ESSAS

(*Ecosystem Studies of Sub-Arctic Seas*)

Scientific Steering Committee

2008 Annual Meeting Report

Halifax, Nova Scotia, Canada

18-19 September 2008

Margaret M. McBride & Ken Drinkwater, Compilers

January 2009

Table of Contents

1. Participation

Members in Attendance:

- Olafur Astthorsson (Iceland)
- Ken Drinkwater (Norway)
- Erica Head (Canada)
- George Hunt (USA)
- Bernard Megrey (USA)
- Jim Overland (USA)
- Yasunori Sakurai (Japan)
- Hyung-Cheol Shin (Korea)
- Kai Wieland (Greenland)

Members Unable to Attend:

- Astrid Jarre (Denmark)
- Vladimir Radchenko (Russia)

Invited Guests:

- Manuel Barange (GLOBEC IPO)
- Enrique Curchitser (USA)
- Earl Dawe (Canada)
- Franz Mueter (USA)
- Ian Perry (GLOBEC Chair)
- Ray Sambrotto (USA, BEST)

ESSAS Project Office

- Margaret McBride (Norway/USA)

2. Introduction

This 4th annual meeting of the ESSAS SSC was held in Halifax, Nova Scotia, Canada (18-19 September) immediately following the 2008 ESSAS General Science Meeting. These meetings were scheduled in conjunction with the ICES Annual Science Conference held in Halifax the following week. George Hunt opened the meeting and introduced the members and guests. After the adoption of the Agenda (Appendix 1), reports were heard from each of the national and international programs affiliated with ESSAS. These were followed by a recap and discussion of the ESSAS Workshops that had been held over the preceding three days. On the second day of the SSC meeting, members discussed future activities and direction of ESSAS.

Since the June 2007 SSC meeting, a new working Group was formed, and its Terms of Reference accepted by the SSC (Appendix 4). Formal affiliations have

been continued with five national programs: BEST (Bering Sea Ecosystem Study, USA); BSIERP (Bering Sea Integrated Ecosystem Research Program, USA); ISE (Iceland Sea Ecosystem study); J-ESSAS (Japan-ESSAS); N-ESSAS (Norwegian-ESSAS). Formal affiliation with three multinational programs have been continued: ESSAR (the IPY consortium, Ecosystem Studies of Sub-arctic and Arctic Regions); MENU (Marine Ecosystems of Norway and the US); and NORCAN (Norway-Canada Comparative Study of Marine Ecosystems).

3. New ESSAS Working Group 4

Climate Effects at Upper Trophic Levels (WG CUTL)
Co-Chairs: Earl Dawe (Canada) and Franz Mueter (USA)

Background

Several sub-arctic ecosystems have experienced major 'regime shifts' in fishery resources between demersal fishes and crustaceans. Examples include recent changes on the Newfoundland-Labrador shelf from fisheries dependent on cod and other demersal fishes to dependence on shrimp and crab. The reverse was evident in the eastern Bering Sea where fishery dependence changed from crabs to walleye Pollock. Several recent studies have advocated that such changes in ecosystem structure are regulated at high trophic levels by predation pressure ('top-down' effects). However there is also evidence that such changes in ecosystem structure may be largely due to effects of ocean climate variation on early life history stages and lower trophic levels (bottom-up effects). Either of these effects would operate in conjunction with effects of fishing in regulating the biomass of demersal fish and crustacean resources.

Objective

The objective of this working group is to assess the effects of ocean climate variation and fishing on the interactions between gadoid fishes and crustaceans by conducting a comparative study across multiple sub-arctic marine ecosystems.

The hypothesis is that Gadoid fish and crustaceans respond in opposite ways to ocean climate variation. Such variation results in differences in productivity and abundance between gadoids and crustaceans. The more specific working hypothesis is that a cold oceanographic regime favors production and survival of early life history stages of crustaceans whereas a warm regime favors production and survival of early life history stages of gadoid fishes.

Approach

The working group, consistent with the broader ESSAS principle, will take a comparative approach. Comparisons will be conducted across multiple ecosystems and between two species groups, gadid fishes and crustaceans, as well as among multiple species or 'stocks' within each group, where applicable.

As a basis for comparative analyses, the best available time series from each system will be compiled, including species-specific abundance indices, fisheries catch data, and ocean climate variables. Additional variables that could impact any life history stage (eggs, larvae and early demersal/benthic stages, adults), such as indices of mortality due to predation and fishing will be included where available.

The analysis would delineate sub-groups between and within the two major species groups that show common associations with ocean climate variables. Similarities and differences (between and within ecosystems and species groups) will help identify ecosystem features that are related to the functional mechanisms governing gadoid – crustacean interactions and dynamics. Linkage with other ESSAS Working Groups, and other studies, will be essential to determining functional mechanisms.

Activity to Date
Initial discussions regarding interest in a collaborative project such as this one first took place during the ESSAS annual meeting in St. Petersburg, Russia, in June 2006. An initial planning meeting was held in Anchorage, Alaska, in December 2007, with participation only from representatives of the Eastern Bering Sea and the Newfoundland-Labrador Shelf. Subsequent efforts have been limited and focused on recruitment of WG members. The last members were recruited during the 2008 ESSAS annual meeting in Halifax. Membership is now complete (Appendix 5). Terms of Reference were developed in March 2008 (Appendix 5). A student has been recruited to compile and analyze data and will be supervised by Franz Mueter, University of Alaska Fairbanks.

Membership: (Co-chairs in bold)
Eastern Bering Sea & Gulf of Alaska *(**F. Mueter**, J. Zheng, S. Sideek, D. Urban)*
Labrador/Newfoundland *(**E. Dawe**, D. Stansbury)*
Barents Sea *(C. Hvingle)*
Iceland / East Greenland *(O. Astthorsson)*
West Greenland *(A. Burmeister, K. Wieland)*
Oyashio Current region *(Y. Sakurai, O. Yamamura)*
Sea of Okhotsk *(V. Ozhigan, B. Berenboim)*
General modeling expertise and link to working group 3 *(Enrique Curchister)*

A general discussion followed a presentation given by Earl Dawe stating rationale, objective, approach, initial activities and membership Working Group 4:

- **ACTION:** Franz Mueter will send Margaret minutes from a WG4 planning meeting in Anchorage, Alaska, in December of 2007.

- **MOTION:** George Hunt made the motion that WG-4 formally be adopted as a part of ESSAS. **MOTION PASSED**.

- **QUESTION**: How many Working Groups does ESSAS need? **RESPONSE**: There is a limit to how broad ESSAS can get without fractionating into separate disciplinary groups that would have limited interaction. It was agreed that no specific limits should be set at this point.

4. SSC Membership

George Hunt encouraged members of the SSC to become more active, noting that certain members exhibit a lack of responsiveness to e-mails. The status of Astrid Jarre was discussed specifically with respect to her pattern of not attending ESSAS meetings. The question posed as to whether or not she should be asked to rotate off the SSC. It was agreed that no rotations will be made at this point, but some clarification from Dr. Jarre will be requested.

MOTION: That Earl Dawe be appointed to the SSC as representative of WG-4. **MOTION PASSED.**

ACTION: The question of additional SSC members for countries not currently represented prompted discussion and recommendations. Specific names mentioned were: Søren Rysgaard (Greenland); and Jinping Zhao (China). Ken Drinkwater will look into the potential of extending formal invitations to both.

5. National Programs

Korea

Hyung-Cheol Shin

Korea shares the concerns of other countries associated with sub-Arctic waters:

- Inflow of warmer water from the Pacific or Atlantic Oceans that affect a general decline in levels of sea ice; and
- Associated alterations in ecosystem functioning and levels of biodiversity.

In response, the Korean Ocean Affairs Ministry provides support, in form of a research grant, for a multi-disciplinary project being carried out by the Korea Ocean Research & Development Institute (*KORDI*) which collaborates with research institutions and universities in Russia, Japan and Canada. Korea's research program in sub-Arctic seas has often been conducted using borrowed platforms:

- Studies of the Barents Sea, Svalbard region, and the Okhotsk Sea have been conducted onboard Russian research vessels;

- Studies of the Bering Sea and Chukchi Sea have been conducted onboard a Japanese research vessel, the Oshoro Maru.
- Studies of the Central Arctic have been conduced onboard China's research vessel, the Snow Dragon, which has served as a replacement for the research platform provided earlier through the Russian-American Long-term Census of the Arctic (RUSALCA) project.

Korea has representation on, and collaborates with: the Arctic Ocean Sciences Board; the Pacific Arctic Group; and the ESSAS program. It will also participate at the 2009 Arctic Science Summit Week (ASSW) in Bergen, Norway.

The Korea Polar Research Institute plans to probe the globe on R/V Araon — Korea's first-ever ice breaking research vessel — scheduled to be completed in late 2009. At roughly the size of other Antarctic ice-breaking vessels, Araon (6,950 GMT) will travel 3 knots in 1 meter-thick seasonal ice, and will feature state-of-the-art oceanographic research equipments and facilities onboard:

- A room dedicated to taking Conductivity-Temperature-Depth (CTD) measurements;
- Hull-mounted ADCP (38 kHz) & LADCP (sentinel);
- Underway undulating profiler (EIVA);
- Scientific fish-finder, fisheries sonar;
- MOCNESS, RMT, and Rectangular Mid-water Trawl;
- Uncontaminated seawater supply; and
- Aquarium, Biology Lab, Chemistry Lab, and Cold Lab

Target areas for research will be the:

- Bering Sea, Chukchi Sea, and Canada Basin connection;
- The Okhotsk Sea; and
- The Atlantic side (once every few years)

Monitoring stations will be established up and down the coast to support research on:

- Catastrophic reduction of sea ice and new overlying water masses;
- The contributing factors and what happens next;
- How the northern hemisphere will be changed;
- The relative alignment of data rich areas with others;
- Properties of light enrichment.

Comprehensive and multi-disciplinary consideration will be given to paleo-oceanograpic components of the ecosystem and geological evolution. Constraints include some uncertainty about upper trophic levels/large predators, and opportunities for collaborative exchange.

Korea plans to take a more active role within ESSAS within the next 2 years.

Japan

Yasunori Sakurai

In addition to making a short presentation on J-ESSAS, results from recent research on walleye pollock were provided.

Does the extent of ice cover affect the fate of walleye pollock?

Jun Yamamoto, Mio Osato and Yasunori Sakurai

Introduction

In the late-winter and early spring, walleye pollock, *Theragra chalcogramma*, spawn pelagic, individual eggs at mid-water depths. Some of the spawning grounds occur below sea ice, such as in the Sea of Okhotsk, but the effect of cold, low-saline water derived from melting sea ice on eggs is not well known. The present study examined the effect of cold, low-saline water on the survival and hatching success of walleye pollock eggs.

Materials and Methods

Live adults pollock were collected by rod fishing in late January, 2007 and 2008 at the mouth of the Funka Bay, Southwestern Hokkaido Japan, where is known as the main spawning grounds of the Pacific Stocks occurring around Japan. The fishes were moved to and reared at 5^{o}C and two different salinities (29.1 in 2007 and 33.0 in 2008) in a circular tank (10ton). The natural spawned eggs were collected and maintained under 35 different temperature and salinity conditions (seven temperatures; -1.0, 0.0, 2.0, 5.0, 7.0, 9.0, 11.0^{o}C: five salinities; 24.0, 27.0, 30.0, 33.0, 35.0) to examine the optimal temperature and salinity range for the normal hatching, and the developmental time at the each condition. This study used the developmental stage by Kendall and Kim (1993). To clear the movement of eggs in the spawning grounds, the change of the buoyancy during the development was examined by liner density column (Coobms, 1981). Summary of the density gradient columns were shown in Table 1.

