Abstracts

Theme I:

Asgeir Sorteberg (Univ Bergen, Norway): Arctic temperature and sea ice changes: Forcings and feedbacks. ***(Keynote)***

There have been large changes in the arctic climate system over the past decades. Using high-latitude (>65°N) station data a warming rate of 1.4°C per century (1875–2008) has been estimated. The trend is 1.6 times stronger than the Northern Hemisphere trend. This Arctic amplification has been attributed to both local feedbacks such as the ice–albedo feedbacks and turbulent forcing to larger scale feedbacks involving poleward oceanic and atmospheric energy transports, but the effect of the different mechanisms have proven difficult to quantify. In concert with the temperature changes satellite estimates of sea ice extent over the last 30 years has shown a severe decline in summer extent and submarine records covering parts of the Arctic Ocean indicates an ice thickness loss during the end of the melting season of 1.6 m (53%) over the last 40 years. A decline that is faster than anticipated in the Intergovernmental Panel on Climate Change Fourth Assessment Report (IPCC AR4). As with temperature, sea ice variability and changes is a complex interplay between changes in radiative forcings, atmospheric and oceanic circulation variability and strong positive feedbacks that might amplify the initial change. A wide range of forcing factors and feedbacks has been proposed in the literature. The talk will review some of the proposed Arctic temperature amplification mechanisms and possible mechanisms affecting the speed of sea ice decline.

James E. Overland (NOAA PMEL, Seattle, USA): Arctic Surprises: Sea Ice loss and Increased Arctic/Sub-Arctic Linkages. ***(Keynote)***

Recent data over the last decade show an Arctic wide temperature increase consistent with model projections of global warming rather than showing regional warming patterns which would have been caused by natural variability as occurred in previous Arctic warming episodes such as the 1930s. While a major surprise was the nearly 40% loss of September sea ice extent in 2007, the major change is that in every year since then sea ice has been below 30% and that much old, thick sea ice has disappeared. Extensive forest fires are another major Arctic change. These shifts seem to be rapid and occurring 20-30 years earlier than expected by steady processes in climate forecast models. Perhaps several Arctic feedbacks are kicking in? Even though Arctic temperatures and the average temperatures of the Northern Hemisphere have increased over the last decade, this does not mean that temperatures smoothly increase in all regions at the same rate. For example, increased north-south (meridional) winds coming out of the Arctic in late autumn and early winter 2005, 2008, 2010, but especially 2009 brought record cold and snow conditions to northern Europe, eastern Asia and eastern North America. The Arctic is normally dominated a very stable “Polar Vortex” of counter-clockwise circulating winds surrounding the North Pole which traps the cold Arctic air mass at high latitudes. However, during early winter of 2009-2010 the

Polar Vortex weakened due to higher geopotential heights over the Arctic, allowing cold air to spill southwards and be replaced by warm air moving poleward, a *warm Arctic –cold continent* climate pattern. One indicator of a weak Polar Vortex is the North Atlantic Oscillation (NAO) index which in December 2009 through February 2010 had its most negative value (weak vortex) in 145 years of record. Meteorological attribution to these sub-Arctic events is difficult. Certainly random chaos in the development of weather patterns can produce such extreme events. There is a potential impact, however, from Arctic regions where heat stored in the ocean in sea-ice-free and thin ice areas has been released to the lower atmosphere during autumn. One would not expect a sub-Arctic impact in every year or the in the same locations every year. The Barents Sea seems to be part of the Arctic wide warming pattern, while northern Europe is in the sub-Arctic high climate variability zone.

Salve Dahle (Akvaplan-niva, Norway): On drifting ice to the North Pole.

During the period 1937 to 1991 Russian scientists carried out studies in the Polar Ocean using drifting ice as observation platforms. They studied a whole range of different scientific disciplines, such as climate, meteorology, oceanography, ice dynamics, earth magnetism, depth and ocean floor topography, dynamics of biology in ice and water, water and ice chemistry etc. These studies were the first real studies of the Polar Ocean and basin since Fridtjof Nansen on his Fram drift across the Polar Ocean 40 years earlier. Most of the information gained in these brave studies of the Arctic was totally unknown to science, and after these studies the Polar Ocean was no longer a white spot. Also the endurance and sacrifices of the scientists using drifting ice as a platforms during the long polar night is remarkable. At the same time this was the cold war period, and the studies had to be carried out secretly.

Vidar S. Lien (IMR, Norway) and Alexander G. Trofimov (PINRO, Russia): The Barents Sea – Arctic Ocean gateway: Water mass characteristics and transformations.

Dense water masses produced at high latitude shelves play an important role in the world oceans thermohaline circulation. As a part of the IPY project BIAC (Bipolar Atlantic Thermohaline Circulation), we have investigated the characteristics and transformations of the intermediate and deep water masses which exit the Barents Sea through the St. Anna Trough and flows into the Arctic Ocean. Results from a total of 142 CTD-stations covering the St. Anna Trough and the outflow area between Novaya Zemlya and Franz Josef Land are presented. The observations reveal the presence of two modes of Atlantic derived water masses in this area: Atlantic Water modified within the Barents Sea, and Atlantic Water from the Arctic entering the St. Anna Trough from the north. The two Atlantic derived water masses show opposite temporal patterns in temperature, despite their common source, which points to the importance of regional processes in determining their characteristics. The data also show a substantial modification of the Barents Atlantic Water, and the end product observed downstream in the Arctic Ocean, termed Barents Sea Branch Water, comprises a wide range of densities, and the densest part has the potential to cascade down to at least 2000 m depth in the Arctic Ocean. The Atlantic Water entering from the Arctic is the only water mass with temperature above 0 degrees C observed in the St. Anna Trough. Therefore, the Barents Sea may not be considered as an important source of oceanic heat for the Arctic Ocean, if one uses the common reference temperature -0.1 degrees C as an estimate of the temperature within the Arctic Ocean.

Randi Ingvaldsen, Harald Loeng, Sigrid L. Johansen and Ole Humlum (IMR, Norway): Barents Sea climate variability during the last decade.

Since the 1970s there has been observed a general warming in the Barents Sea. Strong temperature increase has been observed in the boundary areas where Atlantic Water (AW) enters, also in the northern regions where AW enters from the north. Compared to the 1990s, the strongest increase during the 2000s has occurred in the deeper water masses connected to the Atlantic Water (AW) inflow, and this may have impact on the physical conditions in the Barents Sea. Earlier literature has documented a link between the flow of AW into the Barents Sea and large scale atmospheric features such as the North Atlantic Oscillation (NAO). More recent studies shows that this relation broke down in the mid/late 1990s, and suggests that the high temperatures observed the last decade may be linked to a weaker subpolar gyre in the Atlantic Ocean.

When predicting future temperature changes, it is important to also address the natural climate variability. Analyzing time series spanning more than a century, dominant frequencies may be identified and used for predicting the temperature variations caused by natural climate variability for the period 2010-2045.

Boris N. Kotenev, Andrey S. Krovnin and G.N. Rodionov (VNIRO, Russia): Climate trends forecast for the Norwegian Sea and the Barents Sea for the period 2012-2025.

The qualitative evaluation of the climate tendencies of the North Atlantic, the Norwegian Sea and the Barents Sea shows that warming phase is near to end. However, SST in those seas will remain high until 2012-2013. The cooling phase will start afterward. Nevertheless, positive phase of the Atlantic Multidecadal Oscillation (AMO) in the North Atlantic will continue till 2025-2027.

Bjørn Ådlandsvik, W. Paul Budgell and Anne Britt Sandø (IMR, Norway): Regional climate scenarios for the Barents Sea.

Two future climate scenarios for the Barents Sea has been obtained by downscaling the results from global climate model runs with the use of a regional ocean model. Comparison with recent observed climate is used to validate the downscalings and assess the added value over the raw global results. The projected future changes in sea ice and hydrography for the period 2051-2065 are discussed.

Igor Esau (Nansen Centre / Bjerknes Centre, Norway) and Irina Repina (Obukhov Institute for Atmospheric Physics, Moscow, Russia): Observations and fine-resolution large-eddy simulations of the katabatic wind over Kongsvegen glacier, Kongsfjorden and Ny Ålesund

Using results of several field campaigns run jointly by Norwegian and Russian Institutions on the Kongsvegen glacier and in Ny Ålesund, we were able to set up numerical experiments with the fine-resolution large-eddy simulation model PALM. The computer experiments recovered a three dimensional structure of the atmospheric boundary layer flow in a large (30 km by 50 km) micrometeorological domain at the resolution of about 30 meters with the realistic topography taken from the ASTER project (See Figure). This is the finest resolution and the largest domain simulations completed for this area to date. The simulations allow studies of the katabatic wind development in both time and space as they include the summit of the glacier and the area of the breeze front out over the open ocean. In particular, we calculated the spatial distribution of the air-sea turbulent fluxes and the atmospheric boundary layer depth over Kongsfjorden. We also map topographical stagnation zones were concentration of cold and possibly polluted air can be expected. One of such zones is located close to Ny Ålesund. Climatologically, it could give a cold bias when assessing the regional climate on basis of sparse meteorological measurements.

