Long term bilateral Russian-Norwegian scientific co-operation as a basis for sustainable management of living marine resources in the Barents Sea

12TH Norwegian- Russian symposium
Polar Environment Centre, Tromsø, 21-22 August 2007
Program

21 August 2007

0800-0900 Registration

0900-1000 Opening addresses (Chair: T. Haug)
Opening statements by convenors Ole Arve Misund (IMR) & Yuri Lepesevich (PINRO)
Opening statement by State Secretary Vidar Ulriksen, Norwegian Ministry of Fisheries and Coastal Affairs
Opening statement by V.K. Zilanov, Head of Fisheries Department of the Murmansk Region
Opening statement by PINRO (Research Director Yuri Lepesevich)
Opening statement by IMR (Director Tore Nepstad)

1000-1030 Invited keynote speaker (Chair: T. Haug)
Guðrún Marteinsdóttir (Marine Research Institute, Reykjavik, Iceland):
Has man learned to manage cod?

1030-1100 Coffee break

1100-1400 Theme session I: Establishment and maintenance of long time marine data bases (Chair: T. Haug)

N.A. Yaragina (PINRO), B. Bogstad (IMR) & Yu.A. Kovalev (PINRO):
Reconstructing the time series of abundance of Northeast Arctic cod (Gadus morhua), taking cannibalism into account.

N.V. Zuykova (PINRO), P. Aagotnes (IMR), V.P. Koloskova (PINRO), H. Mjanger (IMR), K. H. Nedreaas (IMR), H. Senneset (IMR), N.A.Yaragina (PINRO) & S. Aanes (IMR):
Age reading of Northeast Arctic cod otoliths through 50 years of history. (To be presented by K. Drevetnyak, PINRO)

A.Pedchenko, A.Karsakov, V.Ivshin, & V.Guzenko (PINRO):
Russian research on oceanographic sections in the Barents Sea.

V. Ivshin, A. Pedchenko (PINRO), Ø. Skagseth & R. Ingvaldsen (IMR):
Study of the spatial variability in thermohaline characteristics and water structure on the standard sections in the western Barents Sea.

E. Eriksen (IMR) & D. Prozorkevich (PINRO):
Long time survey series on 0-group in the Barents Sea

20th anniversary of the PINRO-IMR cooperation in the investigations of feeding in the Barents Sea – results and perspectives.

P. Fauchald (NINA):
Seabird monitoring and the Barents Sea ecosystem.

S.-R. Birkely (Akvaplan-niva) & B. Gulliksen (NFH):
Establishment and maintenance of regular photographic monitoring of rocky bottom localities from North Norway to Spitsbergen

1400-1500  Lunch
To be served at the symposium venue

1500-1800 Theme session II: Development and improvement of new methods and models (Chair: Y. Lepesevich)

N.A. Yaragina (PINRO), K.H. Nedreaas (IMR), V. Koloskova (PINRO), H. Mjanger (IMR), H. Senneset (IMR), N. Zuykova (PINRO) & P. Ágotnes (IMR):
Fifteen years of annual Norwegian-Russian cod comparative age readings. (To be presented by K. Drevetnyak, PINRO)

A.K. Frie (IMR) & V. Svetochev (SevPINRO):
Building time series from IMR and SevPINRO data sets on reproductive parameters of harp and hooded seals.

T.I. Bulgakova (VNIRO, Moscow):
The simulation of Norwegian spring spawning herring dynamics to evaluate various variants of the harvest control rule.

O.A. Bulatov, V.M. Borisov, B.N. Kotenev & G.S. Moiseenko (VNIRO, Moscow)
The estimation of the Barents Sea cod stock by the GIS-methodology.

Basis of methodology of fisheries - ecological monitoring and new approaches to stock and estimation of living marine resources.

L.B. Klyashtorin (Federal Institute of Fisheries and Oceanography) & A.A. Lyubushin (Institute of Physics of the Earth, Russian Academy of Science):
Cyclic changes of climate and major commercial stocks of Barents Sea. (To be presented by V. Borisov, VNIRO)

S. Bakanev & B. Berenboym (PINRO)
Applying the Bayesian approach in assessment of red king crab (Paralithodes camtschaticus) and northern shrimp (Pandalus borealis) stocks in the Barents Sea.

I. Shafikov (PINRO):
Probabilistic approach to the estimation of marine biological objects by the data of aerial surveys (To be presented by V. Zabavnikov, PINRO)

1930  Dinner
To be served at the symposium venue.
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Climate swings and ecosystem effects. 25

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V.L. Tretyak (PINRO):
Long term variation and adaptive relationship between the life cycle parameters of the north-east Atlantic cod *Gadus morhua*. 27

K. Drevetnyak (PINRO) & K.H. Nedreaas (IMR):
Spatial migration pattern of deep-water redfish (*Sebastes mentella* Travin) in the Barents Sea as inferred from long-term research survey series. 28

1100-1130 Coffee

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Marine mammals distribution and numbers in the Barents Sea in modern stage with connection of climatic changes. 30

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Oil hydrocarbons and PAH in the Barents Sea sediments. 32

S.J. Cochrane (Akvaplan-niva), S.G. Denisenko (ZIN) & L.L. Jørgensen (IMR):
How does ice cover affect the benthic fauna in the Barents Sea? 33
A. Filin (PINRO), S. Tjelmeland (IMR) & J.E. Stiansen (IMR):
Ecosystem dynamics and fisheries management in the Barents Sea.