Table 1. Summary of the density gradient columns

Temperature	(^{o}C)	5.0/5.0
Top/Bottom		18.0/42.0
Salinity		14.0/33.0
Top/Bottom		
Dens. (σt)		

The density of the eggs in the column was determined by the density cubes of 14.8, 20.0, 24.9, 30.0σt (Martin Instrument Company). The vertical velocities of the eggs in the spawning grounds, Funka Bay and Nemuro-Strait eastern Hokkaido where is known as the spawning ground of the Nemuro Strait Stock, were estimated using the Stokes law (Sundby 1987).

Results and Discussion

The hatching rate of normal larvae was low below 2^{o}C and high between 2 and 9^{o}C, but showed no significant differences over the salinity range examined (Fig.1), indicating temperature <2.0^{o}C is unfavorable condition for the hatching and the successful of the normal hatching is controlled by temperature rather than salinities. Additionally, there were no differences in the hatching days after the fertilizations and the developmental stages among the salinities, suggesting that developmental time also controlled by temperature.

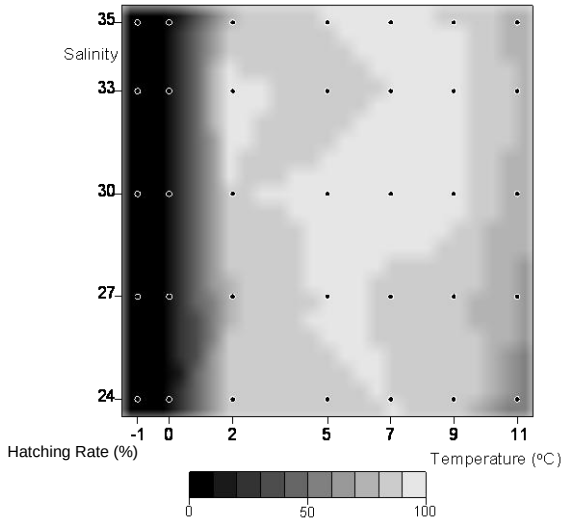

Fig.1. Rate of hatching (%) at 35 different temperature and salinity conditions.

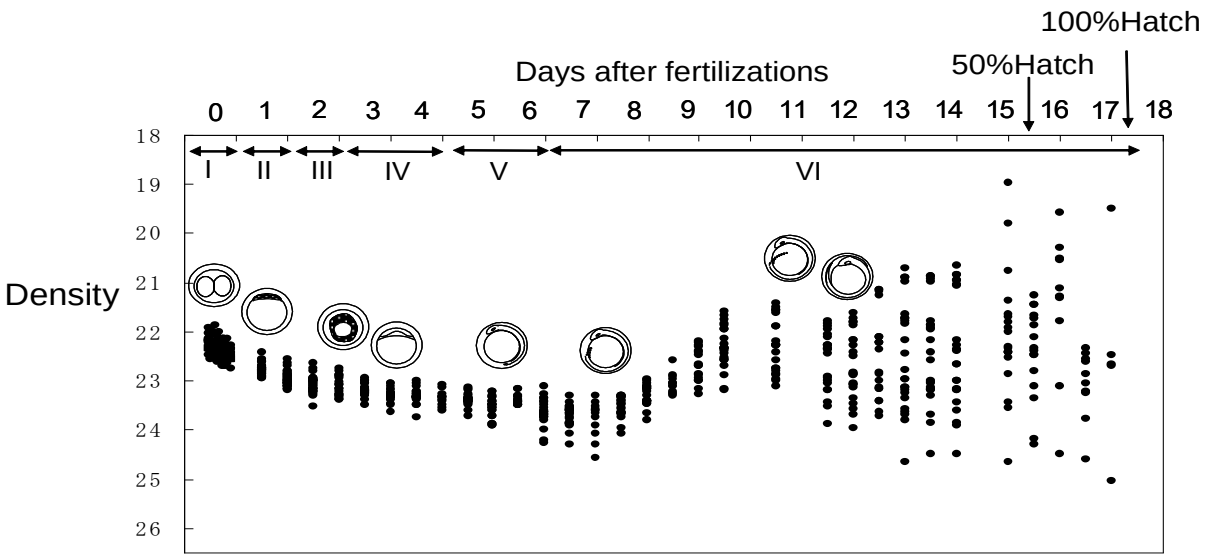

Fig. 2 Changes in egg density (σt) during development. The axis of density is inverted.

Although, eggs were spawned under different water properties in 2007 (Temp. 5^{o}C, Sal. 29.1, Dens. 23.0 σt) and in 2008 (Temp. 5 ^{o}C, Sal. 29.1, Dens. 23.0σt), buoyancy of eggs soon after fertilization showed no difference. Coombs et al. (2004) showed the buoyancy of the eggs is affected by the ratio of the volume of the vitelline mass with almost same osmotic pressure to the adult and the volume of the peri-vitelline space which osmotic pressure is almost equal to the sea water. The pollock eggs have much larger volume of the vitelline mass than that of vitelline space. Thus, the primary buoyancy of egg is probably determined by the adult. The change of the density of the egg during the development was shown in Fig.2. The density ranged 19.0-25.1(σt), and gradually increased by stage VI (late stage), then the densities changed varied. The estimated vertical velocities of egg were 10.8 m/s in the Funka Bay and 9.6 m/s in the Nemuro-Strait, suggesting that the eggs reach the surface approximately 7 hours in the Funka Bay and 21 hours in the Nemuro Strait after spawning. It suggests that eggs were exposed the surface cold water in the early developmental stage.

Nakatani and Maeda (1984) suggested that eggs resist cold temperature after morula stage. The stage of developmental when eggs reach cold water is probably a key factor determining hatching success.

References

Coombs, S. H. 1981. A density-gradient column for determining the specific gravity of fish eggs, with particular reference to eggs of the mackerel *Scomber scombrus*. *Mar. Biol.* **63**: 101-106.

Coombs, S. H., G. Boyra, L. D. Rueda, A. Uriate, M. Santos, D. V. P. Conway and N. C. Halliday. 2004. Buoyancy measurements and vertical distribution of eggs of sardine (*Sardina pilchardus*) and anchovy (*Engraulis encrasicolus*). *Mar. Biol.* **145**: 959-970.

Kendall, A. W. and S. Kim. 1989. Buoyancy of Walleye Pollock (*Theragra chalcogramma*) eggs in relation to water properties and movement in Sherikof Strait, Gulf of Alaska. *Can. Spec. Publ. Fish. Aquat. Sci.*, **108**: 169-180.

Sundby, S. (1983). A one-dimension model for the vertical distribution of pelagic fish eggs in the mixed layer. *Deep-Sea Res* **30(6A)**: 645-661.

Nakatani, T. and T. Maeda. 1984. Thermal effect on the development of walleye pollock eggs and their upward speed to the surface. *Bull. Japan. Soc. Sci. Fish*. **50**: 937-942.

USA
Ray Sambrotto

An outline of the research undertaken as part of the Bering Sea Ecosystem Study (BEST) and the Bering Sea Integrated Ecosystem Research Program (BESIERP) were presented along with some initial results.

- **MOTION:** George Hunt made the motion that BEST and BESIERP both be represented at ESSAS meetings, and that formal contact persons be established. Reports from both programs should be presented at annual ESSAS SSC meetings. **MOTION PASSED**

Canada
Erica Head

Canadian Participation in NORCAN
A group of Canadian scientists from the Bedford Institute of Oceanography (Dartmouth, NS) and the North West Atlantic Fisheries Laboratory (St John's, NFLD) are participating in the NORCAN project. In this project manuscripts are being prepared jointly by scientists from Canada and Norway to compare aspects of the ecosystems of the Labrador/Newfoundland Shelf/Sea with those of the Barents/Norwegian Seas. First drafts of these papers should be finished by the end of 2008. This project is discussed in more detail under multinational activities.

The following papers, based on the NORCAN comparisons, were given during 2008.

Head, E., Pepin, P., Melle, W., Broms, C., Bagøien, E. Comparative analysis of some aspects of the ecology of *Calanus finmarchicus* in Canadian and Norwegian Sub-Arctic Seas – presented at the March Ocean Sciences Meeting.

Head, E., Stenevik, E., Melle, W., Harris, L., Gaard, E., Gislason, A., Broms, C., Prokopchuk, I., Ellertsen, B., Gentleman, W. / A comparison of egg production and egg mortality for *Calanus finmarchicus* in the Labrador and Norwegian Seas – presented at the June ALSO Meeting.

Participation by Canadian scientists in ESSAS Working Group 4
A new Working group on "Relative effects of ocean climate variation on demersal fishes versus crustaceans" has been formed. Earl Dawe (North West Atlantic Fisheries Laboratory, St John's NFLD) will be one of the Co-Chairs of this new working group.

Canadian monitoring programs in the NW Atlantic

The Atlantic Zone Monitoring Program (AZMP)

This program operates on the Canadian Atlantic continental shelf and in the Gulf of St. Lawrence. It includes coastal times series stations, which are sampled about twice per month, sections with stations that are sampled 2-3 times per year and a series of fisheries survey cruises, which sample once or twice a year given areas. Hydrographic profiles are taken, and water and net plankton samples are collected. Reporting is annual at inter-regional meetings and written reports appear in the Research-Documents published by the Canadian Science Advisory Secretariat (http://www.meds-sdmm.dfo-mpo.gc.ca/csas/applications/Publications/publicationIndex_e.asp#RES).

The following papers, based on using the comparative approach within the AZMP area, were published in 2008.

Johnson, C.L., Leising, A.W., Runge, J.A., E.J.H., Pepin, P., Plourde, S., Durbin, E.G. (2008) Characteristics of *Calanus finmarchicus* dormancy patterns in the northwest Atlantic. ICES J. Mar. Sci. 65: 339-350.

Head, E.J.H., Pepin, P. (2008) Seasonal cycles of *Calanus finmarchicus* abundance at fixed time series stations on the Scotian and Newfoundland shelves. AZMP Bulletin No. 7, 17-20.

The Offshore Monitoring Program

This program operates along a transect in the Labrador Sea and in the slope waters beyond the Scotian Shelf. The same suite of measurements is made and the same samples are collected as in the AZMP.

The following paper, based on 10 years of observations in the Labrador Sea was presented at the ICES Annual Science Meeting that followed the ESSAS Annual meeting in Halifax in September 2008.

Head, E., Azetsu-Scott, K., Harrison, G., Hendry, R., Li, W. K. W., Yashayaev, I., Yeats, P. Changes in environmental conditions and the population dynamics of *Calanus finmarchicus* in the Labrador Sea (1990–2006).

New projects for which funding has been secured

Life-history modeling for *Calanus finmarchicus* on the Newfoundland and Scotian shelves and in the Labrador Sea.

