergetic models to compare anchovy and sardine growth potential in the California Current region and suggested that anchovy growth is dependent on the community structure of near-shore eutrophic waters, and that sardine growth is possible under offshore oligotrophic conditions. Additionally, he discussed the importance of accurate representation of plankton size structure for mechanistic models of sardine and anchovy populations.

Wolfgang Fennel introduced a NPZDF (nutrient, phytoplankton, zooplankton, detritus and fish production) model with two-way coupling between prey and predators, hence, mass balance between NPZD and fish or prey fish and predator fish are conserved. The model was applied to the Baltic Sea, where the fish dynamics is dominated by two prey (sprat and herring) and one predator (cod). To demonstrate performance of the model, the effects of eutrophication and fishery scenarios were addressed (Fig. 1).

Three 3-D NPZDF models were presented by George Triantafyllou, Shin-ichi Ito and Kate Hedström. Triantafyllou *et al.* introduced a super Individual-Based Model (IBM) of the European anchovy in which particles representing fish have information of fish population, adding to those of age, position, length, and weight of the fish. This Lagrangian model is coupled to a biophysical model based on the Princeton Ocean Model (POM) and the European Regional Seas Model (ERSEM). Moreover, the ERSEM was assimilated to satellite-derived phytoplankton density. Ito *et al.* introduced a super-IBM of the Japanese sardine (Fig. 2) and clearly showed the significance of the density-dependence effect on fish distribution and growth. They also demonstrated the importance of predators on migration of prey fish. Hedströme *et al*. used a community biophysical model; the Regional Ocean Modeling System (ROMS) for the physical circulation model and NEMURO (North Pacific Ecosystem Model for Understanding Regional Oceanography) for the NPZD model. They intend to include a fishery effect in their model and extend it to an end-to-end model. They noted difficulties of such a state-of-art NPZDF model, including spatially locating eggs after spawning and scaling the predator–prey interactions among fish species.

In the final talk, Kenneth Rose addressed issues that arise with developing complicated models in general, and new issues specific to the development of end-to-end models.

Open discussion was held in the afternoon session. Based on the presentation by Rose, participants discussed end-to-end models and how they deal with different issues, particularly zooplankton dynamics and linkages with upper and lower trophic levels. Several attendees expressed concern over the uncertainty and increasing error derived from coupling different models, especially when outcomes from one model are used as input for a chain of other models. Also, strong concern was expressed on how to evaluate performance or validate the models because of the multi-scale nature of these models. No single data set seems to be sufficient. After recognizing the valuable review by Plagányi (FAO Fish. Tech. Paper 477, 2007), the group discussed the need to quantitatively compare performance of models for different processes and promote the use of the best modeling approach option for each question. In this sense, keeping modeling approaches diverse was considered a better strategy than agreeing to a single model. Assemblages of models, as done by the climate community, does not seem to be a feasible approach for end-to-end models. However, the group believed it would be useful for small pelagic fish and climate change research to compile and/or develop different models for at least some of the major small pelagic fishing regions, specifically the Benguela, California, Humboldt, and Kuroshio/Oyashio Currents.



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Dr. Enrique Curchitser (enrique@marine.rutgers.edu) is a physical oceanographer at Rutgers University in New Jersey, U.S.A. In spite of living near the Atlantic, most of his work focuses on the Pacific Ocean. His main interests are the intersection of climate and biology, regional climate impacts, and numerical modeling. His current projects range from downscaling climate scenarios in the northeastern Pacific and Bering Sea to trying to understand the low-frequency fluctuations in global sardine populations. Enrique is a member of PICES Working Group on Evaluation of Climate Change Projections.

Dr. Shin-ichi Ito (goito@affrc.go.jp) is Chief Scientist of the Physical Oceanography Section at the Tohoku National Fisheries Research Institute of the Fisheries Research Agency of Japan. Shin-ichi completed his graduate work in physical oceanography at Hokkaido University and became an observational physical oceanographer at the institute. His main field is the Oyashio Current and the mixed water region. He has deployed more than 30 moorings and is handling a water glider. His research includes development of a fish growth model coupled to the lower trophic level ecosystem model NEMURO.FISH (North Pacific Ecosystem Model for Understanding Regional Oceanography.For Including Saury and Herring). Shin-ichi is Co-Chairman of the ESSAS Working Group on Modeling Ecosystem Response. Within PICES, he serves on the Physical Oceanography and Climate Committee (POC), FUTURE Advisory Panel on Status, Outlooks, Forecasts, and Engagement (SOFE-AP), and joint PICES/ICES Working Group on Forecasting Climate Change Impacts on Fish and Shellfish (WGFCCIFS).