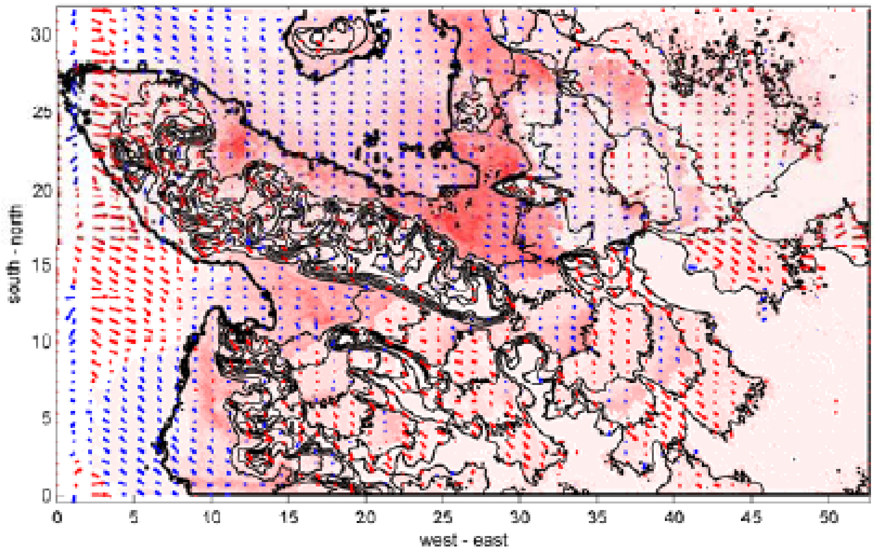

Figure. The near surface wind in the PALM simulations using 2048 by 1024 by 96 grid points, vertical resolution at the surface is 13 m. The shading corresponds to the concentration of the passive scalar emitted from the surface. Blue arrows correspond to the katabatic wind. The simulations were run for 6 model hours.

Anton Korosov, Lasse H. Pettersson and Annette Samuelsen (Nansen Centre, Norway): Detection of decadal climate change based on consistent satellite observation of the Nordic Seas aquatic ecosystem ***(Poster).***

During the last decades, there has been a significant warming trend over the Arctic, corresponding in average to approximately 5°C/century. The warming has not been uniformly distributed, as there has been a slight cooling over the eastern Canada, northwest Atlantic and Greenland area, and a stronger warming over Siberia. The trend is a manifestation of a strengthening of the North Atlantic westerlies, with increased heat and moisture transport responsible for a row of warm and wet winters experienced in the North-east Europe experienced in the end of last century. For the Nordic Seas area (i.e. Norwegian, North and Barents Seas), the predicted temperature increase from the 1961 to 1990 period is ranging from 3°C in the south to 6°C in the Fram Strait and eastern part of the Barents Sea region. In the Arctic Ocean, the warming is exceeding 8°C north of the Siberia, while north of Alaska, Canada, and Greenland it is only 5°C. There has been a substantial change in the climate conditions in the Nordic Seas during the period with reliable instrumental records. Here are some key observations: large salinity anomalies, more polar water and eastward shift of the front between Atlantic Water (AW) and Polar Water (PW), a reduction in the deep water formation in the Greenland Sea, a warming of the deep waters and reversal of the deep currents in the Nordic Seas, and a reduction in the Faroe Bank overflow. The worldwide aquatic environments respond to the ongoing changes in the Earth System including climate variations and anthropogenic forcing. Monitoring of occurring alterations of aquatic ecosystems becomes now one of the most urgent tasks. Given large dimensions of oceans, marginal seas and large freshwaters, satellite monitoring proves to be an indispensable component of the total system of monitoring systems. Presently, satellites with dedicated missions including monitoring of aquatic ecosystems status are successively launched to assure data continuity through at least the next decade. Merging of data obtained by satellite sensors of the same mission and concatenation of data from different missions is a highly challenging task since data streams from the sensors differ in many parameters as well as their technical specifications. This task is thought to be most successfully resolved through utilization of the Neural Network emulation when optical signals from two different sensors obtained for one and the same scene within a short time interval are analyzed in order to establish a robust interrelationship based on solid statistical data. Due to combination of marine and terrestrial abiotic factors coastal ecosystems certainly suffer the most drastic alterations. Therefore the most evident influence of the climate change on aquatic ecosystems occurs in the coastal zones. These waters are characterized by high concentrations of suspended matter and organic constituents and this is the reason why most of the standard algorithms, originally developed for open ocean waters, are untenable for processing ocean color data taken over coastal zones. Evidently, advanced algorithms based on neural networks or multivariate optimization approach and additionally adjusted for regional conditions should be applied. Objective: Detection of seasonal and inter-annual changes of essential climate variables based of consistent decadal satellite observations of coastal aquatic ecosystems of the Nordic Seas. Decadal time series of satellite observations of ecology-relevant water constituents, which are known to be mostly chlorophyll (CHL), dissolved organic carbon (DOC), suspended minerals (SM), and Sea Surface Temperature (SST) combined with in situ sampling of biology and water chemistry and a dynamic model, allow us to better understand important changes of water bodies within the European Arctic system, namely the Norwegian Sea, The North Sea and the Barents Sea. To address the impact of changing climate on decadal time scales, we propose to expand collaboration between NIERSC and NERSC by application of the advanced non-satellite-specific algorithm developed at NIERSC and adjusted for regional conditions at NERSC. Applying our algorithm to SeaWiFS, MODIS and MERIS data, we will generate CHL, DOC, SM and SST maps for all cloud-free days from 1997 to the present (more than 10 years of satellite monitoring). The main advantage of the algorithms is that it is capable of retrieving concentration values accurately both in open waters and in coastal regions. For obtaining continuous satellite dataset we will use merging techniques for stitching data from different sensors. In the international ESA GLOBCOLOR project it has been shown that merging can be effectively applied for open ocean remote sensing data. We plan to use the developed technologies and our own experience of merging of SeaWiFS and MODIS data (in the Bay of Biscay) for development of an advanced procedure for merging ocean color data from coastal zone. The maps of CHL, TSM, DOC concentrations and SST and appropriate new and historical in situ cruise data will be used to investigate recent trends: warmer water temperatures, more frequent extreme storm events, increased rain events which result in increased river discharge. These trends, which have resulting ecological consequences, will then be compared to climate change scenarios developed and evaluated in our other joint research.

Elena L.Vinogradova (P.P.Shirshov Institute of Oceanology, Russian Academy of Sciences, Moscow, Russia): Variability of hydrochemical structure at inner and outer boundaries of Eurasian Arctic estuaries. ***(Poster)***

The river discharge is the main constituent of forming of hydrological and hydrochemical regime of seas and productivity in coastal areas. It also serves as a sensible indicator of climate changes in catchment areas that is a special emphasis to high latitude seas. In addition the reliable assessment of present conditions of the coastal and marine ecosystems in the Arctic region is important to avoid possible ecological problems caused by planned exploitation of oil and gas deposits in the region.

This work aimed in estimation of the relative role of the water chemical composition changes in the downsteams of the Arctic rivers just before their estuaries. This investigation of Ob, Yenisei, Pechora, Northern Dvina downstreams have shown that river runoff is undergone significant changes before inner boundary of estuaries. These changes comparable to changes of chemical composition of river water at the geochemical barrier or in the frame of Marginal Filter. Changes for different parameters vary from 53 to 97%. The main reasons of spatial irregularities of nutrient discharge in the downstream of river are changes of dynamic characteristics of the flow (at widening of a channel the flow velocity sharply falls that leads to the mass setting the particular substances and to the changes of a chemical compound of waters connected with it); influence of orography of river laying down (in the bottom deeps there is a natural accumulation of organic substance); photosynthetic processes; anthropogenic impact.

Chemical composition of river discharge is individual for each river and it is generated by character of a catchment area. The result of expeditions has revealed irregularity of hydrochemical compound along rivers flow and through their cross-sections. In spite of essential mixing waters entered from other region of a catchment area retain their hydrochemical features in a main channel along some distance. This feature is traces as at inner as at outer boundary of estuaries. High concentrations of nutrients as a rule are localized at deeper channel line stations in warm seasons. The highest concentrations of nutrients are often deposited to banks in cold seasons.

Based on the data received in some seasons it should be concluded that a zone of river-sea interaction considerably drifted to the North for 1993 – 2005 – 2007 - 2010.

Theme II:

Svein Sundby (IMR, Norway): Impacts of climate variability and change across trophic levels in the arctic and subarctic marine ecosystems ***(Keynote)****.*

The arctic and subarctic regions of the Earth's marine ecosystems have undergone larger climate variability than most other marine ecosystems during the 20th century. The impacts on theses marine ecosystems have also been shown to be large and better documented than for other regions of the world's oceans. Similarly, projections on anthropogenic global climate change during the 21th century show larger change at high latitudes. The past impacts of multidecadal climate variability during 20th century are of particular interest in assessing the impacts of anthropogenic climate change during 21th century, since these signals are comparable in persistence and rate of change to that of the anthropogenic signal. Based on time series observations on fish productivity and distribution, I am discussing how boreal and arctic species will have potential for change during the 21th century. Based on modeled projections on phytoplankton production, I am discussing how zooplankton populations, and particularly the boreal key species, will have the potential to change their productivity and distribution during the 21th century. Further, I will discuss how the changes in plankton link up with the past observed changes in fish populations. Finally, I will discuss the mechanisms behind such ecosystem changes, and the possibility that these changes might occur in abrupt steps rather than as a continuous change.

Oleg Titov (PINRO, Russia): Fishery and oceanographic aspects of performance of the Barents Sea ecosystem and the experience with their application by the ICES AFWG ***(Keynote)****.*

One of the most important practical and theoretical problems connected with study of marine ecosystems is prediction of recruitment values in commercial fish populations. One of the experiments on application of the ecosystem approach for prediction of NEA cod recruitment abundance was modeling s with the use of data on physical and chemical status of environment (Titov, 1999; Titov, 2001). The models (Titov *et al*., 2005), as well as several other statistical models (e.g. Bulgakova, 2005; Stiansen *et al*., 2005; Svendsen *et al*., 2007), have been compared by the ICES AFWG and adopted for practical use. Thus at present, natural processes, influencing the dynamics of the marine ecosystem, are taken into consideration when predicting values of cod recruitment. This leads to increase in prediction accuracy of recruitment abundances of cod and, correspondingly, to decrease in error at prognostication of TAC. Based on the experience gained by author during the development of prediction models the paper discusses the physical and chemical processes in the Barents Sea ecosystem, which reflect the impact of climate change on cod population.