This is a collaboration between scientists at DFO and Dalhousie University. A new model has been developed and was presented at the ICES meeting following the ESSAS meeting in Halifax in September 2008:

Neuheimer, A.B., Gentleman, W.C. — Spatial variability in Calanus finmarchicus phenology: application of a new individual-based model (IBM)

Projects within the Department of Fisheries and Oceans related to International

Governance and climate change issues

These include (i) hydrographic, chemical, plankton and benthic surveys of Orphan Knoll, a seamount to the east of the Newfoundland Shelf, (ii) measurements of pH on the Scotian Shelf and in the Labrador Sea and (iii) stable funding in support of the Continuous Plankton Recorder (CPR) survey between St John's and Reykjavik.

Projects at the planning stage

A new program "BASIN" is being developed for the North Atlantic. The goal of this program is similar to that of ESSAS, but covering a different geographical range. The goal of the BASIN program is to understand and predict the impact of climate change on key species of plankton and fish, and associated ecosystems and biogeochemical dynamics in the North Atlantic Sub-polar Gyre System and surrounding shelves, in order to improve ocean management and conservation. The science plan is nearing completion. The Scientific Steering Group met with members of funding agencies from Canada, the US and Europe in an informal discussion at the ICES Annual Science Meeting held in Halifax the week following the Annual ESSAS meeting.

The question was raised as to whether some of these projects wished to become formally affiliated with ESSAS.

West Greenland

Kai Wieland

While ecosystem studies are being conducted in Greenland waters, attempts to engage those actively involved in the research into ESSAR have not been successful. Attempts to convince Greenland researchers that this will be worthwhile will continue.

Kai Wieland suggested that a copy of the SSC Meeting Report be sent to Klaus Nygaard (Director Greenland Institute of Natural Resources, NUUK Greenland) which may help to influence the Greenland Institute to become involved in ESSAS.

Iceland

Olafur Astthorsson

Iceland´s main contribution to ESSAS program is through The Ecology of the Iceland Sea (ISE) Project which started with a major field phase in 2006. Since then field activity has continued in 2007 and 2008. Further field activity for 2009 has not been decided upon at this stage. The main aim of the project is to further understanding on the Iceland Sea with particular reference to the capelin stock for which the Iceland Sea is the main feeding area. This includes investigations

on hydrography (temperature, salinity, currents, watermasses), nutrients, phyto- and zooplankton and energy transfer throuh the ecosystem and how these factors interlink with respect to the life history and distribution of the capelin.

Field Activity
During 2008 data processing and analysis has been continued while two crusies were also under taken in the Iceland Sea.

The first one during 30 June – 6 May was aimed at the spring onset of production along two transects where detailed studies have been undertaken during previous years. Environmental factors (temperature, salinity, oxygen and nutrients (N, P, Si) as well as biomass and species distribution of phytoplankton and zooplankton were investigated at a total of 22 stations. Profiles of temperature, salinity, *in vivo* fluorescence and oxygen were measured with a CTD (Seabird). Nutrients and phytoplankton were sampled with water bottles at up to12 depths in the same depth profile and zooplankton was sampled with Multinet from surface to the bottom and WP2 net hauls were taken from surface to 50 m depth. Secchi readings were taken in daytime stations.

The preliminary results are the following. The hydrographic conditions were similar to winter time with little or no stratification in the surface waters. Polar water was not found in the western part of the research area as registered earlier in spring time (May 2006 and April 2007) and the ice edge was far away to the west. Secchi readings were high (15-29 m), nutrients were high and phytoplankton biomass low (in vivo fluorescence measurements). The zooplankton collections have hitherto not been processed.

The second cruise was undertaken during 6 August-2 September. During the cruise environmental (temperature, salinity, nutrients), phyto- and zooplankton (biomass and species composition) sampling was undertaken at 161 station. Sampled of phyto- and zooplankton were also collected for trophic studies (fatty acids, isotope ratios). During the cruise several environmental parameters were also registered continuously. Further acoustic registrations of zooplankton on capelin were made continuously. Biological measurements were made on capelin and several other fish species. Trawling for capelin and other pelagic fish was made at 56 stations.

Temperature in the surface layers was somewhat lower than the two previous years while generally the hydrographic conditions were similar. The growth season of phytoplankton was finished; phytoplankton biomass was low, and similarly nutrients. The only exception was in the waters of the Westfjord peninsula near Iceland. Zooplankton biomass similarly low but somewhat higher in the uppermost 50 m the between 50-200 m.

The main change form 2007 relates to the abundance of capelin larvae which now was observed to be 4 times higher than that observed in 2007. The larvae

were observed over an extensive area in the southern Iceland Sea and to a lesser degree near East Greenland. Older capelin (1-3 yr. old) was only rarely observed in limited areas near the East Greenland shelf and in the southern Iceland Sea.

Seminar
During 22 April 2008 participants in the Ecosystem study of the Iceland Sea held a seminar at the Marine Research Institute presenting 9 lectures covering various aspects (hydrography, nutrients, phytoplankton, zooplankton, capelin distribution, modeling of migration) of the Icelandic Sea (ISE) project followed by a discussion on the current status of the project and which should be the next steps.

In November 2007, Olafur Palsson attended a meeting of the Norwegian IPY project (NESSAR) to foster cooperation and comparisons between the two projects (ISE and NESSAR).

Publications
Palsson, O.K., H. Valdimarsson, S.R. Olafsdottir, H. Gudfinnsson, A. Gislason, and S. Sveinbjörnsson. 2008. Vistkerfi Íslandshafs (The ecosystem of the Iceland Sea, In Icelandic). Hafrannsokastofnunin Fjolrit, 130, 21-23.

ACTION: Olafur Astthorsson will send Margaret McBride detailed information on progress made by the Marine Research Institute in Iceland on ESSAS-related projects within the Iceland Sea Ecosystem Program.

Norway
Ken Drinkwater

NESSAS (Norwegian component of the Ecosystem Studies of Sub-Arctic Seas) is funded by the Research Council of Norway and is in its final year of a 4 year project. Its aims were to quantify and predict the impact of climate variability on the Barents Sea marine ecosystem. A meeting was held in November 2007 to review the progress in the project and was held jointly with two other Norway GLOBEC projects, the IPY project NESSAR (Norwegian component of the Ecosystem Studies of Sub-arctic and Arctic Regions) and the INFERNO (Effects of Interactions between Fish Populations on Ecosystem Dynamics and Fish Recruitment in the Norwegian Sea) projects. During this the last year of NESSAS, a paper was written on the systematic spatial change in atmospheric circulations, showing up as a sudden jump from the conventional AO/NAO pattern to an unprecedented dipolar leading pattern during the last 6-8 years. These changes are partly responsible for the recent dramatic ice loss and a large part of the wintertime temperature changes seen during the last decade. Studies of the heat budget of the Barents Sea are nearing completion, having shown that for the period 1948-1997 horizontal heat transports and vertical air-sea heat fluxes seem to be equally important to the observed temperature variability, but

after 1997, the heat transports appear to be the dominant factor. Downscaling from the General Circulation Model (GCM) to the regional model for the North Atlantic using ROMS has been carried out and validation for the Barents Sea and Nordic Seas appears to be good. The NORWECOM phytoplankton model for the North Atlantic and Arctic has been extended to include a zooplankton module thus allowing for grazing of the phytoplankton. A paper on recruitment of Barents Sea shrimp in relation to its environment and the spawning stock was written showing that the abundance of 1 and 2 year old shrimp has a positive correlation to temperature. Studies on Barents Sea capelin show that the large-scale environment has a impact on how the capelin distribute through changing the location of the water masses that capelin prefer, but the capelin stock size determines how capelin distribute within the preferred water mass. A larger stock spreads out to meet the greater food demand. NESSAS scientists had four papers published as part of the ESSAS special volume in Deep-Sea Research and one of the scientists was a co-editor of the volume. A hydrodynamic-ecological model forced by a GCM has been run to examine the effects of loss of summer ice in the Arctic, the so-called “Blue Arctic” scenario. Results suggest primary production will increase in the Arctic, but *C. finmarchicus* will not able to establish itself in the cold Arctic water. *C. glacialis* seems to do well in a Blue Arctic, but this is a shelf species and it is not known if it will be able to establish itself in the deep Arctic Basins. A model of capelin under future change indicates that it will likely move farther north and east in the Barents Sea with the possibility of establishing new spawning grounds on Nova Zemlya and Svalbard. A game theory model was developed for blue whiting to analyze the stability of agreements among the countries exploiting this stock. In addition, work has been carried out on how cooperative agreements on the blue whiting are likely to be affected by climate change. NESSAS also continued to support Norwegian contributions to the ESSAS annual meeting in Halifax. NESSAS scientists have written or are involved in writing several papers as part of NORCAN and MENU (Marine Ecosystem Comparisons between Norway and the US) (See Multinational Activities). A full proposal to extend MENU through model comparison between the US and Norway was submitted to the Research Council of Norway and a companion US proposal was submitted to the NSF/NOAA program CAMEO. Results from NESSAS, including a synthesis of the project, will be presented at the Arctic Frontiers conference in Tromsø in January, 2009.

The foci of the NESSAR IPY project are the fronts between the warm, salty Atlantic waters and the colder, fresher Arctic or Polar waters. In this the second year of the project, the main activities were three cruises. Two were to the Barents Sea. The first was from 25 February through 7 March on the *RV Lance,* during which a broad-scale survey of the hydrography and currents in the vicinity of the Polar Front over Bear Island, Spitzbergen, and Hopen Banks was conducted. The second cruise was on the RV Jan Mayen from 24 April through 18 May, during which extensive data collections were carried out on physical oceanography and ecology. The objective of this cruise was to obtain springtime data on the Front over Storbanken for comparison with last year’s summer data.

Sampling included hydrography (CTD, both profiling and towed), turbulence, currents (Ship mounted ADCP), nutrients, chlorophyll-a, phytoplankton (bottles and nets) and zooplankton (nets and optical plankton counter). Few fish (capelin) were observed on the echo sounders so no fish trawls were taken. Unfortunately heavy ice on Storbanken prevented us from sampling the front there so we moved to Hopen Bank. In addition to the frontal studies sampling was carried out along a production gradient from Atlantic waters to the ice edge. The Polar Front was found at the edge of the bank and represented a boundary in community structure. In the Norwegian Sea we conducted research from the vessel Johan Hjort from 22 May through 9 June south of Jan Mayen Island. Two current meter moorings were recovered and re-deployed on the Jan Mayen Ridge to investigate the exchange of water between the Norwegian and Iceland seas. Hydrographic data were also collected along the Ridge. This year emphasis was on along-front variability. The sampling was similar to that for the Barents Sea although in addition we deployed two autonomous gliders. One malfunctioned but the other traversed the Front over a 5-6 day period. Bacterial production measurements in the vicinity of the Front were also taken. As last year there was deep (50-300 m) front in both temperature and salinity located on the east side of the Ridge and shallow (0-50 m) salinity front. In addition to the field work a model of the front in the Barents Sea is being developed. Presentations of the NESSAR results were given at the Ocean Sciences Meeting in Orlando, Florida (USA), at the SCAR/IRSC IPY Open Science Meeting in St. Petersburg (Russia), and will be given at the PICES meeting in China in October, 2008. NESSAR scientists also participated in the Norway GLOBEC meeting in November 2007 where results from the cruises to the Barents Sea and the Norwegian Sea were presented.

Follow-up Discussion
During the follow-up discussion the question of Russian activities was raised as to whether there was a recent report from Russia but no report was available. Also, how does Russia see itself being involved in ESSAS activities?

- **ACTION:** Ken Drinkwater will contact Vladimir Radchenko regarding these issues.

