GLOBEC-ESSAS meets in Hakodate, Japan

George L. Hunt, Jr.[1], Egil Sakshaug[2] and James Overland[3]

[1]University of Washington, Seattle, USA (glhunt@uci.edu)
[2]Norwegian University of Science and Technology, Trondheim, Norway
[3]Pacific Marine Environmental Laboratory/NOAA, Seattle, WA, USA

Professor Yasunori Sakurai hosted the second annual meeting of the GLOBEC regional programme Ecosystem Studies of Sub-Arctic Seas (ESSAS), in Hakodate, Japan, from 4 to 9 June 2007. The ESSAS Hakodate meeting was opened with a welcome address by the Vice Mayor of Hakodate, Toshiki Kudoh, followed by welcoming remarks by Professor Yasunori Sakurai and George Hunt. The sea-ice workshop, which was co-convened by Egil Sakshaug, Sei-ichi Satoh and John Bengtson, followed immediately. A total of 67 people attended the workshop, including a number of graduate students from the Hokkaido University Graduate School of Fisheries Sciences.

Attendees at the ESSAS Workshop, Hakodate, Japan, 4-7 June 2007.

The first day of the workshop included 15 invited talks by scientists from France, Japan, Korea, Norway, and the USA on sea ice, physical oceanography, and ice-biota in sub-Arctic seas. Louis Legendre gave an introductory overview of the ecology of sea ice systems, and then there were talks on "monitoring and methodological progress", "physical characteristics", "phytoplankton and zooplankton", "fish" and "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 discussed the possibility of writing review papers for refereed journals, with the expressed goal of distilling new knowledge by synthesising existing knowledge from different seas. To this end, the workshop split into two groups during the second day to discuss the possibility of writing two review papers, focusing on "Hotspots" and "Thresholds of change", respectively. Both groups emphasised identification of mechanisms that are crucial for improving models and relevant for modelling the biological impact of climate change in the Arctic.

The Hotspot group suggested a paper, *Mechanisms of hotspot generation in subarctic seas – relationship with sea ice*, with hotspots here defined as areas of high productivity and/or biomass. The rationale was that hotspots are spatially and numerically limited and therefore tractable to scientific study and to model and hypothesis testing. Moreover, hotspots are important to food webs in sub-Arctic sea ecosystems overall, including the resilience of fisheries and the success of species at higher trophic levels. Among the hotspots under debate were the 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 "hotbands" (greenbelts) were considered, 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 such as those associated with the retreating ice edge, where the ice-edge bloom follows the retreating ice.

The thresholds for change group suggested a paper entitled *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. The group, moreover, 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 fifty years.

The paper will define what the thresholds are and will also 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, among many, the relationship between sea ice and black