Harald Loeng (IMR, Norway): From the Barents Sea to the Arctic Ocean.

Physical factors that make arctic marine ecosystems unique are a very high proportion of shallow continental shelves, dramatic seasonal change, low temperature, extensive permanent and seasonal ice-cover, and a large supply of freshwater from rivers and melting ice. Because of these conditions, many of which are challenging for marine biota, arctic marine ecosystems have a large number of specialists, many of which are not found elsewhere. These organisms have through time been able to adapt to the environment, they are still challenged by extreme inter-annual variations.

The possible pathways by which climate variability may affect ecological processes are many and vary across a broad range of temporal and spatial scales. Climate variability affects fish both directly through physiology, including metabolic and reproductive processes, as well as through affecting their biological environment (predators, prey, species interactions) and abiotic environment (habitat type and structure). Furthermore, ecological responses to climatic variation may be immediate or lagged, linear or nonlinear, and may result from interactions between climate and other sources of variability.

The presentation will focus on physical and biological characteristics of Arctic Ocean and the Barents Sea, and how ecosystems interact. There is ample evidence of the effects of climate variability on the marine ecosystems, e.g. the response of the abundance and distribution of fish species associated with long-term temperature changes. These occur as direct physiological responses as well as indirectly through effects on the prey, predators or competitors. However, many aspects of the interaction between the atmosphere and the ocean, and between climate and the marine ecosystem require a better understanding before the high levels of uncertainty associated with present predicted responses to climate change can be significantly reduced. This understanding can only be achieved through monitoring and research. The later should include comparisons between and among other sub-Arctic and Arctic regions.

Ken Drinkwater and the NESSAR Team (IMR, Norway): The Polar Front and its influence on the Barents Sea ecology.

The IPY Project NESSAR (Norwegian Component of the Ecosystem Studies of Subarctic and Arctic Regions) carried out field studies of the physical dynamics, as well as the structure and function of the marine ecosystems, in and around the Polar Front on Spitzbergen Bank and Storbanken in the Barents Sea during 2007 and 2008. The Polar Front is density compensating with strong interleaving between the Arctic and Atlantic waters. Mixing at the front occurs through current shear and double diffusive processes and although turbulence levels are elevated in the vicinity of the front, they are still relatively weak. As a result, the vertical mixing is too weak to break down the stratification and hence, there is no evidence of increased primary production at the Polar Front. On Storbanken, small zooplankton were found to be more prominent at the front and large zooplankton away from the front. Capelin show a similar distribution with small individuals in the front and larger capelin away from the front, especially up on top of the Bank in the Arctic waters. The interaction of the sea-ice edge and the Polar Front on Spitzbergen Bank will also be discussed. Finally, the possible effects of climate change on the Polar Front and its impact on the biology will be addressed.

Nils Chr. Stenseth (CEES, Univ Oslo, Norway): The effect of climate on the ecological dynamics in the Barents Sea.

This lecture will summarize much work on the modeling of time series data on fish and plankton together with climate data from the Barents Sea marine system. It is shown how data of different quality and length can be combined so as to improve our understanding of how the marine system is affected by climate forcing. A concluding plea of the lecture is that long-term data (in spite their varying quality) are of great value in our effort to try to understand how the marine system will be affected by climate change. The lecture also provide examples of rewarding collaboration between Norwegian and Russian scientists.

Igor Manushin, N. Anisimova, and P.Lubin (PINRO, Russia): Long-term changes of macrozoobenthos in the southeastern Barents Sea.

The Barents Sea is one of the marine arctic areas which have been studied more protractedly and systematically. The archives of PINRO contain a big quantitative and qualitative benthos data array. The large-scale benthos surveys for the Barents Sea carried out in the 1920s, 1960s and 2000s allow us to observe the changes in bottom communities due to various factors. This paper studies the influence of climate on benthos communities of the southeastern Barents Sea, the area, which is least effected by such apparent anthropogenic factor as fishery and located on the border of arctic and boreal biogeographic regions.

The paper studies bottom communities in the southeastern Barents Sea in the cold (the 1920s), transitional (the 1960s) and warm (the 2000s) climatic periods. The bottom biota in the cold period is characterized by high biomass of benthos with the highest proportion of the Arctic species as compared with other climatic periods. In the transitional period, benthic biomass reduced and the portion of species, which were cosmopolites, increased. The studied period of long warming, as well as that one of cooling is characterized by the increase in benthos mean biomass but, owing to the Arctic boreal species in this case.

The results obtained permit us to assume that the stability of environment is a more important factor for the productivity of the benthic communities in the studied area.

Lene Buhl-Mortensen, Pål Buhl-Mortensen, Børge Holte, Lis L. Jørgensen and Anne Helene Tandberg (IMR, Norway): Baseline mapping: a necessity for an assessment of effects on climate changes on benthic communities.

The MAREANO-mapping-programme collects and describes the benthic biodiversity, the physical environment and the biotopes in Norwegian waters. Since 2006, seabed areas down to 2700 m depth in the Barents Sea and the northern parts of the Norwegian Sea have been documented using video, beamtrawl, epibenthic sled and grab; producing a comprehensive dataset with a total of 607 video-mapped and 125 benthos-sampled stations.

The data produced by the MAREANO-program is to be used in the Norwegian governmental management of the Norwegian seas. The main task until now has been to provide new knowledge about environment and resources in the Barents Sea to support the implementation of the Norwegian Barents Sea management plan and its revision in 2010. The information provides a baseline for management of the environment and biodiversity in the area. Using the extensive data of MAREANO as a baseline for future comparisons will enhance the possibilities of detecting biodiversity-changes in the benthos. Comparison with historical records from the same areas can also provide an early indication of climate related changes in the benthic ecosystems in the northern areas.

Indications of changes in distribution, north-limit and south-limit, of benthic species will be presented, together with a discussion of the validity of comparisons to historical data.

Michael L. Carroll, William G. Ambrose Jr. (Akvaplan-niva, Norway), Benjamin S. Levin, Gregory A. Henkes (Bates College, Lewiston, Maine, USA), Haakon Hop (Norwegian Polar Institute), William Locke (Bates College, Lewiston, Maine, USA) and Paul E. Renaud (Akvaplan-niva, Norway): Pan-Svalbard growth rate variability and environmental regulation in the Arctic bivalve Serripes groenlandicus.

Growth histories contained in the shells of Arctic bivalves provide records of environmental and biological information over lifetimes spanning decades to centuries, thereby linking ecosystem responses to climatic variations over a range of scales. We examined growth rates and temporal growth patterns from 260 individuals of the circumpolar Greenland Cockle (*Serripes groenlandicus*) collected between 1997 and 2009 from 11 sites around the Svalbard archipelago. Environmental conditions at these sites varied from strongly Atlantic-influenced on the west coast to high-Arctic in northeast Svalbard. Absolute growth was up to 3 times greater at the most strongly Atlantic-influenced locations compared to the most Arctic-influenced areas, and growth performance was generally greatest in those sites in closest proximity to the West Spitsbergen Current. Growth chronologies up to 34 years in length exhibited substantial inter-site variability, but there were also common temporal features consistent with phase-shifts in large-scale climatic drivers. We also observed a common signal evident in the aggregated dataset indicating an overriding regional driver of bivalve growth: the Arctic Climate Regime Index (ACRI). Interannual variability in growth rates was also related to regional manifestations of the large-scale drivers, including sea temperature atmospheric pressure, and sea ice extent. Growth patterns at one site, Rijpfjorden, on the northeast coast of Svalbard, appeared broadly representative (R=0.81) of the entire dataset. These results demonstrate that sclerochronological proxies can be useful retrospective analytical tools for establishing baselines of ecosystem variability and for identifying key ecosystem drivers across spatial and temporal scales.

Paul Wassmann and Marit Reigstad (Univ Tromsø, Norway): Climate induced changes in primary production and pelagic-benthic coupling in the northern Barents Sea.

Despite of the rapid changes in Arctic Ocean physical forcing and ecosystem function, quantitative ecological knowledge is limited and physically-biologically couple models are few. This is also true for the Barents Sea, the best-known Arctic ecosystem. As a first step an evaluation of future development of biogeochemical cycling has thus to be explored through examination of conceptual models that address climate warming and ecosystem development. Here we present three conceptual models of biogeochemical cycling and climate warming in the seasonal ice of the Arctic Ocean, based upon experience from the Barents Sea. They aim at to understand, in a conceptual and semi-quantitative manner, the future develop of productivity and the fate of carbon in the future Arctic Ocean, in particular the pelagic-benthic coupling. The SINMOD model will then be applied to provide quantitative estimates on the time variation and spatial distribution of primary and secondary production. We speculate that the largest changes will take place in a) the northern sections of today's seasonal ice zone, which will expand to cover the entire Arctic Ocean (increase in productivity) and b) the southern section that will get exposed to more thermal stratification (decrease in productivity). Due to the thinning of the ice, the significance of ice algae for the total primary production may increase in the central Arctic Ocean, but decrease in the outer seasonal ice zone. The blooms of ice and plankton algae will stretch over longer periods of time, supporting increased pelagic retention processes. The weakening of today's highly episodic primary production and algae blooms in the SIZ will result in lower food concentrations for heterotrophic organisms and more recycling of available energy, changes in life cycle strategies and less variable vertical export. Freshening of the Arctic Ocean, nutrient limitation and a prolonged growing season will shift the community composition towards smaller phyto- and zooplankton forms, more retention and decrease seasonality in pelagic-benthic coupling.

Corinna Schrum, U. Daewel, D. Pushpadas (Univ Bergen, Norway), Evgeniy Yakushev (NIVA, Norway) and M. Årthun (Univ Bergen, Norway) : Decadal variability of hydrodynamics and productivity in the Barents Sea.