6. Multinational Programs

Japan/Russia in the Sea of Okhotsk

Yasunori Sakurai

Due to global warming, the extent of sea-ice has decreased by 20% in the last 30 years. This decrease greatly affects wildlife relying on sea ice and associated materials circulated in the Sea. Japan and Russia have agreed to respond to rapid decrease of sea ice in the Sea of Okhotsk. Intergovernmental cooperation

between these two nations to conserve sea ice in this ecosystem will begin in 2009 with the following objectives:

- Analyze mechanisms of climate change, including the influence of cold air flowing over Siberia on the formation of sea ice.
- Understand the dynamics of runoff from Amur River into the Sea of Okhotsk including provision of fresh oxygen and iron into the North Pacific, and how this affects phytoplankton production and growth.
- Address trans-boundary issues such as pollution from oil spills, and outbreaks of avian influenza.
- Conserve the rich ecosystem surrounding the four Kuril Islands (Etorofu, Kunashiri, Shikotan, and Habomai)
- Understand and protect endangered species in marine and terrestrial components of this ecosystem.
- Develop an integrated database to exchange information about the ecosystem
- Establish a system to rapidly exchange operative information in urgent situations such as oil spills, and outbreaks of avian influenza.
- Understand the effects of sea-ice formation and runoff from Amur River on marine environments in neighboring areas.
- Understand climate change and its effects on ecosystems in the Far East, Siberia, and other regions.

NORCAN — Norway/Canada Marine Ecosystem Comparisons

Ken Drinkwater

Ken Drinkwater updated the meeting on the status of NORCAN (Norway-Canada Comparison of Marine Ecosystems). A total of seven disciplinary papers covering from physics to marine mammals comparing the Barents/Norwegian Seas with the Labrador/Newfoundland Region are in various stages of completion. All of these are jointly authored by scientists from Canada and Norway. The paper on capelin also includes information on the Icelandic stock and is co-authored by an Icelandic scientist. During the spring of 2008 several of the writing groups met in Norway at different times to further develop their papers and to begin writing. The plan was to have first drafts ready by September with the hope to be able to send the completed papers to a journal by the end of 2008. However, to date only one completed draft has been sent. It is still hoped that most of the others will soon be available. Ken indicated that he would be sending out a reminder to the writing groups requesting information on the progress and estimated time to complete the first drafts. In addition, a synthesis paper is planned but will have to wait until most of the disciplinary papers are completed.

MENU — Marine Ecosystems of Norway and the USA

Bernard Megrey

The ESSAS-sponsored project Marine Ecosystems of Norway and the US (MENU), a collaborative project between NOAA/NMFS and Norway's Institute of Marine Research, is now completed. At the 2007 Annual Meeting Bernard Megrey reviewed MENU's accomplishments. Special emphasis was devoted to lessons learned from a detailed comparative analysis of ecosystem structure and function. Information projects from the Northern Hemisphere marine ecosystems including eastern Bering Sea, Gulf of Alaska, Gulf of Main/Georges Bank, and the Norwegian/Barents Sea ecosystems were compared with respect to the environment, biota, fisheries, tropho-dynamics, common features, unique features, fundamental features, important drivers, and controlling processes. The wealth of data permitted several avenues for performing comparisons. Some comparisons that were examined included comparisons between geographically adjacent ecosystems (i.e. between the eastern Bering Sea and Gulf of Alaska), between ecosystems (i.e. eastern Bering Sea and Barents Sea), and cross-basin (Atlantic vs. Pacific) comparisons. One outcome was the conclusion that large multi-national collaborations are almost essential to conduct similar comparisons since local experts are needed to supply data, interpret results, and provide perspective. As further tangible outcome, five papers are scheduled for publication in Progress in Oceanography during 2009:

- Bernard A. Megrey, Jason S. Link, George L. Hunt, Jr., and Erlend Moksness. *Comparative Marine Ecosystem Analysis: Applications, Opportunities, and Lessons Learned.* (HS-00)

- Ken F. Drinkwater, Franz J. Mueter, Kevin D. Friedland, Maureen Taylor, George L. Hunt Jr., Jonathan A. Hare, and Webjørn Melle, *Recent climate forcing and physical oceanographic changes in Northern Hemisphere regions: A review and comparison of four marine ecosystems*. (HS-13).

- Jason S. Link, William T. Stockhausen, Georg Skaret, William Overholtz, Bernard A. Megrey, Harald Gjøsæter, Sarah Gaichas, Are Dommasnes, Jannike Falk-Petersen, Joseph Kane, Franz J. Mueter, Kevin D. Friedland and Jonathan A. Hare. *A comparison of biological trends from four marine ecosystems: synchronies and differences and commonalities.* (HS-02).

- Sarah Gaichas, Georg Skaret, Jannike Falk-Petersen, Jason S. Link, William Overholtz, Bernard A. Megrey, Harald Gjøsæter, William T. Stockhausen, Are Dommasnes, Kevin D. Friedland, and Kerim Y. Aydin. *A comparison of community and trophic structure in five marine ecosystems based on energy budgets and system metrics.* (HS-08).

- Bernard A. Megrey, Jonathan A. Hare, William T. Stockhausen, Are Dommasnes, Harald Gjøsæter, William Overholtz, Sarah Gaichas, Georg

Skaret, Jannike Falk-Petersen, Jason S. Link and Kevin D. Friedland. *A cross-ecosystem comparison of spatial and temporal patterns of covariation in the recruitment of functionally analogous fish stocks.* (HS-03).

MENU conducted detailed comparative analysis of ecosystem structure and function, whereas MENU II will compare different models and their different results (EcoPath, production models, 3d bio-physical models, and system models (ATLANTIS). MENU II proposal have been submitted to CAMEO (USA) and the Research Council of Norway with objective to obtain matching funding. The proposal is ranked as number 3 in the agency as programs to fund and a decision on the proposal to the CAMEO program will be made in the near future but will be depend on whether CAMEO is funded by the US government for 2009. In the Norwegian Research Council the proposal is out for international review and decision will be made in November.

ESSAR – IPY Consortium

Ken Drinkwater

Ken Drinkwater reported on the International Polar Year (IPY) consortium Ecosystem Studies of Subarctic and Arctic Regions (ESSAR) which is lead by ESSAS. The consortium's primary objective is to determine how climate variability and change affect the marine ecosystems of the polar (Sub-arctic and Arctic) seas and their sustainability. This consortium presently includes 10 separate projects covering all ecosystem aspects including physics, phyto- and zooplankton, fish and invertebrates, marine mammals and seabirds. The research consists primarily of field work with some retrospective analyses and modeling. Field studies were undertaken in most projects during 2007 and 2008 with analysis and publication scheduled for the following year or two. Geographical coverage includes most of the sub-arctic and much of the Arctic, with scientists leading or participating from Canada, China, Denmark, Japan, Iceland, Norway, Poland, Ukraine and the USA. Four of the projects are ESSAS sponsored including those from Japan (J-ESSAS), USA (BEST), Iceland (ISE) and Norway (NESSAR). Information on these projects appears in the national reports. No consortium meetings have taken place but it is hoped to do this sometime during 2009. However, a theme session on IPY results will be held at the PICES Annual Science Meeting to be held in late October 2008 in Dalian China for which Ken and George Hunt are co-conveners. Results from several of the ESSAR projects will be presented. Five of the 10 ESSAR projects will be represented as well as a talk on ESSAR itself.

ACTION: Ken Drinkwater will contact ESSAR members to encourage their participation at Arctic Science Week planned to be convened in Bergen during March 2009.

7. Establishment of an ESSAS Project Office

The GLOBEC Regional program ESSAS recently established a Project Office in Bergen, Norway, through funding by the Research Council of Norway and the Institute of Marine Research (IMR) in Bergen. The office is funded at a level of a half time position for a period of 5 years. The Office will help coordinate and promote activities within ESSAS and communicate ESSAS science to both the broader scientific community and the general public. Ms. Margaret Mary McBride will be the ESSAS Coordinator and will head the Office. Ms. McBride is a research fisheries biologist with over 30 years of broad international experience. She holds a B.S. from Brandeis University (1975) and a M.S. in Fish and Wildlife Science from Oregon State University (1989). She studied invertebrate zoology and marine ecology at the Marine Biological Laboratory in Woods Hole, MA; and biostatistics and survey sampling design at the Harvard School of Public Health Sciences. She now works on issues related to ecosystem-based research and management through an Intergovernmental Personnel Action between NOAA Fisheries and IMR. Those who want to contact the ESSAS Project Office can contact Margaret at margaret.mcbride@imr.no or phone + 47 55 23 69 59.

8. Plans for a New ESSAS Website

The ESSAS Project Office has plans to develop a new ESSAS website. It was decided to explore the possibilities of this being done in Bergen and perhaps within the Institute of Marine Research where the Project Office is located. The idea would be to have the ESSAS Coordinator be responsible for updating the website. It was also felt that this was a priority and should be done as soon as possible. Materials (bio-sketch and color portrait) to appear on the ESSAS website were requested of all SSC members.

9. Working Group Reports on 2008 Workshops

During the 2008 Annual Meeting, ESSAS working groups held ½ day or full-day workshops.

Working Group 1

Climate Forcing on Marine Ecosystems Workshop

Jim Overland

The morning session of the Workshop on “Climate Forcing of Marine Ecosystem” was devoted to the application of future climate projections from International Panel on Climate Change (IPCC AR4) models to ESSAS regions. Ken Drinkwater set the context with a talk on ecosystem responses to climate forcing in North Atlantic sub-Arctic seas. He showed examples where the type of

ecosystem response to increased temperature is location-dependent. Different seas are nearer or further in time from potential threshold limits of major bio-geographic or food web changes for specific species.

During the balance of the morning, James Overland and Vladimir Kattsov gave presentations related to the Report from Working Group I on climate model selection. Based on multiple analyses, WG1 has concluded that the IPCC 4th Report models have utility for climate projections out to 2050 for ESSAS seas. The projections, however, vary based on model, location, variable, and evaluation metric. WG1 concluded that there is no one best model. An approach is to determine whether certain models represent outliers when compared to observational data from the 20th century, and then to excluded them from further analysis. It is important to develop observational constraints based on how model hind-casts compare with late twentieth century data in terms of matching means, inter-annual variance, and annual cycles of temperature and pressure. A meta-analysis (comparison of independent studies) was conducted to recommend a subset of models for regional climate projections. Rather than relying on a single model, at least 3-5 models should be considered in any climate projection to account for model-to-model uncertainty. This is the major source of uncertainty in projections out to 2050. Out to 2100, the choice of which economic/social scenario for different greenhouse emissions is the major source of uncertainty.

Loss of sea ice — 38% of summer-sea ice in the central Arctic during 2007 and 2008 — is occurring faster than expected from IPCC projections. This results from the influence of natural variability, in addition to emerging climate forcing from anthropogenic activities, and ice/ocean feedbacks. ESSAS seas, however, which respond to winter and spring ice growth, are mostly decoupled from this summer loss of Arctic multi-year sea ice. In upcoming decades, ESSAS seas will still be dominated by multi-annual to decadal natural variability in sea ice, temperature, winds and related variables.

