ESSAS meets in Hakodate, Japan

by George L. Hunt, Jr., Egil Sakshaug, James E. Overland, and Bernard A. Megrey

Professor Yasunori Sakurai hosted the Second Annual Meeting of the GLOBEC regional program, ***E****cosystem* ***S****tudies of* ***S****ub-***A****rctic* ***S****eas* (ESSAS), from June 4–9, 2007, in Hakodate, Japan. The welcoming address by the Vice-Mayor of Hakodate, Mr. Toshiki Kudoh, was followed by opening remarks from Profs. Sakurai and George L. Hunt who introduced the co-convenors of a 2-day (June 4–5) workshop on "*The role of seasonal sea ice cover in marine ecosystems*": Egil Sakshaug (Norway), Sei-ichi Saitoh (Japan) and John Bengtson (U.S.A.). A total of 67 people attended the workshop, including a number of graduate students from the Hokkaido University Graduate School of Fisheries Sciences.

The first day was dedicated to 15 invited talks by scientists from France, Japan, Korea, Norway and U.S.A., on sea ice, physical oceanography, and ice-biota in sub-arctic seas. There was one overview by Louis Legendre, 3 talks on "monitoring and methodological progress", 5 talks on "physical characteristics", 4 talks on "phytoplankton, zooplankton", one talk on "fish", and 3 talks on "marine mammals and seabirds". An important benefit of the workshop was the opportunity to learn about recent results from Japanese research in the Bering Sea and the Sea of Okhotsk.

A common denominator for the workshop was to clarify the underlying mechanisms that regulate fluctuations in productivity and biomass at different trophic levels, especially the role of changes in seasonal sea ice cover brought about by climate fluctuations. Furthermore, the workshop participants discussed the possibility of writing

Participants at the ESSAS Second Annual Meeting in Hakodate, Japan, June 4–9, 2007.

review papers for refereed journals, with the expressed goal of distilling new knowledge by synthesizing existing information from different seas. To this end, during the second day, the participants divided into two groups to discuss the possibility of writing two papers that will focus on “Hotspots” and “Thresholds of change”, respectively. Both groups emphasized the need to identify mechanisms to improve the models that are needed to assess the impact of climate change in the Arctic.

The **Hotspots** group suggested a paper tentatively titled “*Mechanisms of hotspot generation in subarctic seas – relationships with sea ice*”, with hotspots defined as areas of high productivity and/or biomass. The rationale was that hotspots are spatially and numerically limited and therefore tractable for observation, modeling, and hypothesis testing. Moreover, hotspots are important to food webs in SAS ecosystems overall, playing roles in the resilience of fisheries and the success of species at higher trophic levels. Among the hotspots under debate were Hudson Strait, the Kurile Islands, Unimak Pass, Shiretoko and the NOW Polynya, which offer examples of more or less different underlying mechanisms for high productivity and biomass. Also considered were “hotbands” (greenbelts), such as those along the western shelf break of the Barents Sea north to Fram Strait, across the Bering Sea, the Sea of Okhotsk and the Greenland slope/shelf, and moving fronts associated with the retreating ice edge, where the ice-edge bloom follows the retreating ice.

The **Thresholds for change** group suggested a paper tentatively titled “*Non-linear biological responses to sea ice [climate] change in Sub-Arctic seas*”, to focus on how non-linear biological responses in sea ice ecosystems may be triggered by climate change when certain thresholds are exceeded. Moreover, the group suggested initiation of a threshold information database for the Sub-Arctic seas. The topic of thresholds is important because there is a high probability of exceeding critically important biological thresholds in Sub-Arctic marine ecosystems during the next 50 years. The paper will define what the thresholds are and will discuss how statistical and dynamical climate models can be applied to estimate the probabilities of future changes in the thresholds. Thresholds can be evident by a failure or switch in annual production, or in altered population status through several years (*i.e.*, regime shift). Non-linear thresholds are evident, for example, in the relationship between sea ice and black guillemot nesting, certain species of fish and *Calanus* species, and the requirements of seals and polar bears for sea ice cover. A crucial question is how statistical and dynamic climate models can be applied to estimate the probabilities of future changes in thresholds.