During the past decades the Barents Sea experienced pronounced changes in hydroynamic-, biogeochemical and higher trophic level conditions. The sea ice cover showed a long-term decreasing trend, which seems to have stabilized the recent years. Barents Sea temperature showed significant multidecadal variability, which was identified to correlate to the Atlantic Multidecadal Oscillation Index AMO (e.g. Levitus, et al., 2009) and covaritions between sea ice and cyclone activity have been identified (e.. Sorteberg and Kvingedal, 2006). Here we aim to investigate the resulting bottom up controls due to the climatically driven changes on the lower trophic level production in the Barents Sea. We will present results from a long-term model run for the Barents Sea from 1948-2008 performed with a regional physical-biological model. The model identifies long term variations in primary and secondary production. We will identify the most important climatic drivers, and illustrate the impact of climatic forcing on lower trophic level production and discuss the variations in dominant climatic drivers over the decades.

Levitus, S., G. Matishov, D. Seidov, and I. Smolyar, 2009. Barents Sea multidecadal variability, Geophys. Res. Lett., 36, L19604, doi:10.1029/2009GL039847.

Sorteberg, A., Kvingedal, B., 2006. Atmospheric forcing on the Barents Sea winter ice extent. J. Clim. 19, 4772–4784.

*Janne E. Søreide (UNIS, Norway), Michael L. Carroll (Akvaplan-niva, Norway), Haakon Hop (Norwegian Polar Institute), William G. Ambrose Jr. (Bates College, Lewiston, USA), Else N. Hegseth (Univ Tromsø, Norway), and Stig Falk-Petersen (Norwegian Polar Institute):**Trophic structure and carbon flow in Arctic- and Atlantic regimes around Svalbard revealed by stable isotopes and fatty acid tracers.*

Stable isotope and fatty acid trophic marker techniques were used to assess trophic structure and carbon flow of zooplankton and benthic components in different marine climatic regimes around Svalbard. Food web variability was related to differences in ice algae vs. phytoplankton carbon sources as well as pelagic and benthic community composition and biomass.

Ice algal carbon sources were particularly important for benthic soft-bottom communities, in addition to phytoplankton carbon sources, whereas the latter was most important for zooplankton. The proportion of ice algal vs. phytoplankton food sources increased from Atlantic- to Arctic-dominated waters and with duration of ice cover. Areas dominated by consolidated pack ice, however, had particularly low zooplankton- and benthic biomass, reflecting the overall low algal production here. Seasonally ice covered areas until June/July, had on average 2-3 times higher benthic biomass than Atlantic-dominated open waters where the ice algae component was lacking. The zooplankton biomass was positively correlated to benthic biomass, and was also particularly high in the moderate seasonal ice covered areas. These areas of particularly high pelagic- and benthic biomasses were dominated by Arctic organisms with opportunistic feeding strategies.

A future warmer climate will lead to increased pelagic biomass of Atlantic-associated species in ice free areas and of Arctic pelagic and benthic species in today's most extreme ice covered regions. In contrast, a reduction in total pelagic and benthic biomass may occur in the biomass-rich regions with moderate seasonally ice cover, since earlier ice break up due to warmer climate will alter the timing and magnitude of the present ice algal and phytoplankton blooms in these areas.

Øystein Varpe (Norwegian Polar Institute), Christian Jørgensen (Uni Research, Bergen, Norway) and Øyvind Fiksen (Univ Bergen, Norway): Double menu for Calanus in the Arctic: what are the life history consequences in a changing climate?

Many animals feed on different food sources at different times of the year. Temporally separated food may constrain growth and reproduction, but may also offer opportunities that are worth exploiting compared to a single seasonal food source. The bimodal primary production in the Arctic, with ice algae production taking place on the underside of sea ice and a pelagic primary production occurring after the sea ice has melted, is one case of temporally separated food sources. Herbivores, such as Calanoid copepods, feed on both these phytoplankton blooms. In *Calanus glacialis* the adult generation produces eggs while feeding on ice algae in spring while the offspring generation feeds on the later pelagic bloom. Matching the occurrence of life cycle stages with the two food sources and surviving the period in-between feeding events are among the challenges of this way of life. Here we model the life cycle of a Calanoid copepod presented with a spring and summer food source, the ice algae and the pelagic phytoplankton bloom, respectively. We predict optimal annual routines found by dynamic programming, including the timing of growth, reproduction and seasonal migrations, and compare with previous models where a single pelagic phytoplankton bloom was modelled. With declining sea ice distributions in the Arctic, the ice algae bloom may become insignificant and adaptations to this food source maladaptive. We discuss potential changes caused by a move from a twofold to a single food source, or by a mismatch with either of the two food sources.

Stig Falk-Petersen, Malin Daase, Eva Leu, Anette Wold, Øystein Varpe (Norwegian Polar Institute), Janne E. Søreide, Jørgen Berge (UNIS, Norway), Daria Martynova (Russian Academy of Science, St. Petersburg), Delphine Benoit University of Quebec, Canada), Gerald Darnis, Louis Fortier (Laval University Quebec, Canada) and Ketil Eiane (Univ Nordland, Bodø, Norway): Timing of the blooms determines the life strategy of Arctic Calanus glaciali.

The Arctic herbivores, the *Calanus glacialis* , is key specimes in Arctic marine ecosystems transferring energy from ice algae and phytoplankton to higher trophic animals. *Calanus* converts low energy carbohydrates and proteins into high energy lipids, which makes it an extremely lipid-rich food item for higher trophic levels. The copepods also form aggregations and patches making them concentrated, high-energy prey for carnivorous zooplankton, fish, sea birds, and marine mammals in the Barents Sea as well as other Arctic Seas. Reproductive process and growth, lipid accumulation, seasonal migration and diel vertical migration, and spatial aggregations are timed with the Arctic ice algal and phytoplankton bloom. We present new data on the timing of both the ice algal and phytoplankton blooms and relate these to the timing of the ontogenetic migration, reproduction, growth and the seasonal lipid accumulation of the *Calanus glasialis* from ice-covered Arctic waters. A pan-Arctic review of the life cycle strategy of *Calanus glacialis* is included, based on the latest data from the PanAME, CLEOPATRA and CFL projects.

Andrej Shadrin (Lomonosov Moscow State University, Russia), Elena Eriksen (IMR, Norway), Valerij Makhotin (Lomonosov Moscow State University, Russia), Harald Gjøsæter and Samuel Subbey (IMR, Norway): Embryological studies of capelin eggs under different temperature conditions.

The aim of the study was to determine if and how temperature conditions during incubation and biological characteristics of parent fish had any influence on incubation period and ratios of malformations and mortality during that period. Incubation was carried out on 3850 artificially fertilized eggs from 77 pairs of capelin (25 eggs from each pair). The eggs were incubated at two different temperatures: 5° and 8°C. Length, maturity stage, occurrence of food in the stomach, and age of each parent fish were recorded. The eggs were inspected at regular intervals (6-8 times during the experiment) and development stage, possible malformations, and mortality were recorded. After hatching, these observations continued for the larvae until they eventually died.

While there was a clear difference in incubation period among the groups of egg kept at 5°C (normal temperature at the spawning beds in Finnmark) and 8°C (an extremely high temperature), it was difficult to detect any clear differences in mortality or malformation of eggs or larvae either based on temperature or on biological characteristics of the parents.

Various graphical methods were applied to study the prevalence of malformations and the rates of mortality, in addition to standard statistical methods.

Randi Ingvaldsen and Harald Gjøsæter (IMR, Norway): Impact of marine climate variability and stock size on the distribution area of Barents Sea capelin.

The spatial distribution of the Barents Sea capelin at the end of the feeding season shows large inter-annual variations. Using data for the period 1972-2010 we investigate if observed changes in the capelin distribution area can be explained using stock size, the individual ambient temperatures preferred by capelin, ocean temperatures in the outer boundaries of the capelin distribution, and summer ice cover.

The results show a strong relation between distribution area and stock size up to the late 1900s/early 2000s. This is likely caused by a large stock extending the feeding area to meet the increasing food demand. During the last decade a general expansion of the capelin distribution area has occurred and the relation to stock size changed. Simultaneously, there has been a northward shift of the high-concentration areas, and capelin distributed widely but in lower concentrations. This shift/expansion seems to be related to the high temperatures and extremely low ice cover observed in the northern Barents Sea during the last decade. The study shows that climatic conditions sets the large-scale terms for the distribution of capelin, while stock size determine how the capelin choose to use the available area.

Haakon Hop (Norwegian Polar Institute) and Harald Gjøsæter (IMR, Norway): Polar cod and capelin in relation to water masses and sea ice conditions.

Polar cod (*Boreogadus saida*) and capelin (*Mallotus villosus*) are both key species in the Arctic marine food web. Here we review, compare and contrast polar cod and capelin, and conclude with predictions on effects of climate change on these two species. Polar cod is more important in the high-Arctic systems, whereas capelin is more important in sub-Arctic systems. The species occur sympatrically in the Barents Sea, with large standing biomasses ($0.5\text{-}1.5 \times 10^6$ t polar cod *vs* ($5\text{-}8 \times 10^6$ t capelin). Both species aggregate in large schools and utilize zooplankton food sources, such as calanoid copepods, although with some niche segregation since polar cod feed to a larger extent on pelagic and sympagic amphipods, whereas capelin feed predominately on krill. Both species are of suitable size as high-energy prey for many predatory fishes, diving seabirds and fish eating marine mammals. The lipid content (mainly triacylglycerol) of both fishes is high, but distributed differently. Polar cod contain lipids (up to 60% of wet weight) in their large livers, whereas capelin contains lipids (up to 20% ww) in their muscle tissue. The distribution of these species are largely dependent on water masses, with polar cod being associated with cold, sub-zero Arctic water, whereas capelin is distributed further south into Atlantic water masses. The distribution of polar cod seems to be more static than that of capelin, which distribution tends to extend further north in warm years and fluctuate grandly based on predator-prey relations. The species overlap in distribution near the polar front, in the marginal ice zones, and in fjords in Svalbard. However, polar cod is more associated with the ice than is capelin, and juvenile polar cod are often found in water wedges and cracks in drifting sea ice. Global warming with reductions in sea ice thickness and extent, as well as increase in sea temperature, is expected to affect these two species differently. Polar cod will likely become more pelagic, with more restricted distribution, whereas the future distribution of capelin is expected to involve an expansion to the north and east, although with considerable inter-annual fluctuations.