1400 Lunch

Lunch is served onboard RV “GO SARS” _en route_ to Skjervøy. O.A.Misund (IMR) will be our host on the research vessel, and we will get a presentation of the recent joint ecosystem report by H. Gjøsæter (IMR) and A. Filin (PINRO) during the trip.

1945 Departure from Skjervøy, MS “Polarlys”

The coastal vessel MS “Polarlys” will take us back to Tromsø.

2030 Symposium dinner

Served in the restaurant onboard the coastal vessel, MS “Polarlys”.

2345 Arrival in Tromsø
Abstracts

Key note

Guðrún Marteinsdóttir (University of Iceland and the Marine Research Institute, Natural Science Building Askja, Sturlugata 7, 101 Reykjavik, Iceland; telf: +354-525-4621, email: runam@hi.is):

Has man learned to manage cod?

During the last decades, all cod stocks of the North Atlantic have been exposed to gradually rising fishing pressures due to increasing demand and in part to improvements in technology that result in increasingly efficient fishing practices. At the same time, all stocks have experienced changing environmental conditions, which, together with increasing fishing pressures, are thought to be responsible for the historical fluctuations in stock abundances and structures. Stock sizes, and the age and size structures of stocks have consequently been depleted. Such drastic changes in population sizes have raised concerns about potential (selective) changes in genetic composition and loss in genetic diversity. Today many of the stocks are heavily overfished and some are considered to have reached the stage of recruitment overfishing. In this paper, the state of knowledge concerning the genetic composition as well as trends in landings, fishing mortality, stocks size, stock composition and recruitment among all major cod stocks in the North Atlantic, is reviewed.
Theme session I:
Establishment and maintainance of long time marine data bases

N.A. Yaragina (PINRO), B. Bogstad (IMR) & Yu.A. Kovalev (PINRO):

Reconstructing the time series of abundance of Northeast Arctic cod (Gadus morhua),
taking cannibalism into account.

Cannibalism is probably the most important and also the most variable cause of natural
mortality for age 1-4 Northeast Arctic cod. Also, the proportion of cod in the diet of Northeast
Arctic cod increases with increasing size of the predatory cod. For this stock, long time series
describing diet composition are available (qualitative stomach content data for 1947-2004 and
quantitative data for 1984-2005). These data were analysed together with survey indices for
young cod and abundance of capelin, the most important prey item for cod. The abundance at
age 1-3 cod indicated by the survey indices and the abundance of these age groups in cod
stomachs are well correlated. An inverse relationship between mortality induced by
cannibalism and capelin abundance was found. It is outlined how the qualitative and
quantitative stomach content data could be combined to include cannibalism in the estimates
of cod abundance back to 1947.
N.V. Zuykova (PINRO), P. Aagotnes (IMR), V.P. Koloskova (PINRO), H. Mjanger (IMR),
K. H. Nedreaas (IMR), H. Senneset (IMR), N.A. Yaragina (PINRO) & S. Aanes (IMR):

**Age reading of Northeast Arctic cod otoliths through 50 years of history.**

Norwegian and Russian Marine Research Institutes have investigated the possibility that
biases in age reading from otoliths may have contributed to the long-term trends observed in
stock productivity (growth, maturation rate, fecundity), reduction in age diversity, shifts
towards early-maturation and loss of large and repeated spawners of the Northeast Arctic cod
stock. To determine possible variations in age reading between contemporary and historical
time period, randomly chosen material from each decade for the period of 1940-1980’s was
re-read by two groups of experts. Additionally, the quality of old otoliths being stored in
paper bags for more than 50 years was assessed. Although some year specific differences in
age determination are seen between historic and contemporary readers, there was no
significant effect on age readings discrepancies on length (size) at age for the historic time
period seen as a whole. The bias in age at maturation, on average, is small but systematically
negative, i.e. the age at maturation determined by the contemporary readers is younger than
determined by the historical readers. The difference is largest in the first sampled years, ≈-0.6,
and the difference decreases with time, ≈-0.28-0 in the 80’s. The study shows that the cod
otoliths could be reliably used for age and growth studies even after prolonged storage.
Russian research on oceanographic sections in the Barents Sea.

PINRO and IMR are providers and guardians of the longest oceanographic time series in the Barents Sea yet available. Monitoring of both oceanographic conditions in the sections and fish stocks are very important for estimation of climate changes, thermohaline circulation and their effect on the Barents Sea ecosystem.

Remote sensing from satellites having been applied in the last decades provides high resolution, in terms of space and time, when collecting information about many aspects of the marine environment. However, presently, much of this covers only the surface skin of the ocean, and is limited in terms of the physical composition of the sea water.

Taking into account the importance to maintain and continue the time series scientists of PINRO and IMR carry out researches to support regular oceanographic measurements in the standard sections, data of which are used as indicators of environmental changes in the Barents Sea.