The afternoon was devoted to the related issue of downscaling, i.e. how to infer local scale 0(10 km) climate impacts based on the large scale 0(200 km) projections from IPCC models. Two approaches noted by John Walsh are: 1) a statistical fit of observational data to IPCC and NCAR reanalysis fields of variables; and 2) the use of high resolution numerical ocean models driven by boundary conditions from IPCC projections (dynamical downscaling). Foreman presented an application of statistical downscaling for coastal winds. Enrique Curchitser, Simon Prisensberg, and Paul Budgell discussed regional ocean models, and approaches to dynamical downscaling. A final discussion by Mike Foreman concluded that for ESSAS purposes the dynamical downscaling approach is necessary to capture local oceanographic features such as fronts, current jets, and eddies.

Working Group 2

The Importance of Advective Processes in Sub-Arctic Seas

Ken Drinkwater

Ken Drinkwater discussed possible follow up to the Advection Workshop. While it was clear from the workshop that advection plays an important role in subarctic seas, the workshop presentations were not focused on any particular issue (although the most common was on larval drift) and due to the limited time did not cover a number of other advection related issues especially relating to physical effects such as heat transport into or out of the subarctic seas, transport of ice, etc. As a follow up to the workshop, he suggested that a review paper on the role of advection in subarctic seas could be written or instead one on the possible changes to advection under climate change and what impacts this would have on the ecology of the subarctic seas. The two ideas might even be combined. He stated that he would think more about these papers and contact some of the presenters for their views. He will report back to the next ESSAS SSC meeting regarding possible papers but noted that due to other commitments he could not begin writing any paper on advection before at least next year.

During the 2008 Annual Science Meeting in Halifax, WG-2 also sponsored a Workshop on Advective processes, their role in coastal marine ecosystems, and their vulnerability to climate change. This Workshop was being convened by Ken Drinkwater.

During the 2009 Annual Science Meeting in Seattle, Washington, WG-2 plans to follow-up the Advection Workshop with a half-day joint workshop with ASOF (Arctic Shelf-Ocean Fluxes) that will be convened by Ken Drinkwater.

Working Group 2

Hotspots, Thresholds and Ice Models: Follow-up to Hakodate meeting

George Hunt

George Hunt will continue leading the paper on Hotspots and hopes to have an advanced draft by next year's meeting. John Bengtson will likewise continue work on the paper on Thresholds although and will present an update at the 2009 ESSAS SSC meeting.

Working Group 3

Ecosystem Comparison with ECOPATH

(Bernard Megrey)

The charge of WG-3 is to model marine ecosystem response; however, understanding must be achieved before modeling can begin. A necessary first step toward understanding any marine ecosystem (and its response) is to

determine its community structure and function and its variability. Obtaining such understanding has proved difficult because of the complexity of marine ecosystems and its many interacting components

Testing hypotheses by conducting in situ manipulative experiments at the scale of ocean basins is impractical and conclusive cause-and-effect evidence of underlying mechanisms is not possible. The comparative approach is useful in such situations. Comparisons can identify the main internal and external variables of the system, potential gaps in knowledge in one system compared to others, comparable key species or species assemblages, and comparable trophic levels and food-web structures.

Comparisons allow the opportunity to take a broad perspective which provides the ability to draw generalizations, determine what is fundamental to ecosystems in general and what is unique to particular ecosystems, and provide new insights into mechanisms through which ecosystems respond to physical forcing

At the 2008 ESSAS Annual Meeting in Halifax, Nova Scotia, Canada, a workshop was convened by members of Working Group 3 (Bernard Megrey - NOAA Alaska Fisheries Science Center, USA; Shin-ichi Ito - Tohoku, National Fisheries Research Institute, Japan; and Kenneth Rose - Louisiana State University, USA) on Modeling Ecosystem Response with the objective to take a very basic first level approach to address the above-mentioned challenges. Subarctic marine ecosystems were compared by applying one common modeling approach to multiple ecosystems using the Ecopath modeling paradigm (EwE).

An ecosystem/Ecopath presentation rubric was supplied to presenters to help facilitate comparisons among the various ESSAS ecosystems. This included items such as the physical background and setting, geography (latitude and longitude boundaries, surface area, and average depth), climate (major seasonal, multiyear and decadal influences), hydrography and bathymetry (major currents and circulation patterns and significant aspects of bathymetry), the role of ice (is ice important? what role does it play?), biological background and setting, nutrients (major nutrients, limiting nutrients, range or annual average levels), primary producers (community composition/dominate taxa, annual production cycle, maximum/average production rates, total primary production etc), zooplankton (community composition/dominate taxa, maximum/average production rates etc), benthos (community composition/dominate taxa, biomass estimates or trends), fish (community composition/dominate taxa, biomass estimates or trends, catch trends of top 5 species, total catch over past 5 years), seabirds (community composition/dominate taxa, biomass estimates or trends), marine mammals (community composition/dominate taxa, biomass estimates or trends, catch trends of top 5 species), trophic interactions (major energy/mass pathways, trophic bottlenecks, etc), a trophic food web connection diagram from Ecopath software, fisheries and management systems, major natural and anthropogenic drivers, critical factors that cause ecosystem change, and

preparation of a trophic linkage diagram. Presenters were also requested to deliver a version of their Ecopath model so that it could be archived within the ESSAS website.

Workshop Presentations
Regrets: Several participants that were scheduled to appear had to offer their regrets. These included co-chairs Shin-ichi Ito and Kenneth Rose as well as Vladimir Radchenko, Kerim Aydin, and Astrid Jarre. WG3 did have the benefit of unanticipated presentations from Orio Yamamura and Yasunori Sakurai. The workshop agenda is presented in End Note I.

Since WG3 was at the end of three days of workshops, the agenda was dynamic as we tried to accommodate unanticipated presentations as well as carryovers from the previous two days. The following description does not follow the organized agenda in Endnote I because of the reason mentioned earlier.

Presentations started with Orio Yamamura's report on "Advective supply of offshore prey into the continental shelves in the Oyashio area: the role of tidal currents". This was followed by an analysis by Michio J., Kishi on the application of different lower tropic levels marine ecosystem models, results from a side-by-side comparison of various ecosystem configurations and conclusions about the benefits of comparative analysis. After these, Bernard A. Megrey gave a presentation on lessons learned from the ESSAS-sponsored Marine Ecosystems of Norway and the US (MENU) project.

These were followed by individual Ecopath presentation on various ESSAS ecosystems including the Norwegian/Barents Sea (Skaret), eastern Newfoundland Shelf (Bundy), eastern Bering Sea (Aydin – delivered by Bernard A. Megrey), Icelandic Sea (Astthorsson), western Greenland Sea (Jarre – delivered by Kai Weiland), and the Oyashio-Kuroshio current region (Hakamada). These were followed by a presentation by Budgell on a comparison of ice dynamics using two versions of the ROMS model for the Barents and eastern Bering Sea and an unanticipated presentation by Yasunori Sakurai on the effects of sea ice on the fate of walleye pollock. For the most part, all presenters on ESSAS ecosystems using EwE conformed to the suggested presentation rubric to varying levels depending on the information they had at hand.

The workshop ended with a discussion session focused on the following questions designed to stimulate discussion.

Q1: What is similar?
Q2: What is different?
Q3: Which systems should be considered for comparison?
Q4: Should other approaches, other than Ecopath or the meeting template, be considered?
Q5: Is it possible to compare ecosystem models without considering decisions

made by the modeler? How does that impact interpretation or ability to compare?
Q6: Are results from EwE, as a first step, sufficient to effectively compare ESSAS ecosystems – considering Q5 and consequences for the number of species and metrics derived from them?
Q7: How do we foster multidisciplinary and international collaborations required to carry out comparisons?

The consensus from the audience was that the session was received well and moved forward the goals of ESSAS as they concerned ecosystem comparisons.

Outcomes and Action Plan:
Plans were discussed to take the workshop results and prepare a manuscript to submit for publication in a peer-reviewed publication. A follow-up meeting was scheduled for the following morning. At this meeting, it was decided to prepare a data catalogue to determine if sufficient information was available to prepare a paper on comparisons of ESSAS ecosystems for submission to a peer-reviewed publication outlet. Megrey will prepare a template of available information products useful for comparisons and distribute it to representatives from individual ecosystems. From the catalogue, an evaluation will be made as to the likelihood of a suitable publication arising from the information gathered. Plans are in place for Megrey and Hunt to meet with Radchenko at the October PICES in Dalian China to gauge the Russian interest to include the Sea of Okhotsk ecosystem in the comparison.

Finally, WG3 prepared a proposal to GLOBEC to fund an inter-sessional workshop to coordinate the preparation of an end-to-end marine ecosystem model (see End Note II).

10. Merger with IMBER and long-term plans of ESSAS

Ken Drinkwater reported on the possible future links to IMBER (Integrated Marine Biogeochemistry and Ecosystem Research) and particularly the results of the IMBER-GLOBEC Transition Task Team (TTT) meeting held in Reading, UK, 30 July-1 August. The Transition Task Team was set up to recommend to SCOR and IGBP how the second phase of IMBER should proceed to accommodate new developments in marine ecosystem research that need addressing after the completion of the GLOBEC at the end of 2009. Eight members attended, only one of who is part of IMBER (the rest being GLOBEC people) with John Field from South Africa as the chair. Hugh Ducklow is a biogeochemist who is not affiliated with either GLOBEC or IMBER was unable to attend. The TTT decided that its report should include a draft Implementation Strategy for IMBER's second phase from 2010-2014. It does not provide detailed implementation plans, which have been, or will be, developed by the regional programs or topical working groups.

The TTT is suggesting IMBER Phase 2 integrate ecosystem studies from physics and biogeochemistry to the upper trophic levels of food webs and through to human dimension issues, including responses to climate change. The task team is suggesting emphasizing: 1) the human dimensions of marine global change, 2) regional research programs, 3) comparative analyses within and among regional programs, and 4) emerging scientific issues. For example, for the latter ocean acidification and the assessment and comparison of the skill of biogeochemical ecosystem models to project ecosystem responses to different global change scenarios were identified. The TTT is recommending the following regional programs be incorporated into IMBER, while others may be added later:

1. ICED (Southern Ocean) – Already part of IMBER
2. SIBER (Indian Ocean) - Already part of IMBER
3. CLIOTOP (Focus on top predators in open ocean)–Continuing after GLOBEC
4. ESSAS (Arctic Ecosystems)–Continuing after GLOBEC
5. BASIN (North Atlantic) – New proposed comparative studies

Ken emphasized to the TTT that ESSAS was still uncommitted in regards to joining IMBER as it was something that would have to be decided by the ESSAS SSC and would be dependent upon how IMBER planned to proceed in the future.

The TTT will address its remaining terms of reference in their final meeting in December 2008. These include data management issues, Scientific Steering Committee, Working Groups, International Project Office and National Committees and contacts. The interim report from the first meeting was not to be circulated except to the heads of SCOR and the IGBP as well as GLOBEC and IMBER for their initial reaction to insure that the TTT is on the correct track. John Field has reported that reaction so far to the report has been positive but he did not state who the responses came from. Following the second meeting in December, the TTT will complete its report and it will then be circulated to the general scientific community, especially the GLOBEC and IMBER scientists.

There was much discussion following the presentation. Options besides joining IMBER were to “go it alone” or become a program under SCOR or IGBP directly. During the discussion it was eventually agreed that it is likely that neither SCOR nor IGBP would accept us as a direct member since they are pushing to have IMBER be the sole organization addressing marine issues. Some favored seeking funds from national funding agencies, as well as PICES, ICES and NPRB. Some expressed the concern that biogeochemistry and upper trophic level research are quite different in their approaches and thinking and attempts to marry the two will be difficult.