Jan Erik Stiansen, Silje Seim, Geir Odd Johansen and Harald Gjøsæter (IMR, Norway): The south-western distribution limit of polar cod in the Barents Sea – a useful indicator of climate variation?

Polar cod has a wide distribution in the Arctic, and the southern limit passes through the Barents Sea. The distribution and abundance of this species has been studied during joint Norwegian-Russian surveys (capelin surveys and ecosystem surveys) during autumn. Being a typical cold-water species, the polar cod do normally not penetrate far into Atlantic water masses, and the main distribution area is to the north and east of the polar front. However, the distribution area, and in particular the south-western range of this area, varies over the observation period.

This paper reviews the results obtained for polar cod distribution during the FishExchange project, which ended in spring 2011. One of the deliverances from that project is a database where observed fish distribution and catch positions are organized for several species, including polar cod. For this species, the catches has been low in the recent period, which renders the polar cod well suited as an object for analysis of natural changes in geographical distribution.

Olav Sigurd Kjesbu, Jon Egil Skjæraasen, Fransisco Rey (IMR, Norway), Christian Jørgensen (Univ Bergen, Norway): The link between temperature, fish size, spawning time and reproductive success of Atlantic cod.

Factors affecting spawning and larval survival in marine fish are of fundamental importance in understanding population demography. Physiological processes associated with reproduction and early larval growth are regulated, in part, by water temperature, which also affects the phytoplankton bloom and thereby the zooplankton peak. Changes in marine climate associated with global warming may therefore have dramatic effects on the reproductive success of marine fish. We examined the reproductive success of Northeast Arctic cod (*Gadus morhua*) in a climate scenario. Previous studies have documented that vitellogenesis for cod generally starts around autumnal equinox, and that oocyte growth is positively associated with ambient water temperature. Furthermore, spawning appears to occur earlier in larger fish when temperatures are above 5º C. This size - dependent spawning time is not apparent at lower temperatures. Utilizing this information we examined the links between water temperature, body size, spawning time and predicted match/mismatch with the zooplankton peak and resulting larval survival for Northeast Arctic cod in a conceptual theoretical model.

Bjarte Bogstad, Gjert Endre Dingsør, Harald Gjøsæter and Randi Ingvaldsen (IMR, Norway): Changes in the relations between oceanographic conditions and recruitment of cod, haddock and herring in the Barents Sea.

Data from the years 1946-1992 suggests a positive relationship between high temperatures and recruitment of cod, haddock and herring in the Barents Sea as well as a correlation between the recruitment of these three species. Data from recent years suggests that this relationship no longer holds. The recruitment process is broken down into periods (spawning to 0-group and 0-group to age 3) and the correlation between oceanographic conditions and survival in these periods is investigated. Several oceanographic variables (such as temperatures and inflow) are included in the analysis, as well as zooplankton abundance.

Boris N. Kotenev, Andrey S. Krovnin, Vladimir M. Borisov and M.V. Bondarenko (VNIRO, Russia): Year classes strength of cod, haddock and herring in the Norwegian-Barents region in relation to forecasted climate changes in 2012-2025.

Perspectives of the year classes' strength of the North-West arctic cod, haddock and herring till 2025 have been discussed in relation to the Climate trends forecast for 2012-2025. Possible seasonal and interannual variability of physical and biological conditions of survival rates and growth rates were taken into consideration.

Geir Odd Johansen, Edda Johannesen and Kathrine Michalsen (IMR, Norway): Size and age dependent geographic distribution of NEA cod in the Barents Sea - effects of physical conditions and abundance.

The geographic distribution of NEA cod in the Barents Sea exhibits seasonal variation. The distribution varies between different size and age groups during the development of the year classes, and as a function of life history events such as spawning. In this work we describe the variation in large scale geographic distribution of cod observed at standard surveys in late winter and autumn in the last three decades. The distributions of selected year classes are followed through their life span from 0-group to mature fish, where possible. Year to year variation and seasonal variation are described both within and between year classes. The geographic distributions are related to bottom depth and temperature conditions, and the variation in ambient temperature is described for different age groups throughout the time series. The effects of year class strength are also considered. The purpose is to describe large scale distribution and migration patterns of cod and how it varies as a function of potential driving factors in a period of considerable climate variation and a long term trend in ocean warming. The results will synthesise several years of observations of NEA cod geographic distribution and may serve as input to spatially structured models and climate effect studies.

Andrey V. Dolgov and A.L. Karsakov (PINRO, Russia): Species-specific habitat conditions and possible changes in the distribution of fishes in the Barents Sea under climate change.

Habitat conditions for different fish species in the Barents Sea (preferable depth, water temperature and salinity) are examined and classification of species according to these characteristics is done based on the data from the Russian autumn-winter bottom fish surveys for 1998-2010. Dependence of the coverage and limits of distribution of the most important and typical fish species on oceanographic characteristics at different standard sections is analysed. The impact level of climatic changes for all fish species groups selected by habitat conditions on their distribution in the Barents Sea and possible changes in their distribution are examined.

Magnus Aune Wiedmann, Michaela Aschan and Raul Primicerio (Univ Tromsø, Norway): Vulnerable fish species in the Barents Sea.

Species interacting with many other species might be destabilizing for the ecosystem network, and might eventually be removed from the system. Information about Barents Sea fish species is compiled into one large life trait matrix. The degree of ecological overlap between species is identified using cluster and multivariate analyses based on information from the matrix. This will yield information about the Barents Sea food web structure, which in turn can be connected to the functional redundancy of the fish species in the Barents Sea ecosystem. This work is a part of the project on Barents Sea Ecosystem Resilience (BarEcoRe) that is funded by the Norwegian Research Council.

Konstantin V. Drevetnyak, M.Yu. Antsiferov and P.A. Murashko (PINRO, Russia):The effect of climate fluctuations on demersal fisheries in the Barents Sea and adjacent waters.

Survey of the scientific literature on fish has showed that the majority of species demonstrated changes in distribution and migrations in the period of climate change. However these changes are seldom assessed qualitatively.

The authors attempted to assess qualitatively the changes in distribution and migrations of white fish in the Barents Sea and adjacent waters based on the data from the Russian demersal fisheries in that area.

Emma L. Orlova, Andrey V.Dolgov, I.P. Prokopchuk and A.P.Yakovlev (PINRO, Russia): Influence of climatic changes in the Barents Sea on functioning of trophic complex makroplankton-pelagic fishes-cod.

Based on long-term data reflecting climatic fluctuations in the Barents Sea as well as their influence on important components of the ecosystem (makroplankton, planktivorous fishes, predatory fishes), variability of biological parameters and various quantitative ratios in the trophodynamic structure of this area are described. Species composition and distribution of makroplankton, abundance, distribution and food habits of capelin and polar cod as well as stock state, migrations distance and feeding peculiarities of cod were analysed. The most remarkable changes were observed during three periods - cold 1970-1998, warm and abnormally warm 1999-2006 and 2007-2009, which characterize main features of functioning of this trophic complex.

Anne Kirstine Frie, Tore Haug, Ulf Lindstrøm, Kjell Nilssen and Tor-Arne Øigård (IMR, Norway): Variability in population parameters of Northeast Atlantic harp seals; responses to changes in sea temperature and ice cover?

Harp seals are dependent on ice as a substrate for whelping, nursing, resting and moulting. Poor ice is particularly critical during the whelping period since early break-up of the ice may disrupt lactation and reduce the availability of haul-out platforms during the first weeks of independent feeding. This may lead to increased mortality of pups and long term cohort effects such as reduced growth and reproductive rates. Changes in sea temperatures and ice cover may also affect harp seals more indirectly by changing abundance, diversity and distribution of prey species.

The two Northeast Atlantic harp seal stocks share summer feeding grounds in the Northern Barents Sea but differ in their choice of whelping habitat. Barents Sea/White Sea harp seals whelp on annual ice formed in the White Sea, while Greenland Sea harp seals whelp on multiannual ice off Northeast Greenland. In both areas, the availability of suitable whelping ice has decreased or become more unpredictable over the past decades. In the Greenland Sea, however, recent pup production estimates are historically high, while pup production estimates in the White Sea appear to have dropped by 50% since 2004. Both stocks show historically low female maturation rates and there is evidence of reduced body condition in Barents Sea/White Sea harp seals.

This presentation summarises long and short term trends in body condition, reproductive parameters and pup production in Barents Sea/White Sea and Greenland Sea harp seals and examines their possible links with changes in sea temperature/ice cover as well as other ecosystem characteristics including harvest regimes.

Evgeniy Yakushev (NIVA, Norway): Modeling of the role of organic matter production and destruction on the carbonate system seasonal changes in the Barents Sea.

This work aimed in studying of the role of seasonality of the biogeochemical processes of organic matter production and decay in the seasonal changes of the carbonate system (pH, pCO2, aragonite saturation). Data received at a transect Tromsø – Spitsbergen with a Ferrybox equipped SOOP vessel was used for verification. A 2D simplified vertical model was used to parameterize the hydrophysical processes of at a Coast-Open Arctic section. The biogeochemical processes were parameterized using OxyDep, simplified biogeochemical model aiming time scales seasonal and larger, that considered inorganic nutrient (NUT), dissolved (DOM) and particular (POM) organic matter and biota (BIO). Dissolved inorganic carbon (DIC) and alkalinity (Alk) were considered as independent model parameters. DIC changes were correlated with NUT using Redfield ratio, Alk was changed in the marine boundary of the modeled transect. The carbonate system equilibration was considered as a fast process and calculated at every time step using the iteration procedure. The carbonate system modeling was described on the base of standard approach (Dickson, 2010). According to the model estimates the summer formation of DOC and POC and their further destruction can play a compatible role in the carbonate system seasonal dynamics. Modeled seasonal variations of pH (~0.2) are close to the observed ones t, i.e. 7.94-7.99 in February and 8.04-8.16 in August (pH(Tot)).The received results allowed to demonstrate that the upper layer water pCO2 varies from 480 ppm in winter to minimum values of 280 ppm during the OM production period. Therefore summer invasion of CO2 should be replaced by winter evasion. The received results can be helpful for planning of expedition studies and analyzing of the archived field data, as well as for elaborating of the interannual and multidecadal changes models.