On June 6, the ESSAS Working Group 1 on *Regional Climate Prediction* (WGRCP) held a 1-day workshop to provide quantitative estimates of the magnitude and uncertainty of future climate change, and the frequency distribution of the large natural variability known to influence marginal seas in the ESSAS region of interest. A major resource for the development of these future climate scenarios is the recent output from 22 state-of-the-art coupled atmosphere–ocean climate models which are part of the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4). The workshop provided background material on the IPCC AR4 process and results, investigated the state of the art in high resolution physical models of the ESSAS seas, and charted a path forward for WGRCP during the next 2 years.

During the workshop, Vladimir Kattsov, John Walsh, Tore Furevik (*in absentia*) and James Overland reported on the AR4. The process involved 450 lead authors, 130 countries, and represented 6 years of work. The physics was first published in February 2007, while direct results from the 22 climate models have been available for review over the last 2 years. A major AR4 conclusion is that most of the observed increase in global average temperature since the mid-20th century is very likely due to observed increase in anthropogenic greenhouse gas concentrations contributed by humans. Observed changes in high latitude regions over the last 45 years are shown in **Figure 1**.

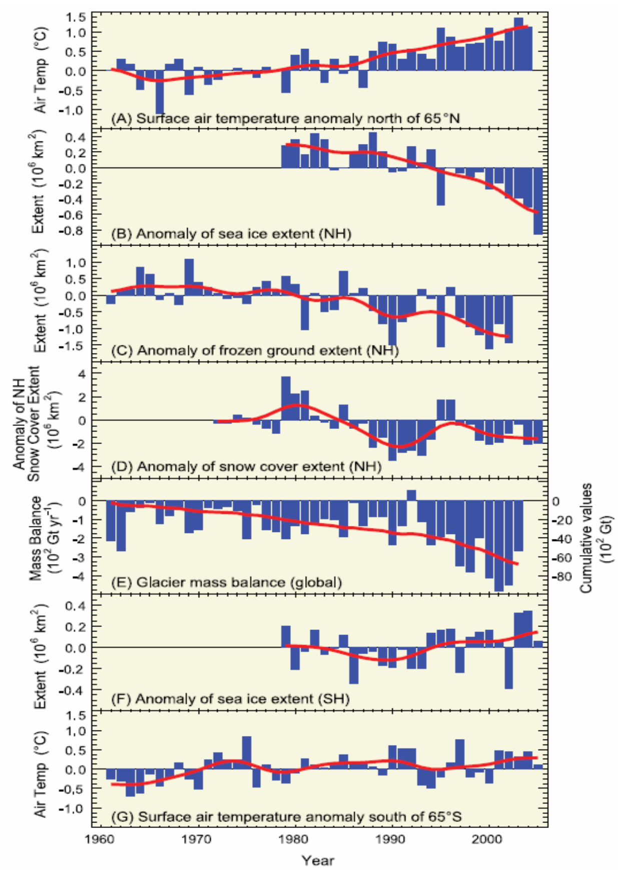

Fig. 1 IPCC summary of recent variations in polar temperatures and cryospheric variables. Note change of more than 1°C in temperature and 20% in ice loss in the North, but no systematic changes in the South.