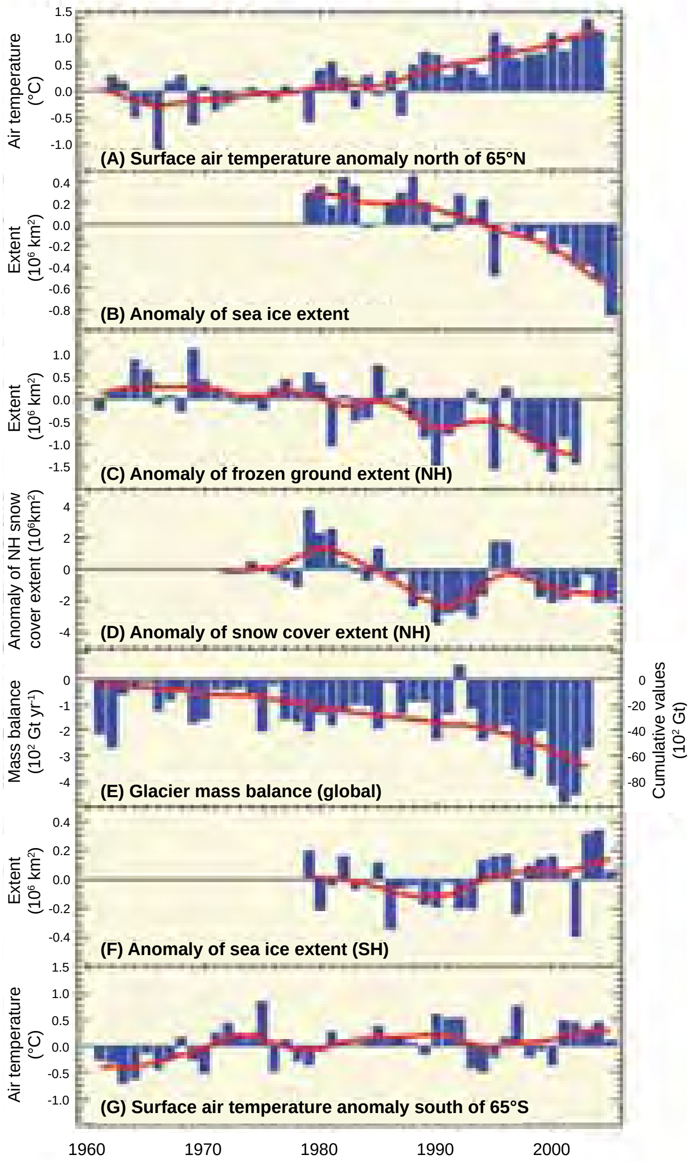

Figure 1. IPCC summary of recent variations in polar temperatures and cryospheric variables. Note, a change of more than 1 degree C temperature and 20% ice loss in the north, but no systematic changes in the south.

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 Wednesday, 6 June, the ESSAS Working Group 1 on Regional Climate Prediction (WGRCP) held a one-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 the ESSAS marginal seas. A major resource for the development of these future climate scenarios is the recently available 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 regions, and charted a path forward for the WG during the next two years.

During the workshop, V. Kattsov, J. Walsh, T. Furevik (*in absentia*), and J. Overland reported on the AR4. The process had 450 lead authors, 130 countries contributed, and the report represented six years of work. The physical science basis was published in February 2007, while the direct results from the 22 climate models have been available for review over the last two 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 green house gas concentrations. Observed changes in high latitude regions over the last 45 years are shown in Figure 1.

The AR4 forecast models appear to be much improved from the Third Assessment Report of six years ago in terms of spatial resolution, better ice parameterisation and ocean physics. Because of a lag effect, climate projections out 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 reports, comparison with data, the large community involvement in AR4, and the modelling of key processes such as greenhouse warming and ice-albedo feedback. The second conclusion was that there are an 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 possibilities for selection approaches suggested to address this issue such as the use of a single indicator versus multivariate statistical fitting and seeking regional-specific output versus inter-regional consistency in output. Exploration of these rules and their statistical rigor is a challenge for the Working Group for the next year.

P. Budgell, H. Nakamura, and J. Zhang discussed high resolution modelling for the Barents Sea/North Atlantic, waters near Japan, and the Bering Sea. The Barents is a nested ROMS model at 4 km resolution. Hindcasts of ice variability are handled well by the model, given good meteorological forcing. The difficulty for downscaling the IPCC results to this model relates to the selection rules mentioned above, as most IPCC models over-predict the extent of cold temperatures. The models for Japanese waters predict an intensification of the Kuroshio with