Benjamin Planque, Edda Johannesen, Kathrine. Michalsen (IMR, Norway), Raul Primicerio (Univ Tromsø, Norway), Maria Fossheim, Randi Ingvaldsen (IMR, Norway) and Michaela Aschan (Univ Tromsø, Norway): Barents Sea Ecosystem Resilience under global environmental change, BarEcoRe: 2010-2013 ***(Poster)****.*

The influence of climate warming on the Barents Sea ecosystem is documented by the long-term ocean temperature increase observed since the 1960s and the projected increases of up to 3°C by 2050. The impact of climate warming on Barents Sea communities can be exacerbated by fisheries. The project addresses the effects of climate warming on the structure, dynamics and resilience of the Barents Sea ecosystem, integrated with the effect of fishery. Detection and forecasting of changes in ecosystem resilience and robustness under global warming and fisheries will be based on a broad battery of inferential tools including multivariate analyses of spatio-temporal changes in community structure, retrospective and prospective modelling of populations distributions, mapping of life history and feeding traits affecting species vulnerability, analysis of trophic interactions and food web structure, and early warning signals of abrupt changes detecting reductions in ecosystem resilience. The main outputs of the project, including a vulnerable species list, mapping of future populations distributions under warming scenarios, characterization of regime shifts, reliable early warning signals of abrupt ecosystem changes, provide tools needed for management of the Barents Sea ecosystem under global environmental change.

Emma L. Orlova, V.N. Nesterova, and O.V.Goncharova (PINRO, Russia): The implementation means of Calanus hyperboreus and Mallotus villosus reproductive strategies in the Barents Sea (2002-2009) ***(Poster).***

The features of the behavior of two representatives, having the different feeding types: the predator (capelin *Mallotus villosus*) and prey (a large crustacean copepods *C. hyperboreus*), were investigated during phyto- and zooplankton cycling at high latitudes, coinciding with a period of intensive feeding of capelin, taking into account the reproductive strategies which is to adapt the life cycles of these species to the environmental conditions (Falk-Petersen et al., 2009; Pasternak, 2010), In accordance with the *C. hyperboreus* type feeding - the rapid accumulation of energy during phytoplankton growth and an early the females and the older copepodites illumination from the surface layer (early summer) in order to avoid "trophogenic zone" (Pasternak, 2010), on the one hand, it is protection from predators on the other - contributes to their increased availability for capelin in the lower water layers. Thus, the feeding strategy of capelin implements, aspireing to the maximum feeding of large preys species before the winter. Most clearly it was shown in 2008, when the waters north of 78 ˚ N, large capelin actively fed exclusively by C. hyperboreus females, which contributed to the increased their fat accumulation.

Elena Eriksen and Gjert Endre Dingsør (IMR, Norway): Does high jellyfish biomass influence 0-group haddock in the Barents Sea? ***(Poster)***

Haddock (*Melanogrammus aeglefinus*) is an ecologically important fish species in the Barents Sea. 0-group recruitment (4-6 months old) varies considerably during the last three decades and has shown an increased frequency of strong year-classes in the 2000s. It has been suggested that the abundance of gelatinous zooplankton is increasing in many marine ecosystems around the globe, and the biomass of Barents Sea jellyfish (mostly *Cyanea capillata*) was extremely high during 2001-2003. High amount of jellyfish can significantly impact the pelagic community through direct predation on egg and larvae and competition for food, as well as cascading effects. In contrast, young haddock find shelter among the jellyfish tentacles to avoid predation. Unfortunately, the significance of these interactions is poorly known.

The Joint Norwegian-Russian 0-group survey has been carried out annually in August-September from 1965-2003, and since 2004 the 0-group investigations have been part of a Joint Norwegian-Russian ecosystem survey. The survey provides data for the estimation of abundance indices for 0-group fish of the most important commercial fish species. In the present paper we used spatial data of 0-group haddock (target species) and jellyfish (non-target, by-catch) to analyse the variation of the geographical distribution and abundance of these two species in relation to possible interaction between them. The central area of the Barents Sea is an important area for high densities of 0-group haddock, overlapping with the area where the majority of jellyfish biomass was observed.

Elena Eriksen, Geir O. Johansen, Randi Ingvaldsen and Jan E. Stiansen (IMR, Norway): How is year class strength of 0-group cod in the Barents Sea influenced by its dynamics and geographical distribution? ***(Poster)***

North East Arctic cod is a commercially and ecologically important fish species in the Barents Sea. Survey data on young-of-the-year (0-group) fish have been collected annually in August-September for more than 30 years. During this period, the climate in the Barents Sea is characterized by a strong increasing temperature trend, from the cold late 1970s to the very warm 1990s-2000s. In addition to environmental changes, high human activity, mainly through fishing influences the Barents Sea ecosystem. Historically, the cod landings have varied dramatically being high during 1950s-70s thereby leading to decreasing spawning stock biomass and weaker recruitment, followed by strongly decreasing landings in the 1980s. Here we analyse the dynamics in the geographical distribution of cod and specify the main area, which contribute significantly to the 0-group abundance. We also analyse the effect of climate variation, spawning stock and other factors on the geographical distribution. Data from the scientific surveys (1980-2010) is used to answer the questions: What is the variation of the geographical distribution and which factors affects it? How does the dynamics in occupation area influence on the year class strength?

Andrey V. Dolgov (PINRO, Russia) and Edda Johannesen (IMR, Norway) (the list of authors can be extended): Structure of the Barents Sea fish community as result of climatic fluctuation. ***(Poster)***

Interannual variations in catches of warm-water and cold-water fish species in various seasons, depending on changes in oceanographic conditions, are analysed based on the data from Russian and Norwegian surveys for 1998-2010. Moreover, the ratio between fishes in the catches from different zoogeographical groups among different taxonomic, ecological and functional groups and its variations in warm and cold years are examined.

Bjarte Bogstad, Padmini Dalpadado (IMR, Norway), Haakon Hop (Norwegian Polar Institute), Emma Orlova, G. Rudneva, I. Prokopchuk and V. Nesterova (PINRO, Russia): Feeding of polar cod in the Barents Sea related to food abundance and oceanographic conditions. ***(Poster)***

In the Barents Sea, diet data for polar cod (*Boreogadus saida*) have been collected during the Joint Norwegian-Russian ecosystem surveys in August-September during the period 2006-2010. Stomach analyses data indicate that polar cod mainly feed on hyperiids, copepods and euphausiids, as well as other invertebrates. Large polar cod may also prey on fish. The temporal and spatial variation in stomach fullness and diet composition are investigated and related to prey abundance and oceanographic conditions. The diet overlap between polar cod and capelin (*Mallotus villosus*) is also investigated.

Nathalia A. Yaragina and Andrey V. Dolgov (PINRO, Russia): Long-term variations in the importance of prey species for demersal fishes in the Barents Sea under climate change. ***(Poster)***

Spatial, seasonal and inter-annual variations in the importance of the most valuable prey species for cod and haddock (macroplankton, capelin, herring, polar cod, their own juveniles, etc) are examined based on the data from field and quantitative analyses of the cod and haddock diet for 1949-2010. Furthermore, special attention is paid to the effects of climatic changes on the importance of different prey species in the cod and haddock diet and on dominant species shifts in warm and cold periods.

Olga Svetocheva (MMBI, Russia), Elena Eriksen and Tore Haug (IMR, Norway): Barents Sea Ammodytidae and their ecological significance for the top predators during summer feeding ***(Poster)***.

Ammodytidae are small schooling benthopelagic fish, which are usually found at depths of 10-150 meters, and in the brackish and marine waters of the Atlantic, Pacific and Indian Oceans, and mainly in the northern hemisphere. In the Barents Sea Ammodytidae are represented mostly by *Ammodytes marinus* which are distributed along the Norwegian coast, in the Southeast and between Novaya Zemlya and Bear Island. *Ammodytes tobianus* and *Hyperoplus lanceolatus* were reported along Murman and the Norwegian coasts. *A. marinus* spawns during November-February at depths of 25-100 m, and feeds on plankton. Their high activity is correlated to periods with strong tidal currents; when they leave their bottom hides and form large shoals.

During 0-group surveys in August-September in the Barents Sea, *Ammodytes marinus* was mainly distributed in the south-eastern area of the Barents Sea. Abundance varied between 98 and 165192 millions, with an annual average of 36694 million individuals. The biomass was almost twice as high in cold years than in warm years, ranging from 300 to 175 thousand tonnes. Ammodytidae were mostly distributed over limited areas with local biomasses as high as 80 thousand tonnes. Therefore we believe that *A. marinus* may be an important component in the food web in the south-eastern area of the Barents Sea. The southern Barents Sea is important feeding area for several seabirds, fish species, seals and whales.

Ringed seals *(Pusa hispida*), harp seals *(Phoca groenlandica),* bearded seals *(Erignathus barbatus)* and minke whales (*Balaenoptera acutorostrata*) have been observed to be feeding on Ammodytidae in this area during July-December. Unfortunately, the significance of these interactions is poorly documented. Seal diets are often investigated based on digested food from the stomach and intestines, where particularly otoliths are used for fish identification.