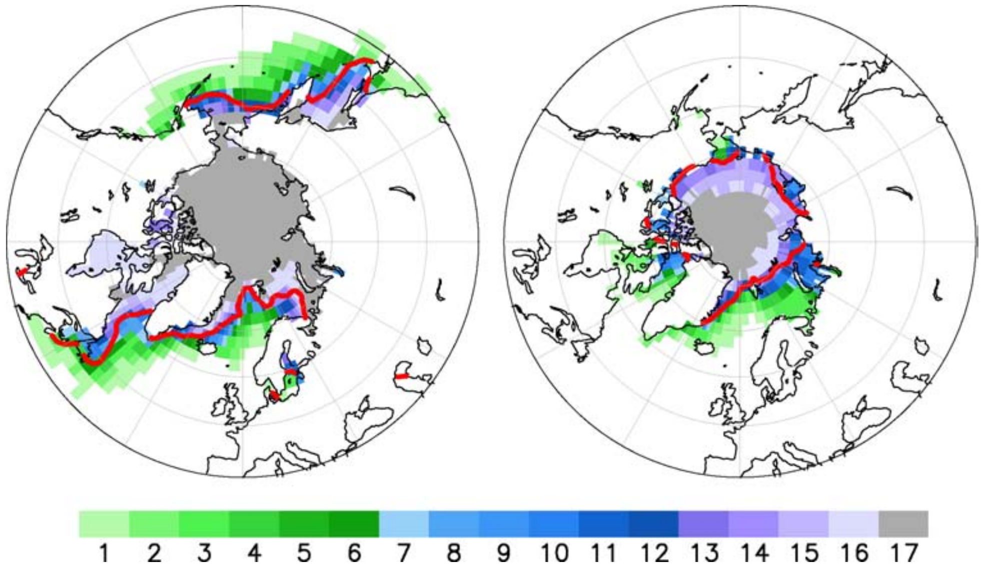

Fig. 2 Sea ice in 17 IPCC AR4 models compared to recent data (red line) for March (left) and September (right). The colors indicate how many models have ice this far south. Note that about 5 of the models have too much ice in the Pacific and the western Atlantic in winter. The Barents Sea has a large percentage of models that have too much ice in both seasons.

The AR4 forecast models appear to be much improved from the Third Assessment Report of 6 years ago in terms of spatial resolution, better ice parameterization and ocean physics. Because of a lag effect, climate projections to 2050 depend more on known CO_2 concentration increases than differences in economic or conservation scenarios. Thus, the largest uncertainties in future climate projections are from model-to-model differences. Models that are run several times with slightly different starting conditions (termed ensembles) seem to capture some of the natural variability in climate when the models are compared to 20th century data. **Figure 2** shows that the models vary in terms of how much ice they produce relative to recent observations.

The first conclusion from the workshop was that, while there are still problems with the details of some of the variables, there is utility for ESSAS in the temperature, sea ice, and perhaps ocean stratification projections from a subset of the IPCC AR4 models. This conclusion was based on model improvements compared to previous IPCC reports, comparisons with data, the large community involvement in AR4, and the modeling of key processes, such as greenhouse warming and ice–albedo feedback.

The second conclusion was that there are a number of outliers among the group of models compared to 20th century data, and that a carefully crafted set of rules for the selection of appropriate models would be helpful to constrain the uncertainty in future climate projections. There were several approaches suggested to address this issue, such as the use of a single indicator versus multivariate statistical fitting, and seeking region-specific output versus inter-regional consistency in output. Exploration of these rules and their statistical rigor is a challenge for WGRCP for the next year.

Paul Budgell, Hisashi Nakamura and Junlin Zhang discussed high resolution modeling of the Barents Sea/North Atlantic, waters near Japan, and the Bering Sea, respectively. The Barents Sea ROMS (**R**egional **O**cean **M**odel **S**ystem) model is nested down to a 4-km resolution. Hindcasts of ice variability are handled well by the model, given good meteorological forcing. The difficulty with downscaling the IPCC results to the Barents Sea model is associated with the selection rules mentioned above. Most IPCC models over-predict the extent of cold temperatures. Models of Japanese waters predict an intensification of the Kuroshio with global warming; realistic simulations require an eddy resolving model ($0.1° \times 0.1°$). The Bering Sea model has a multi-category sea ice thickness, tides, and a POP (**P**arallel **O**cean **P**rogram) ocean model. It is able to describe some of the basic features of sea ice advance and retreat, ocean circulation, and SST. These regional models are areas of ongoing research. The third conclusion of the workshop was that further refinement of these models should be encouraged to couple (downscale) these models to the range of variability shown by the IPCC models.