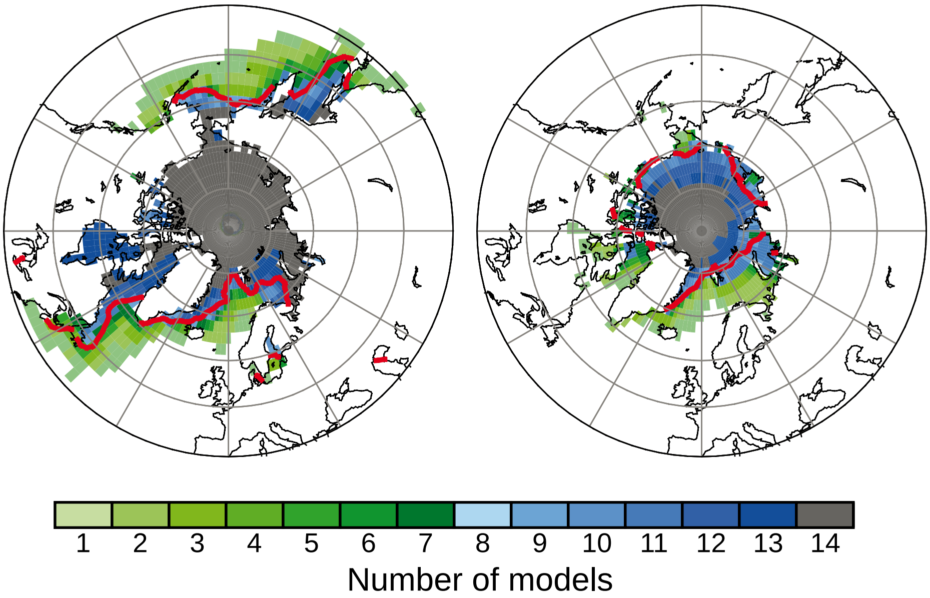

Figure 2. Sea ice in 17 IPCC AR4 models compared to recent data (red line) for March (left) and September (right). The colours indicate how many models have ice this far south. Note that about 5 of the models have too much ice in the Pacific and the western Atlantic in winter. The Barents Sea has a large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

global warming; realistic simulations require an eddy resolving model (0.1 x 0.1 degree). The Bering Sea model has a multi-category sea ice thickness, tides, and a POP 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 active areas of research, and the third conclusion of the workshop was that further work with these models should be encouraged and that planning of coupling (downscaling) of these models to the range of variability shown by the IPCC models should be explored.

M. Wang, G. Hunt and K. 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 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. In the Pacific, it was pointed out that it is important for the modelling group to know from the biologists where, what months, what variable(s) and why (species and impact) potential ecosystem stress points may occur.

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

During the morning of 7 June, ESSAS Working Group 3 on Modelling Ecosystem Response convened a half-day workshop under the leadership of B. Megrey, S.-I. Iito and K. Rose. The purpose of the workshop was to develop a strategy for future work by WG3. Thus, the workshop reviewed recent efforts to model marine ecosystems and conduct comparisons of ecosystems using models of ecosystem function. During the plenary, four presentations were made. One concerned the status of the MENU (Marine Ecosystems of Norway and the US) programme, one covered possible collaborative opportunities with working groups 1 and 2, one discussed a JGOFS model comparison experiment, and the final presentation discussed some NEMURO applications, comparison of models from the NEMURO family of models, and the EUR-OCEANS model shopping tool 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, the possibility of preparing a proposal to create an IOC/SCOR working group on high latitude ecosystems, membership suggestions, and the preparation of an action plan.

The final day and a half of the meeting was devoted to the ESSAS Science Steering Committee that evaluated the activities of ESSAS to date and formulated plans for the future. It was agreed to hold the next ESSAS Annual Meeting in Halifax, Nova Scotia, from 15 to 19 September 2008. This meeting will revisit the progress on the threshold and hotspot syntheses papers, and will focus attention on the various roles that advection plays in the sub-Arctic seas. Plans are underway to show off North Atlantic hospitality and local seafood specialities.

The Hakodate meeting was enlivened by a fine reception on the Monday evening and on the Tuesday evening by a visit to a hot spring spa followed by a traditional Japanese dinner that was greatly enjoyed by all. On Saturday, Professor Yasunori Sakurai guided a lucky group of participants to a fisherman's festival in a small fishing port where we were invited by the revellers to partake of numerous seafood delicacies barbequed on the docks of the village. Professor Sakurai then took us to visit a hot spring spa near Oonuma Lake National Park and after a refreshing soak, we walked some of the many footpaths around the lake.

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