Ammodytidae have very small otoliths with large shape variation (Fig 1). Although some Ammodytidae otoliths of 0.5-1.2 mm length have been found in seal intestines, difficulties in otolith identification and missing of otoliths due to digestion may increase uncertainties in diet analyses substantially. In the White Sea, Ammodytidae were found in 40-100% of samples of ringed and 10-80% of samples of bearded seals during autumn (September).

Figure 1. Sand eel otoliths with lengths (OL): 2,0 mm (A), 2,2 mm (B), 2,4 mm (C), 2,3 mm (D)

The distribution of grey seals (*Halichoerus grypus*) and harbour seals (*Phoca vitulina vitulina*) overlap with dense concentrations of *Ammodytidae* in the southern Barents Sea. Most likely both species feed on Ammodytidae, although this is still not documented.

Apparently, Ammodytidae can be significantly influenced through direct predation and climate change. For different reasons, the fish group is poorly studied in the Barents Sea, even though it is an important ecosystem component.

T.A. Karaseva and T.V. Shamray (PINRO, Russia): Monitoring of external pathologies in fish as a method of integral estimation of changes in the ecosystem of the Barents Sea under the influence of nature and climate factors ***(Poster).***

The life activity of land vegetative and animal organisms including human beings is known to be highly dependent on climate changes. In particular the temperature anomalies make favourable conditions for the spread of dangerous epidemics. As for the aquatic animals, many aspects of this problem have remained open till now. Therefore any observations connected with estimation of fish health in the periods of climate changes are urgent and of scientific and practical interest.

PINRO has been carrying out the monitoring of external pathologies in the commercial fish species of the Barents Sea and adjacent areas since 1999. Every year 6 groups of pathologies maximally reflecting the spectrum of possible changes in fish organisms are registered. The results from the analysis of the basic data are used for annual estimation of health in fish populations and the quality of their habitat.

In 2001, found in fish was a disease, which had not been known before. It was conditionally named “red eye syndrome”. Most of sea fish species had no immunity against a new infectious agent that caused a wide spread of the disease in the northern areas. It is assumed that the pathogenic organism had been brought from the warm areas of the World Ocean or being an aboriginal species it had got favorable conditions for development owing to warming of the Barents Sea in the last decade.

In this connection given are the data on nature, dynamics and spread of the new disease in the Arctic seas and the Northeast Atlantic, as well as possible negative consequences of epizootic for the Barents Sea ecosystem are discussed.

Vladimir Zabavnikov and Ilyas Shafikov (PINRO, Russia): Marine mammals and their possible influence on fishery under current state conditions in the Barents Sea ***(Poster).***

In the recent five years the temperature of the Barents Sea was high and anomalous high that influenced the specific and quantitative composition of marine mammals registered in the sea area. The investigations revealed the increase in numbers of whales permanently inhabiting the Barents Sea and the areas of their occurrence, as well as extended occurrence period of animals sometimes entering the area. Changes in distribution, quantity and species composition of marine mammals may influence the fish stocks and fishery in the Barents Sea.

Corinna Schrumm (Univ Bergen, Norway) and Evgeniy Yakushev (NIVA, Norway): Modeling of PCB propagation in the Barents Sea. ***(Poster)***

PCB is one of the most dangerous pollutants present in the seawater.. In the certain Sea regions this pollutant accumulates in the bottom layers, that leads to an increase of its content in fish above the maximum allowable concentration level. The goal of this study was to understand the reasons of formation of the patchiness of PCB distribution in the Sea. As a basic hydrophysical model we used the 3D model ECOSMO/HAMSOM. Processes of advection and turbulence were parameterized for years 1966 and 1990 that are characterized by different circulation intensity. The boundary conditions for the model were taken from the existing model estimates and observations. To parameterize the processes of accumulation in biota and organic matter we used a simplified 4-component biogeochemical model (biota, detritus, dissolved organic matter, nutrient). The application of the model allowed to analyze the role of affecting factors, i.e. flux from the atmosphere, river input, formation and melting of the sea ice, sinking, burying and exchange with the neighboring regions. The simulated model results allowed to demonstrate that in the case of intense circulation regime we can expect higher concentrations propagating further into the Sea and increasing in bottom water compared to the weak circulation regime. The model also predicted higher concentrations in surface waters of the western Barents Sea in case of less intense winds and weak circulation. The modelled PCB concentrations thereby cover the full range from 0-40 pg/l, indicating the large degree of spatial variability of PCB in the Barents Sea. Specifically, the bottom concentrations might vary considerably in neighbouring regions.

Theme III:

Alf Håkon Hoel (IMR, Norway): Implications of climate change for the management of living marine resources. ***(Keynote)***

A changing climate poses a host of challenges to the management of living marine resources. Broadly speaking, these falls in two categories: how to limit the contributions of fisheries to emissions of climate gases ("mitigation") and how to respond to the climate challenge through management measures ("adaptation"). The current global climate regime, as laid down in the Kyoto Protocol, requires developed countries to cut their emissions to an average of 5,2% of 1990 levels by 2008-12. What will be the contribution of fisheries in this respect? In relation to adaptation it is fundamental to recognize that the fishing industry is in the business of adapting to change in the natural environment. Adapting to fluctuations in resources and changes in geographical range is an area of expertise in the industry and its managers. Good governance in fisheries are generally associated with three elements : scientific knowledge, regulations of fishing activity, and enforcement of regulations. The consensus among the scientists who have studied the issue is that good management is essential. Climate change does not demand a wholesale retooling of management, but rather more of the same in terms of current best practices.

Evgeny Shamray and Yuri Lepesevich (PINRO, Russia): If the management of living marine resources ought to be effected by climate changes? ***(Keynote)***

It is known that climate changes have a noticeable influence on the spacious and seasonal distribution of marine living resources, stock state and structure. In particular, in the warm years, highly migratory fish are more widely distributed in the sea area than in the cooling periods and herewith the main areas of wintering, spawning, feeding and also fishing are shifted. As a rule this promotes the improvement of the conditions of feeding due to the diet diversification and the reduction of the intraspecific competition, higher survival of juveniles and has a positive impact on the abundance of the following year-classes. The influence of climate changes on the stock status of living marine resources does not only consist in change of their areas. The extension of the distribution area of some species may lead to strengthening of their predation on juveniles of the others or the intensification of food competition between species having occupied different areas before. Hence some changes in the status of stocks may occur. The change of areas causes the redistribution of stocks between the areas of different jurisdiction and, consequently, a high probability of the change in their fishing pattern. Despite the scientific and management organizations of a different level developed the diverse package for fishery regulation and stock protection, the requirement to improve it in the conditions of climate change is very urgent. Redistribution of fish stocks opens up the new possibilities of their economical development. At the same time it might result in conflicts arising between both the states already having the rights to fish marine living resources and the new pretenders to their exploitation.

Ingolf Røttingen and Sigurd Tjelmeland (IMR, Norway): The collapse of the Norwegian spring -spawning herring stock; Climate change or fishing effort?

The stock of Norwegian spring-spawning herring collapsed at the beginning of the 1970-ies. The fishery and climatic change have been given as the main factors for the stock collapse.

The aim of the paper is to seek out the relative importance of these explanatory variables for the stock collapse. In 1999 the agency for the management of Norwegian spring-spawning herring (coastal states RFMO) decided on a harvest control rule that a present forms the basis for the annual TAC. The starting point for the present paper is a counter-factual that considers the effect from the fishery on the stock if this harvest control rule was decided on in 1949, 50 years before it actually happened. A central part of the paper is an analysis of stock/recruitment relations that incorporates climate (temperature) changes that took place in the period 1950-1990.

Vladimir M. Borisov, M.A. Bogdanov and I.V. Tarantova (VNIRO, Russia): Sea surface temperature (SST) dynamics and year class strength of the capelin (Mallotus villosus) in the Barents Sea.

The influence of the temperature conditions of the Barents Sea on the year class strength of capelin has been investigated. Data on temperature conditions derived from satellite monitoring. Data on the year class strength were based on the results of the annual Russian-Norwegian hydroacoustic surveys. Certain negative correlation between cooling season duration westward of 35W and the abundance of capelin 0-group has been determined. As the cooling season duration depends on its start date, there is a possibility to make long-range forecasts of relative abundances of the new capelin year classes. The range of forecasts is 6-7 months for 0-group and 18-19 months for the age “1+”.

Daniel Howell (IMR, Norway), Anatoly Filin (PINRO, Russia), Bjarte Bogstad, Jan Erik Stiansen and Elena Eriksen (IMR,Norway): Unquantifiable uncertainty in projecting stock response to climate change: Example from NEA cod

Data from the years 1946-1992 suggests a positive relationship between recruitment of cod in the Barents Sea and the sea temperature at the Kola section during the year of spawning. However analysis of subsequent data from 1993-2009 indicates that this relationship no longer holds. This change in the recruitment dynamics will clearly have an impact on our understanding of future stock dynamics and long term yield. It also highlights the impacts on our ability to predict biological responses to climate change arising from possible future changes in similar relationships in other species and ecosystems. This paper uses a multi-species “STOCOBAR” forward simulation model to evaluate the dynamics under a variety of climate scenarios and recruitment hypotheses, highlighting the differences between temperature-dependent and temperature-independent recruitment. The divergence between the modelled populations and yields under the different recruitment hypotheses indicates the impossibility of predicting the future evolution of a stock with any degree of certainty, or even with any quantifiable degree of uncertainty. These results highlight the importance of having a management regime that is robust to unpredicted and unpredictable changes in stock dynamics.

Kathrine Michalsen, Edda Johannesen (IMR, Norway), Dimitry D. Prozokevich, Tatyana Prokhorova (PINRO, Russia), Randi Ingvaldsen, Harald Gjøsæter, Mette Mauritzen, Tor Knutsen, Elena Eriksen and Lis Lindal Jørgensen (IMR, Norway): How to investigate climate variation and its effects on species and species interactions.