ACTION: George Hunt will draft a statement from ESSAS to be delivered by Ken Drinkwater (member of IMBER’s implementation planning group) relative to the proposed merger with IMBER.

- George Hunt noted that ESSAS greatly appreciates Ken Drinkwater's efforts in helping us to develop within the structure of IMBER as part of the TTT. We recognize that this relationship will be representative of and facilitate our scientific interests. We ask that he continue his efforts, and obtain further information about how IMBER and ESSAS can complement each other and lend mutual support to achieve project objectives. We would also welcome a better understanding of what responsibilities and obligations ESSAS would have to IMBER, and a better understanding of how IMBER's SSC represents the scope, goals, and objectives of ESSAS.

11. Working Group Plans for 2009

Working Group 1

Regional Climate Prediction (WG RCP)
(Jim Overland)

During 2009, WG1 will prepare a final report on the International Panel on Climate Change (IPCC) model selection techniques. A theme will be chosen for the 2009 ESSAS Annual Science Meeting; speakers on climate prediction issues will be decided upon and invited to participate.

Working Group 2

Bio-Physical Coupling (WG BPC)
(George Hunt)

For the 2009 Annual Science Meeting in Seattle, Washington, WG-2 plans to follow-up the Advection Workshop with a half-day joint workshop with Arctic Shelf-Ocean Fluxes (ASOF) that will be Convened by Ken Drinkwater and perhaps one other.

WG-2 also plans to convene a two day workshop at the GLOBEC OSM that will compare observations and modeling of processes and climate impacts in the maritime Antarctic with those in the sub-arctic seas. Workshop presentations will compare or facilitate comparisons of ecosystem processes from the impacts of climate through all trophic levels including fish, seabirds, marine mammals and fisheries. The focus will be on mechanisms and expected changes, with identification of non-linearities (thresholds) an important component. If contributions permit, it would be valuable to focus on a series of themes for both physics and biota, such as: climate effects on stratification/mixing/ frontal structures with implications for biota. Case studies involving various trophic levels could be presented as examples of effects of physical processes on both lower and higher trophic levels and the interactions among trophic levels. The workshop will provide an opportunity for the modeling communities in the Antarctic and the sub-arctic to compare approaches and progress toward

functional end-to-end models of the effects of climate change on marine ecosystems and their ability to support upper trophic level organisms including sustainable fisheries. Uses of model outputs to compare fundamental aspects of subarctic regions and the Southern Ocean or Antarctic systems are sought. The first level of comparisons will help establish practical marine ecosystem topologies useful to GLOBEC, and perhaps to future IMBER studies. The workshop will explore the similarities and differences in ecosystem structure and function and what are the processes that lead to these differences. As well, comparisons between the impacts of physical forcing such as sea ice, winds, and advection will be investigated. The anticipated responses of each ecosystem to climate change and global warming will be compared. Workshop out**c**ome will be a paper synthesizing results of the workshop for the OSM special issue, plus a white paper or blueprint for moving forward with end-to-end modeling comparisons.

In addition, a proposal was made by Yasunori Sakurai to have a 1-day workshop on 'Climate impact on ecosystem dynamics of marginal and semi-enclosed seas' for the GLOBEC OSM. Marginal and semi-enclosed seas contribute a substantial share to the world fisheries catch and GLOBEC researchers have been very active in studying the impact of climate (climate variability and climate change) on these ecosystems. This work was mainly focused on higher trophic levels, particularly on zooplankton and fish. However, whereas our knowledge on single marginal seas and semi-enclosed ecosystems has very much progressed in these fields, what is missing so far is a synthesis of the respective results. The workshop will compare climatic influences on semi-enclosed and marginal seas on a global scale, including subarctic regions. Ecosystems of interest for this workshop include, because of their GLOBEC history, regions such as the Barents Sea, North Sea, Mediterranean, Baltic Sea, Black Sea, East China Sea, Yellow Sea, Okhotsk Sea, Sea of Japan, 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 have been observed in the North Pacific as well as in the North Atlantic in association with changes in climatic indices such as the NAO, AO and PDO. It was decided that ESSAS will support such an initiative.

Working Group 3

Modeling Ecosystem Response (WG MER)

(Bernard Megrey)

Inter-sessional Modeling Workshop

- WG-3 proposes that ESSAS undertake the design and construction of a state-of-the-art, fully integrated biophysical ecosystem model that simultaneously solves the physical equations of motion using an general circulation model (GCM) of the ocean such as ROMS, the biogeochemical cycles necessary to support biological production (nutrient dynamics) and the primary and

secondary producers using multiple functional groups (phytoplankton and zooplankton) (an NPZ), and finally using a spatially explicit individual-based model to represent the upper tropic level (UTL) functional groups. The UTL group(s) will initially be fishes but could easily be extended to include birds and marine mammals. We propose to build the models for the eastern Bering Sea and the Barents Sea. The goal is to:

1. Improve our understanding of the physical, biogeochemical, and biological mechanisms that cause fluctuations in fisheries production, abundance, and their potential responses to climate change.
2. Investigate the interactions between natural predation and fishing pressure during different ecosystem regimes
3. Develop tools to support the science of an ecosystem approach to resource management.
   a. Demonstrate how end-to-end physics to fish to fishers models can be combined.
   b. Improve projections of fluctuations in fish populations.
   c. Explore how harvesting in a multi-species context can affect target and non-target populations.
4. Perform a comparative analysis between the different sub-Arctic seas to test model robustness in different regions.

- WG-3 proposes to take results of the workshop on Modeling Ecosystem Response at the 2008 Annual Science Meeting to prepare a manuscript to submit for publication in a peer-reviewed journal. A data base is being developed to catalogue available information to conduct such a study comparing ESSAS ecosystems including the Sea of Okhotsk.

For the GLOBEC 2009 Open Science Meeting, WG-3 Proposes to Convene Workshops on:

1. Comparisons of High Latitude Arctic/Subarctic Ecosystems in Two Hemispheres
   - Brief summary of the objectives: This session will compare fundamental aspects of the ESSAS eastern Bering Sea region and the Southern Ocean or IMBR/ICED system. The first level comparison will help establish practical marine ecosystem topologies useful to GLOBEC. Anticipated response of each ecosystem to climate change and global warming will also be compared.
2. Comparison of GLOBEC Modeling Techniques – Failures, Successes, and What Did We Learn?
   - Within the GLOBEC program, an impressive suite of diverse modelling activities (including conceptual, statistical, and dynamic numerical simulation models) have been undertaken by the various regional programs, national activities and multinational programs. This session/symposium would showcase selected invited model applications and compare them using a predefined rubric asking the questions: "Was it successful?", “If not, why not?” and “What did we learn”?

- **ACTION**: George Hunt/Bern Megrey to send message to BEST and BESIERP to request their members become involved in the ESSAS-related modeling efforts.

- **SUGGESTIONS**: Training in ecosystem modeling should be extended to national programs. Also, any required sampling in support of modeling should be requested well in advance to ensure they are incorporated into the relevant national research programs.

Working Group 4

Climate Effects at Upper Trophic Levels (WG CUTL)
(Earl Dawe)

Objectives through June 2009

- Compilation of relevant literature
- Compilation of datasets
- Identify methods of data analysis
- Workshop at 2009 Annual meeting:
  - Review of gadid and crustacean dynamics, their environment, and fisheries in each ESSAS region
  - Begin comparisons

Longer Term Plan

- One (or more) comparative papers based on a review of the literature and new data analyses to summarize important associations between climate variability and the relative productivity of gadoid and crustacean populations in subarctic ecosystems.
- This WG will be a resource to other working groups within ESSAS, to the larger ESSAS community, and to other researchers on retrospective and future climate change issues in regards to gadoid and crustacean resources.
- Assess future responses to climate variability based on identified relationships/mechanisms and climate scenarios for each region.

ACTION: Franz Mueter will send M^3 minutes from the WG4 planning meeting in Anchorage, Alaska

12. Relationship with PICES

At the 2007 PICES Annual Meeting during October in Victoria, Canada, Ken Drinkwater made a presentation on behalf of ESSAS to the PICES Council. He thanked them for their ongoing scientific collaboration and encouragement, as

well as financial support to ESSAS. Further, ESSAS requested that the Physical Oceanography Committee within PICES would provide support for a PICES scientist to attend the ESSAS Annual Meeting in Halifax. This was followed up and Dr. Mike Foreman (Canada) attended the 2008 ESSAS ASM. A poster providing details on the ESSAS activities and organization was all presented at the 2007 PICES Meeting. Drs. Hunt and Drinkwater have also been invited and will attend the 2008 PICES Meeting in Dalian, China, during October as observers on behalf of ESSAS.

George Hunt stated that ESSAS has been formally requested to participate in the PICES North Pacific Ecosystem Status Report that will focus on the Bering Sea.

Circulation Research in East Asian Marginal Seas (CREAMS) is an Asian marine science research group that will meet at PICES this year in Dalian. ESSAS will attend that forum in an attempt to promote collaboration and cooperation and build partnerships.

13. Future Meetings

Upon invitation from George Hunt, the next SSC meeting will take place in Seattle, WA at the University of Washington in June 2009 immediately prior to the GLOBEC Open Science Meeting in Victoria.

ACTION: George Hunt will look into the potential for NSF support to convene an ESSAS Open Science Meeting in 2011 that reflects the ESSAS scientific results over the first approximately 5 years. May-June was the proposed time frame and either Hawaii was suggested as the proposed location.

14. Response to Recommendations & Action Items from the ESSAS 2007 Hokadate Meeting

- **Recommendation** from the 2007 SSC Meeting in Hakodate
  Result: The invitation from Erica Head to host the 2008 ESSAS Annual Science Meeting in Halifax September 15-17, with the SSC meeting to follow on September 18-19, was gratefully accepted. The tentative agenda developed by the SSC was helpful in planning both space and financial requirements.

Appendix 1

Agenda

ESSAS SCIENTIFIC STEERING COMMITTEE MEETING

Halifax, Nova Scotia, Canada
18 - 19 September 2008

Thursday 18 September:

09:00: Introductions and adoption of the Agenda

09:15: SSC Membership: Need to add someone from WG-4; Rotations off SSC; and needs for new members

09:30: Reports of the New Working Group 4 on Climate Effects at Upper Trophic Levels: Franz Mueter and Earl Dawe

10:00: Reports from National Programs
(Please NO DATA OR SCIENTIFIC RESULTS!)

- Korea: Hyung-Cheol Shin
- Japan: J-ESSAS - Yasunori Sakurai
- USA: BEST/BSIERP - Ray Sambrotto

10:30: COFFEE Break

- Canada - Erica Head
- West Greenland - Kai Wieland
- Iceland, ISE - Olafur Astthorsson or Olafur K. Palsson
- Norway: N-ESSAS/N-ESSAR - Ken Drinkwater

12:00: LUNCH Break

13:30: Discussion of Progress with National Programs

14:00: Reports from International Programs

- Russia/Japan in the Sea of Okhotsk – Yasunori Sakura
- Canada/Norway in North Atlantic, NORCAN- Ken Drinkwater
- USA/Norway in multiple areas, MENU - Bernard Megrey

14:30: IPY, Arctic, Other Regions, ESSAR - Ken Drinkwater

15:00: Discussion: Where we are in terms of comparative studies and collaborative international efforts. Can we do more or better?