Muyin Wang, George Hunt and Kenneth Drinkwater (*in absentia*) discussed the climatology of the ESSAS regions and how the physics may be coupled to the biology. In the example of cod (*Gadus morhua*) in the Atlantic, climate shifts at the extreme southern and northern ranges show the most biological sensitivity. Thus, identifying particular climate thresholds for different species may be a more relevant approach than requiring overall high accuracy from the models. It was pointed out that it is important for the modeling group to learn from the biologists where, when, what variable(s) and why (species and impact) potential ecosystem stress points may occur.

ESSAS Science Steering Committee linking research activities in the Sub-Arctic seas.

The priorities for WGRCP are to: 1) pursue and evaluate a range of IPCC AR4 model selection rules for ESSAS regions; 2) work with other ESSAS Working Groups on matching potential biological impacts from climate change to the limits of credible projections from IPCC; and 3) explore the general area of downscaling, particularly in the context of high resolution ocean models. Strong collaboration with the PICES Working Group 20 on *Evaluations of Climate Change Projections* is anticipated.

ESSAS Working Group 3 on *Modeling Ecosystem Response* (WGMER) convened a ½-day workshop on June 7, led by Bernard Megrey, Sei-Ichi Ito and Kenneth Rose, to develop a strategy for WG 3. They reviewed recent efforts to model marine ecosystems and to compare ecosystems using models of ecosystem function. One presentation concerned the status of the MENU (**M**arine **E**cosystems of **N**orway and the **U**S) program, one focused on collaborative opportunities with ESSAS Working Groups 1 and 2, one discussed a JGOFS model comparison experiment, and the final presentation reviewed some NEMURO applications, comparison of models from the NEMURO family of models, and the EUROCEANS "model shopping" web page (http://www.eur-oceans.eu/WP3.1/shopping_tool/index.php?mode=fromEuroceans). The remainder of the plenary covered topics such as the draft terms of reference, preparing a proposal to create an IOC/SCOR Working Group on *High Latitude Ecosystems*, membership suggestions, and developing an Action Plan.

The final 1½ days were devoted to the ESSAS Science Steering Committee meeting to evaluate activities to date and to formulate plans for the future. Of immediate interest to the PICES community is the plan to have the next ESSAS Annual Meeting from September 15–19, 2008, in Halifax, Nova Scotia, Canada. The main purpose for this meeting is to revisit progress on the threshold and hotspot syntheses papers, and to focus on the roles of advection in Sub-Arctic seas. Since advective processes are important in all of the Sub-Arctic seas and in a number of additional PICES regions as well, it is hoped that PICES members will join ESSAS in Halifax.

The Hakodate experience was enlivened by a fine reception and by a visit to a hot springs spa followed by a traditional Japanese dinner. On Saturday, Professor Sakurai guided a lucky group to a fishermens' festival in a small fishing port where we were invited to sample numerous seafood delicacies barbequed along the wharves of the village. Professor Sakurai then took us to visit a hot springs spa near Oonuma Lake National Park and, after a refreshing soak, we walked some of the many footpaths around the lake.

Traditional Japanese dinner after bathing in the hot springs of Hakodate. Photo by Muyin Wang.

The meeting participants greatly appreciated the generous hospitality of Japanese colleagues at the Hokkaido University Graduate School of Fisheries Sciences. Support for the meeting was provided by the GLOBEC IPO, the city of Hakodate, the North Pacific Research Board, the NOAA Alaska Fisheries Science Center, and PICES. The ESSAS SSC is grateful for this vital support of our scientific activities.