The Barents Sea has been influenced by human activity during many decades; historically mainly through fishing and hunting of marine mammals. Recently, also indirectly through increased ship transport and climate variation.Increased ecological awareness and international focus on effects of climate change have led to the development of a new policy regarding the management of the marine resources worldwide; the ecosystem based approach to management. Knowledge and understanding of structure and function of the ecosystem previously evolved from interpretation of results from separate surveys mapping the abundance and distribution of the commercially most abundant species, and from catch statistics. The new policies do however require another type of data in addition to these, and ecosystem surveys encompassing investigations on hydrography, phytoplankton, zooplankton, commercial and non-commercial fish, benthos, marine mammals, seabirds and pollution have the last years been conducted in the Barents Sea.

The joint Norwegian-Russian autumn ecosystem survey of the Barents Sea was started in 2003 by combining five previous surveys into a single investigation. These five historical surveys were the surveys for 0-group and capelin together with the surveys for shrimp, Greenland halibut and redfish. The survey period has coincided with passing the top of the warmest period since the beginning of the 20th century. The associated decrease in sea ice has allowed access to areas up to 82°N north of the Spitsbergen Archipelago and the northwestern part of the Kara Sea. Thus, the ecosystem-survey is a highly suitable platform for observing the impacts of the warming in the Barents Sea. Change in distribution and abundance of various species has also been observed in the same period.

Even though much more data are now collected at each station and can therefore be compared more easily to each other, the interval between stations have increased and makes the data less synoptic. Changes in survey design from year to year (survey area, distance between stations, sampling, and time at sea) may also affect the interpretation of the data collected. In this paper we will discuss how various aspects of the practical implementation of the data collection in the Barents Sea will affect the results. Data from the survey will be described, examples of analysis given, and suggestions for further improvements of the survey outlined. Some of the questions addressed are; how can data from scientific surveys in the Barents Sea be used to investigate climate variations and effects on species and species interaction? What are the pitfalls of combined surveys and what is gained compared to previous practice? In what way can the scientific surveys be improved to serve the ecosystem based approach to management?

Gennady G. Matishov, D.V. Moiseev, O.S. Lyubina, A.P. Zhichkin, S.L. Dzhenyuk, P.R. Makarevich, E.A. Frolova (MMBI, Russia): Hydrobiological indicators of cyclic climate changes in the Western Arctic during XX-XXI centuries

Climatic changes of marine ecosystems are one of the most important issues of oceanology nowadays. The success of long-term forecasts of climate, bio-resources potential, and conditions of maritime activity depends on the correct interpretation of data on recent hydrophysical and biological processes. It is necessary to assess the input of natural and anthropogenic factors into climatic anomalies, which were especially pronounced in the recent years. The system analysis of MMBI KSC RAS oceanographic and hydrobiological database with the data for more than a hundred-year period of observations at the Kola Transect in the Barents Sea, considering published materials, allowed providing an assessment of oceanological situation at the turn of the 20th and 21st centuries. The dependencies between the thermal state of western Arctic seas and specific features of ecology and cyclic character of cod, red king crab, polychaetes, and other organisms inhabiting the considered area have been determined. It has been shown that in case of lack or absence of hydrometeorological information, climatic dynamics may be assessed by biological indices: abundance, biomass, and migrations of marine commercial organisms.

Jan Erik Stiansen, Sigbjørn Mehl, Geir O. Johansen, Cecilie Kvamme, Bjørn Ådlandsvik (IMR, Norway), Nils A. Ekerhovd and Røgnvaldur Hannesson (Institute for Research in Economics and Business Administration, Bergen, Norway): Future change in the distribution of fish and fisheries in the Barents Sea; experiences from the FishExChange project.

Over the last four years the project “Expected change in the Fisheries in the Barents Sea (FishExChange)”, funded by the Norwegian Research Council, have investigated changes in the spatial distribution of the commercial important fish stocks and it s fishery in the Barents Sea. The presentation will sum up some of the results of this extensive project, and also share the experiences and challenges during the project period. The presentation will also try give a status of where we have come today, concerning effects of climate change on the fish stocks in the Barents Sea, and look at what is possible to say, or not to say, about future change in the fish stocks and fisheries.

Anatoly A. Filin (PINRO, Russia): Simulation of changes in the harvesting strategy of the Northeast Arctic cod as response to the climate change. ***(Poster)***

The paper presents the results of the STOCOBAR model based estimation of the influence of climate induced acceleration in the Northeast Arctic cod growth and maturation on its fishery rate and fishing selectivity. This would need the adjustment of the biological reference points that would be used for the harvesting management. Considered are eventual consequences of different scenarios for the cod stock status and fishery that assume that the changes in survival of cod at the earlier stages of their life history resulted from climate changes. Projections of cod stock and yield that are obtained using different harvesting strategies and the same climate change scenarios are compared.

*Per Arneberg (Norwegian Polar Institute): Climate change in the Barents Sea and projects under the Russian-Norwegian Environmental Commission.**(Poster)***

In the Barents Sea, impacts from climate change and ocean acidification are expected to increase in the future, while the level of fishing activities will remain high and increased oil and gas activities and ship transport are expected. A key question is whether the combined impacts of climate change and these other anthropogenic drivers are likely to put the stability of the ecosystem at risk. To answer this question, a broad approach spanning all relevant disciplines is required. Several of the projects under the Russian-Norwegian Environmental Commission may help to achieve this. Some of these projects are (1) The Joint Russian-Norwegian environmental status Report on the Barents Sea Ecosystem, (2) The Joint Russian-Norwegian Environmental Data Portal (The Barents Portal) and (3) the upcoming project on a joint Russian-Norwegian environmental monitoring program for the Barents Sea. Other projects are more specialized on climate issues, such as the upcoming projects on (1) the effects of climate change on ecosystems and sea ice in the Barents Sea and (2) establishment of archives and databases on climate change. In addition to providing relevant data and knowledge basis, these projects can also contribute to building Russian-Norwegian networks of scientists that can perform relevant analyses and issue joint Russian-Norwegian advises for the governments of both countries.

Martin Sommerkorn (WWF, Norway), Hussein Alidina, Susan Evans, Peter Ewins (WWF, Canada), Miriam Geitz (WWF, Norway), James Snider (WWF, Canada), Alfonso Lombana (WWF, USA) and Mikhail Stishov (WWF, Russia): Towards Navigating the Impacts of Rapid Change through Stewardship: a Resilience Assessment of Arctic Places. ***(Poster)***

Even with major reductions in global GHG emissions, substantial changes will occur in the Arctic this century and these will have huge impacts on ecosystems and people.

The unprecedented rates of change forecast for the Arctic have led WWF to believe that conservation approaches in the 21st century have to embrace change and should apply stewardship approaches focussing on building resilience of the social-ecological system.

This will require, among other measures, a detailed understanding of ecosystem structure and function as well as human adaptive capacity, and how they will likely respond to the direct and indirect impacts of climate change. Given the significant biophysical data gaps for much of the Arctic and the challenges associated with projecting future human use of arctic resources, the analyses required to carry out the above will demand some time and resources to complete comprehensively.

As such, there is a clear need to provide interim products that identify where to concentrate efforts to strengthen the viability of arctic ecosystems, including the services they supply to people. In doing so there is a need to apply concepts that recognize the processes underpinning arctic ecosystems functioning and provide a framework for navigating their dynamics through rapid change.

RACER (Rapid Assessment of Circumarctic Ecosystem Resilience) is a rapid assessment project carried out by WWF that seeks to examine places conferring resilience of circum-arctic marine and tundra ecosystems, including their socio-cultural aspects. The project analyses whether values underpinning system functioning –such as those driving ecosystem processes, diversity, and ecosystem services– are resilient or vulnerable to the projected climate changes. It points to places in the circumpolar Arctic where these values are likely to remain intact, and also provides a structure for similar assessments at the regional or local scale.

The project is guided by a science expert and stakeholder advisory committee. It is anticipated that the methods and outputs from RACER will help accelerate the onset of new approaches to spatial planning, especially land and resource use management plans, to fully incorporate the consequences of unprecedented rapid climatic change in the Arctic.

Lasse H. Pettersson, Anton Korosov, Torill Hamre (Nansen Centre, Norway): Integrated Monitoring and Forecasting of Harmful Algae Bloom Events in Coastal Waters ***.(Poster)***

Over the last several decades the aquaculture fish farming industry in Norway have experienced a massive expansion and it is the second largest export industry after oil and gas. Although improved capabilities and technologies for safe operations the industry are still vulnerable to outbreak of massive harmful algae blooms (HABs) and changes in the environmental conditions in coastal waters. Based on this fact several monitoring precautions are undertaken in Norway to early detect and monitor potential harmful algae blooms and accordingly be better prepared to initiate percussive or mitigation measures.

Since 1998 the Nansen Center has regularly utilized satellite Earth observation data as a supplement to monitoring of the (harmful) algae bloom situations in waters of Norwegian interest. Starting with the SeaWiFS data in 1998 and since 2003 the daily use of both MERIS and MODIS ocean colour satellite data, a range of HAB events have been detected early and their development and decay monitored.

Integration of environmental measurements from different sensors and measurement platforms can improve water quality monitoring and associated risk management in marine, coastal and inland waters. The merging of in-situ field data and satellite or airborne remote sensing data is a prerequisite to efficient monitoring of coastal and marine environments, because of their complementary nature and application areas.

Both types of environmental monitoring data can map similar environmental phenomena and conditions. Remote sensing data delivers an overall picture primarily of the surface distributions of some limited parameters, while in-situ measurements provides localized information of high temporal resolution, for a wide range of parameters, but often at the expense of not being provided with a dense or large spatial coverage.

In the developed monitoring and early warning service concept the environmental data products are integrated in a distributed a web GIS (Geographic Information System) portal – DISPRO for end-users access and analysis.