15:30: COFFEE Break

16:00: Other Old Business
- Workshop on Large Fishery Collapses
- Other items?

16:30: ESSAS Project Office, Ken Drinkwater and Margaret McBride
- Project Office Status
- ESSAS Website – What should go on it?
- What are the long-term priorities for the Office?
- Things to do during the coming year.

17:30: Adjourn

Friday, 19 September

09:00: Reports of Workshop Chairs on 2008 Workshops
- WG-1, Report on Climate Workshop - Jim Overland
- WG-2, Report on Advection Symposium - Ken Drinkwater
- WG-2, Report on follow-up to Hakodate meeting - George Hunt
- WG-3, Report on Ecosystem Comparison with ECOPATH - Bernard Megrey

09:45: General Discussion:
- How many working groups do we need?
- In which areas?
- What should we do next?

10:00: Report on possible merger with IMBER and the long-term future of ESSAS - Ken Drinkwater

10:30: COFFEE BREAK

11:00: Continue discussion of Long-term ESSAS Program

12:00: LUNCH BREAK

13:30: Plans for 2009
- Working Group 1 - Jim Overland
- Working Group 2 - George Hunt
- Working Group 3 - Bernard Megrey
- Working Group 4 - Earl Dawe

14:30: Plans for participation in the GLOBEC OSM

15:00 Coffee Break

15:30: Unfinished Business or Other Business

16:00: Adjourn

Appendix 2

Terms of Reference

ESSAS Working Group 1
Regional Climate Prediction
(WGRCP)

28 February 2007

Introduction

A major goal of ESSAS is to predict the potential impacts of climate variability on the sustainable use of the sub-arctic seas. ESSAS has elected to employ a comparative approach, investigating in each of the sub-arctic seas which energy pathways appear particularly vulnerable to decadal and longer-term climate change. The ecosystem response to climate can be non-linear with thresholds, have complex interactions between species, and different species impacts from similar climate fluctuations. Reducing uncertainty about the future states of ESSAS ecosystems depends on knowledge of the response of the ecosystem to changes in climate and a quantitative ability to project future climate states. The first task represents understanding and modeling the complex linkages between climate variables and species distributions and is a primary focus of the other two ESSAS Working Groups (ESSAS Working Group 2: Biophysical Coupling Mechanisms and ESSAS Working Group 3: Modeling Ecosystem Responses).

A Goal of the **Working Group on Regional Climate Prediction (WGRCP)** is to provide quantitative estimates of the magnitude and uncertainty of future climate change for the ESSAS regions, and the frequency distribution of natural variability, such as the well known ecosystem reorganization of the North Pacific in the mid-1970s and historical inter-decadal variability in the marginal seas of the North Atlantic. Climate elements known to be crucial to ESSAS ecosystems include sea ice cover, ocean temperature, circulation, and stratification.

A major resource for the development of future climate scenarios is the recently available results 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). A preliminary investigation has shown that a subset of these models represents the physical forcing in several ESSAS ecosystems reasonably well based on comparison with *in situ* data for the late 20th century. There are several factors that lead to the perceived credibility of future climate scenarios from climate models, including the differences between models, validation exercises for different physical variables, and matching the spatial scales that are important to ecosystem biology.

Tasks

1. Evaluate the credibility of the 22 IPCC models as applied to each of the different ESSAS regions based on comparison of 20th century hind casts with data, and model to model consistency and physical reliability in their forecasts. Produce a report which provides recommendations on which models perform well for each region.

2. Working within the larger ESSAS framework, establish which seasons, regions and variables are most important to potential ecosystem shifts and provide report on future scenarios and confidence estimates of these conditions for different future time horizons. Assess the contributions from intrinsic climate variability and external anthropogenic forcing.

3. Recommend IPCC models and procedures for downscaling of the model output for use in regional ocean/ecosystem models.

4. Be a community resource on retrospective and future climate change issues.

Implementation

1. The Working Group on Prediction shall exist for a period of three years, ending six months after the 2009 annual meeting of ESSAS.

2. Six to eight members will be chosen from the fields of climate science and numerical modeling. Input from experts on ecosystem processes will be sought through collaboration with ESSAS WG 2 and 3.

3. The development of the proposed products includes conducting workshops held at the annual ESSAS meetings and will require inter-sessional work. The purpose of the workshops is to vet and reach consensus on information made available prior to the workshops from the published IPCC Reports and from direct model evaluations provided by members.

Expected Results

To ensure the perceived credibility of future regional climate scenarios, we will develop a white paper after the ESSAS Workshop in 2007 that examines the differences between IPCC models, identifies the spatial scales and variables that are of relevance to ecosystem-effects of climate change, and delineates further validation exercises for different physical variables that have been performed.

After the ESSAS Workshop in 2008, we plan to have a set of climate predictions for the major ESSAS ecosystems, based on the IPCC climate models. These regional climate scenarios will have sufficient credibility that they can be used by other ESSAS Working Groups as the basis for their ecosystem modeling efforts.

Initial Membership

James Overland,	Acting Chair, USA
Lennart Bengtsson	Germany
Paul Budgell	Norway
Vladimir Kattsov	Russia
Ken Drinkwater	Norway
Mike Foreman	Canada
Hisashi Nakamura	Japan
John Walsh	USA

Appendix 3

Terms of Reference

ESSAS Working Group 2
Bio-Physical Coupling
(WGBPC)

28 February 2007

Introduction

A major goal of ESSAS is to predict the potential impacts of climate variability on the sustainable use of the Sub-Arctic seas. ESSAS has elected to employ a comparative approach, investigating, in each of the sub-arctic seas, which energy pathways appear particularly vulnerable to decadal and longer-term climate change. The ecosystem response to climate can be non-linear with thresholds, have complex interactions between species, and feature different species responses to similar climate fluctuations in different ecosystems. Reducing uncertainty about the future states of ESSAS ecosystems depends on developing the ability to project future climate states as well as predicting the response of the ecosystem to changes in climate. Predicting future climate states is the primary focus of ESSAS Working Group I on Regional Climate Prediction. This requires quantitative estimates of the magnitude and uncertainty of future climate change for the ESSAS regions, and the frequency distribution of natural variability, such as the well-known ecosystem reorganization of the North Pacific in the mid-1970s and historical inter-decadal variability in the marginal seas of the North Atlantic. Predicting ecosystem response requires both understanding and modeling the complex linkages between climate variables and species distributions. This represents the primary focus of two ESSAS Working Groups (ESSAS Working Group 2: Biophysical Coupling Mechanisms and ESSAS Working Group 3: Modeling Ecosystem Responses).

A Goal of the **Working Group on Bio-Physical Coupling (WGBPC)** is to determine how climate-driven variability in physical conditions and processes in the ocean will affect the organisms that make up marine ecosystems and thus the transfer of energy and material through sub-arctic marine ecosystems. Physical aspects of the ocean thought to be crucial to ESSAS ecosystems include sea ice cover, ocean temperature, circulation, and stratification.

A great deal is already known about the responses of organisms to physical variability in the ocean, but the literature is scattered and there is need to summarize what is known specifically about the responses of populations and the ecosystem as a whole in the Sub-Arctic seas and how information gathered in one basin may be applied to ocean regions elsewhere in the Sub-Arctic. Thus

a major task for the WGBPC will be to provide the modelers in the ESSAS WGMER with realistic values for parameterizing predictive models of ecosystem response to climate variability.

Tasks

1. Summarize and evaluate the available information on the responses of marine organisms of the Sub-Arctic seas from phytoplankton to marine **mammals and seabirds to variability in physical attributes of the ocean** such as seasonal sea ice cover, ocean temperature, stratification, and circulation.

2. Working within the larger ESSAS framework, provide the WGMER with a realistic set of values with which to model organism responses to climate-driven variability in the physical attributes of the Sub-Arctic seas.¨

3. Be a community resource on retrospective and future climate change issues.

Implementation

1. The Working Group on Bio-Physical Coupling shall exist for an initial period of three years, ending six months after the 2009 annual meeting of ESSAS. At this time, the ESSAS SSC will evaluate whether the WG should continue, be revised slightly or dissolved.

2. Eight to ten members will be chosen from the fields of biological and fisheries oceanography. Input from experts on future climate variability and the needs of ecosystem modelers will be sought through collaboration with ESSAS WG 1 and 3, respectively.

3. The development of the proposed products includes conducting workshops held at the annual ESSAS meetings and will require inter-sessional work. The purpose of the workshops is to review information on how changes in various physical attributes of the ocean will affect important ecosystem components. Foci of workshops will include the roles of: seasonal sea ice cover, temperature, stratification and circulation.

Expected Results

Workshop products will be one or more review papers based on comparative studies, to be published in the refereed literature, that summarize the important mechanisms whereby the changes in the physical attribute under discussion affect biological constituents of Sub-Arctic ecosystems and their inter-relationships. Where possible, these papers should provide the information necessary for parameterizing the biophysical coupling parameters in ecosystem models of the sub-arctic seas. Where sufficient data are lacking to accomplish this task, there should be a clear statement concerning the lack of specific data that could guide fieldwork during ESSAS.

Initial Membership

George L. Hunt, Jr.	USA, Acting Chair
Earl Dawe	Canada
Elena Dulepova	Russia
Erica Head	Canada
Franz Mueter	USA
Emma Orlova	Russia
Vladimir Ozhigin	Russia
Vladimir Radchenko	Russia
Marit Reigstad	Norway
Sei-ichi Saitoh	Japan
Egil Sakshaug	Norway
Yasunori Sakurai	Japan
Paul Wassermann	Norway
Kai Wieland	Greenland

Appendix 4

Terms of Reference

ESSAS Working Group 3
Modeling Ecosystem Response
(WGMER)

28 February 2007

Introduction

A major goal of ESSAS is to predict the potential impacts of climate variability on the sustainable use of the sub-arctic seas. ESSAS has elected to employ a comparative approach, investigating in each of the sub-arctic seas which energy pathways appear particularly vulnerable to decadal and longer-term climate change. Ecosystem-level response to climate can vary spatially, geographically, and ontogenetically. It can manifest itself locally (i.e., be non-linear with threshold responses), involve complex species-to-species interactions (i.e. ecosystem reorganization in response to climate change, and/or demonstrate different within-species responses between different regional geographic locations within the same ocean basin, all originating from similar climate fluctuations.

Reducing uncertainty about the future states of ESSAS ecosystems depends on knowledge of the response of the ecosystem to changes in climate and a quantitative ability to project future climate states. The first ESSAS goal of prediction requires a fundamental understanding of climate-biological interactions. With understanding comes the ability to model the complex linkages between climate variables and species distributions, which are the primary focus of the other two ESSAS Working Groups (ESSAS Working Group 1: Regional Climate Prediction and ESSAS Working Group 2: Biophysical Coupling Mechanisms).

The goal of the **Working Group on Modeling Ecosystem Response (WGMER)** is to develop conceptual, mechanistic/process, statistical/empirical, and simulation models to facilitate comparison of ESSAS ecosystems and to forecast the impacts of climate change on ecosystem structure and function in multiple ESSAS ecosystems.

Much data has already been collected in ESSAS ecosystems. Thus a major task of WGMER will be to inventory these data and evaluate the suitability of using these data in comparative analysis, modeling and forecasting climate impacts.

Tasks

1. Identify modeling methodologies that will facilitate comparison of the biological, physical, and trophodynamic aspects of the ESSAS ecosystems across regions. Identify and suggest suitable conceptual, mechanistic/process, statistical/empirical, and simulation models to examine for potential application.
2. Assemble existing biophysical datasets and time series from ESSAS ecosystems to facilitate joint comparative studies.
3. Apply the identified candidate models and modeling techniques to ESSAS ecosystems and ecosystem data sets to describe and validate the models.
4. Evaluate ESSAS modeling proposals and offer recommendations to the SSC.

Implementation

1. The Working Group on Modeling Ecosystem response shall exist for a period of three years, ending six months after the 2009 annual meeting of ESSAS.

2. Six to eight members will be chosen from the fields of quantitative ecology and fisheries oceanography. Input from experts on future climate variability and ecosystem process will be sought through collaboration with ESSAS WG 1 and 2, respectively.

3. The development of the proposed products will include conducting workshops held at the annual ESSAS meetings and also inter-sessional workshops as required. The purpose of the workshops will be to review candidate modeling methodology, to facilitate ecosystem comparisons, and the identification of suitable data sets. Inter-sessional work will involve pre-workshop preparation, data analysis, model coding, model application post-workshop report preparation, and the preparation of peer-reviewed manuscripts.

Expected Results

Workshop products will be one or more review papers, to be published in the refereed literature, that summarize the important ecosystem features that facilitate comparison.

Other products will include short position reports on the models evaluated, strategies for implementing the models, recommendations on future data collection and on synthesis of existing data, and methodological recommendations for ensuring appropriate among and between ecosystem comparisons. Joint efforts on these and other specific topics will be done in collaboration with the WG 1 and WG 2.

Initial Membership

Bernard A. Megrey	USA, Co-Chair
Shin-ichi Ito	Japan, Co-Chair
Kenneth Rose	USA, Co-Chair

Paul Budgell	Norway
Lorenzo Ciannelli	USA
Dr. Masahiko Fujii	Japan
Gennady Kantakov	Russia
Franz Mueter	USA

Appendix 5

Terms of Reference

ESSAS Working Group 4
Climate Effects at Upper Trophic Levels
(WGCUTL)

25 March 2008

Introduction

A major goal of ESSAS is to predict the potential impacts of climate variability on the sustainable use of the Sub-Arctic seas. ESSAS has elected to employ a comparative approach to investigate, in each of the sub-arctic seas, which energy pathways appear particularly vulnerable to decadal and longer-term climate change. The ecosystem response to climate change can be non-linear with thresholds, have complex interactions between species, and feature different species responses to similar climate fluctuations in different ecosystems. Reducing uncertainty about the future states of ESSAS ecosystems depends on developing the ability to project future climate states as well as predicting the response of the ecosystem to changes in climate. Predicting future climate states is the primary focus of ESSAS Working Group I on Regional Climate Prediction. Understanding and modeling the complex linkages between observed and projected climate variability and species distributions is the primary focus of two ESSAS Working Groups (ESSAS Working Group 2: Biophysical Coupling Mechanisms and ESSAS Working Group 3: Modeling Ecosystem Responses).

Goals

The main goal of Working Group 4 on Climate Effects at Upper Trophic Levels (WBCUTL) is to assess the effects of ocean climate variation and fishing on the interactions between gadoid fishes and crustaceans by conducting a comparative study across multiple sub-arctic marine ecosystems.

Approach

Gadoid fish and crustaceans are important components of the benthic food web in most subarctic ecosystems and are often among the most important commercial fisheries in these systems. Much is already known about the responses of gadoid fish and crustaceans to physical variability in the ocean. However, there is a need to summarize what is known specifically about the responses of these populations in subarctic seas to climate variability in the context of fishery takes and to contrast and compare these responses among different ecosystems. This working group deliberately focuses on a small set of interacting species to identify consistent associations between the major, commercially important, gadoid fish and crustacean species in each system and

to evaluate their responses to observed climate variability. Identifying associations will improve our understanding of ocean climate effects or 'bottom-up' processes that are important in regulating these populations. Our working hypothesis is that gadoid fish and crustaceans respond in opposite ways to ocean climate variation and that such variation results in differences in productivity and abundance between gadoids and crustaceans.

The physical aspects of the ocean that may be crucial in regulating these responses in the ESSAS ecosystems include sea ice cover, ocean temperature, circulation, and stratification. Our approach is consistent with the ESSAS approach of making comparisons across multiple ecosystems. It is recognized that population responses may not be consistent across all sub-arctic ecosystems, but similarities and differences will help identify ecosystem features that are related to the functional mechanisms governing gadoid – crustacean interactions and dynamics. These mechanisms may operate at the adult stages (e.g. through predation or variations in reproductive success), during early life history stages (e.g. through effects on survival of larval or early benthic/demersal stages) and/or at lower trophic levels (variations in food availability). This study is intended to complement other studies of effects of ocean climate on productivity at low trophic levels (e.g. BSIERP/BEST in the Bering Sea, ESSAS Working Group on Biophysical Coupling) to elucidate how bottom-up processes function in regulating ecosystem structure.

To achieve its goals the working group will engage experts from as many subarctic ecosystems as possible to obtain the best available datasets on variability in abundance of gadoids and crustaceans, as well as relevant ocean climate indices and fisheries takes from each system. Data analyses will be conducted within and across ecosystems to identify important associations and to examine similarities and differences among ecosystems. Results from these analyses should lead to a better understanding of the functional relationships between gadoid and crustacean populations and between climate variability and these populations.

Tasks

1. Summarize and evaluate the available information on the responses of gadoid fish and crustaceans in the Sub-Arctic seas to variability in physical attributes of the ocean (such as seasonal sea ice cover, ocean temperature, stratification, and circulation).
   a. Compilation of relevant literature
   b. Compilation of relevant datasets. For each ecosystem, these datasets should include:
      i. annual estimates of abundance or biomass of important gadoid and crustacean populations
      ii. annual estimates of recruitment to these populations, where available
      iii. total annual harvests from these populations

iv. ocean climate indices thought to be relevant to the populations by local experts

2. Conduct statistical analyses of relevant data sets from each ecosystem, including:
   a. correlation analyses
   b. multivariate analyses of within and between-system patterns of variability
   c. models of species interactions

3. Be a resource to other working groups within ESSAS, to the larger ESSAS community, and to other researchers on retrospective and future climate change issues in regards to gadoid and crustacean resources.

Implementation

1. The Working Group on Climate Effects at Upper Trophic Levels shall exist for an initial period of three years, ending six months after the 2011 annual meeting of ESSAS. At that time, the ESSAS Scientific Steering Committee will evaluate whether the WG should continue as is, continue under revised terms of reference, or be dissolved.

2. Twelve to fourteen members will be chosen from the fields of gadoid and crustacean biology, as well as physical, biological and fisheries oceanography. Input from experts on future climate variability, bio-physical coupling, and the needs of ecosystem modelers will be sought through collaboration with ESSAS WG 1, 2, and 3, respectively.

3. The development of the proposed products includes:
   a. Conducting a workshop to be held at one of the annual ESSAS meetings. The purpose of the workshop will be to review information on how changes in climate will affect gadoid and crustacean populations
   b. Literature searches and data compilation with help from local experts in each of the regions; a student will be recruited to assist with these tasks (funds for a M.S. student for 2 years have been secured)
   c. Conducting data analyses (student, with help from working group members)
   d. Preparing presentations for workshops, preparing manuscripts
   e. Conducting e-meetings as necessary to review progress and coordinate tasks

Expected Results

We anticipate one or more comparative papers based on a review of the literature and new data analyses to summarize important associations between climate variability and the relative productivity of gadoid and crustacean populations in subarctic ecosystems. Where possible, the paper(s) should provide the information necessary to parameterize relevant relationships between gadoid and crustacean populations in ecosystem models of the subarctic seas. Where sufficient data are lacking to accomplish this task, there

should be a clear statement concerning the lack of specific data that could guide future fieldwork.

Regions of study (tentative)
Barents Sea
East Greenland / Iceland
West Greenland
Labrador/Newfoundland
Eastern Bering Sea
Gulf of Alaska
Oyashio Current region

Appendix 6

ESSAS Implementation Plan and Activities

The following 5 components were laid out for the ESSAS Implementation Plan as part of the overall Science Plan (GLOBEC Scientific Report #19, May 2005). For each component, a list of activities that have taken place or are expected in the future is included.

1. Ecosystem Summaries

-Science Plan Background volume (GLOBEC Scientific Report # 20, May 2005)

-Victoria Symposium (May 2005)

-Symposium Volume (results published in late 2007)

-ECONORTH Symposium held in Tromsø 12-15 March 2007 focusing on the Barents/Norwegian Seas

-There remains the need to develop reviews/overviews of the marine ecosystems of the Gulf of St. Lawrence, Hudson Bay, West Greenland, and the Western Bering.

2. Regional Studies

These are the nationally funded regional research programs. To date these include:

-**J-ESSAS** (Japan- ESSAS): Oyashio, and to a lesser extent the Sea of Okhotsk; 2006-2010.

-**NESSAS** (Norwegian ESSAS): Barents Sea; 2005-2008

-**ISEP** (Iceland Sea; 2006-2008 (?) Not yet formally a part of ESSAS

-**BEST** (Bering Ecosystem Study), USA: Eastern Bering; 2007-2010

These also include the IPY Activities which will also be funded nationally.

-**ESSAR** (Ecosystem Studies of Sub-arctic and Arctic Regions)

-IPY Field years 2007-2008

-Proposals written or being writing with funding decisions during 2006

-Expect ESSAR Planning Meeting early 2007 (IPY funds)

3. Comparative Studies

-**NORCAN** (Norway–Canada Comparisons of Marine Ecosystems): 2005-2006: Labrador/Newfoundland-Barents/Norwegian seas

- Workshops (Bergen, Dec. 2005; St. John's, May 2006)

- Writing Meetings (Tentative Dec. 2006)

-**MENU** (pending funding): Bering, Georges Bank/Gulf of Maine, Barents Sea

- Theme session at ICES ASC 2007 (Proposed)

-**Workshop on Role of Sea Ice in Marine Ecosystems** (Hakodate,

Japan, June 2007) ($30K US to be raised)
  - Co-Conveners: Sei-ichi Saitoh, Egil Sakshaug, Higher Trophic Level person
  - Invited Speakers: Co-Conveners to decide

-**Workshop on the Role of Advection in Sub-arctic Seas** (Halifax, 2008) ($20K US to be raised)

-**Workshop on topic yet to be defined** (Seattle, 2009) ($25K US to be raised)

4. Prediction

-**Working Group on Prediction** (WGP) formed.

- TOR written by Jim Overland (Chair) and circulated;
- 1-day Workshops planned for next two annual meetings (WGP will organize physical information and bring to WGBC and WGM for input on biological consequences) ($20K US to be raised for technical support, $5K US for travel support)

5. Synthesis Activities

-**Working Group on Modeling** (WGM) formed

- TOR written by Bern Megrey, Ken Rose and Sei-ichi Ito (Co-Chairs) and circulated; suggested annual meetings associated with workshops ($25K US/yr to be raised).

-**Working Group on Biophysical Coupling** (WGBC) formed

- TOR written by George Hunt (Chair) and circulated; suggest annual meetings associated with workshops.
- Comparison with Antarctic at the GLOBEC Open Science Meeting (2009/2010)

Appendix 7

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*** Members Not Attending**
**** Guests**