The results of these researches and prospects of the related activities by scientists of PINRO are presented in this report.
V. Ivshin, A. Pedchenko (PINRO), Ø. Skagseth & R. Ingvaldsen (IMR):

**Study of the spatial variability in thermohaline characteristics and water structure on the standard sections in the western Barents Sea.**

One of the most important problems in studies of long-period and climatic variations in the ecosystems of the Arctic seas is continuation and maintenance of time series of hydrophysical characteristics. One of the solutions of this problem is to extend the period of observations and to close the gaps in time series of oceanographic sections based on the data from other sections or time series.

To achieve the main purpose of the research, data of observations on the Russian North Cape–Bear Island section and on the Norwegian Fugløy-Bear Island section (both in the western Barents Sea) were used. The centenary section “North Cape–Bear Island” has been done by PINRO since 1920s. However, the frequency and regularity of its realization in the recent decades have significantly decreased. Observations on the Fugløy-Bear Island section have been done quarterly since 1970s.

Our research was carried out in several steps: estimation of the data structure and observation periodicity, analysis of spatial variability in thermohaline characteristics and water structure, selection of areas with coordinated variations in temperature and salinity, filling up of gaps and continuation of time series.

The results of study of the vertical temperature and salinity structure in the sections and their time variability allowed us to single out sites of sections with well coordinated variations in these parameters. The relationship measures between mean values of thermohaline characteristics on the Russian and Norwegian sections were found and regression equations were stated which enables to fill in the gaps in the series of observations along the North Cape-Bear Island section in the periods of no direct observations. It is the authors’ opinion that the research data can be also used to study the problems of the water circulation in the western Barents Sea and advection of the Atlantic waters to the central part of the Sea.
E. Eriksen (IMR) & D. Prozorkevich (PINRO):

**Long time survey series on 0-group in the Barents Sea.**

The knowledge of the size of the recruiting year-classes is an important contribution for a successful assessment. The main goal with the Joint International 0-group survey has been to give an initial indication of year-class strength of the commercially important fish stocks in the Barents Sea. Since 1965 surveys has been conducted by the Institute of Marine Research, (IMR), Norway and the Polar Research Institute of Marine Fisheries and Oceanography (PINRO), Russia. Since 2003 the 0-group survey has been a part of a Joint Norwegian-Russian Barents Sea Ecosystem survey, conducted by IMR and PINRO. Developing of methods for estimating year-class strength/abundance has been an urgent task during the whole investigation period 1965-2006. Dragesund and Olsen (1965), Haug and Nakken (1977), Randa (1984), Dingsør (2005) were the motive power in this process, and was concluded by Dingsør and Prozorkevich in 2005. The biological data that have been collected during the survey is the source for estimating fish abundances. Therefore quality of data and using of joint database was focus in the last time. The joint survey design, surveying, developing of method, abundance estimation by joint data base are key for successful assessment, and joint support indicates the best example of cooperation have never been seen.

20th anniversary of the PINRO-IMR cooperation in the investigations of feeding in the Barents Sea – results and perspectives.

Since 1986 the Institute of Marine Research, (IMR), Norway and the Polar Research Institute of Marine Fisheries and Oceanography (PINRO), Russia, has exchanged quantitative diet data from fish, mainly cod. Diet data can give information about important trophic links in the ecosystem and the strength of those links. Diet data is therefore important for the characterisation of trophic links in the ecosystem, the interrelations between important fish stocks and how natural mortality due to predation influences the dynamics of fish stocks. In this presentation we give an overview over the joint diet data collected by IMR and PINRO the last 20 years, and present some results and perspectives for future work.
P. Fauchald (NINA):

**Seabird monitoring and the Barents Sea ecosystem.**

For the last five years, counts of seabirds at sea have been an integrated part of the Barents Sea ecosystem surveys. The results from these surveys have provided answers to three major research objectives. First, we have investigated the spatial relationships between seabirds and other components of the marine ecosystem. This has given us new insight into trophic interactions and community structure. Secondly, by analysing the relationship between the spatial distribution of seabirds and marine environmental variables we have developed habitat models for the nine most abundant seabird species in the Barents Sea. These results are used by the oil industry in environmental risk assessments. Finally, we investigate the dynamics of the at sea populations of seabirds in the Barents Sea. This will give us new insight into how the abundance of seabirds at sea is related to the fluctuations in the Barents Sea ecosystem and how this again is related to the seabird populations monitored in the colonies.
S.-R. Birkely (Akvaplan-NIVA) & B. Gulliksen (NFH):

**Establishment and maintenance of regular photographic monitoring of rocky bottom localities from North Norway to Spitzbergen.**

The characteristics of many macrozoobenthic organisms, i.e. they are sessile and/or have reduced motility as adults and may have life spans from years to decades, makes them appropriate for accumulating environmental influences over long periods of time. Hence, these groups of taxa are commonly considered as good indicators of changes on long-term scales in marine ecosystems. Permanent monitoring stations consisting of ten to twelve adjacent squares (0.5m²0.5m) were established back in 1976/1980. To ensure the accuracy when revisiting the stations they are marked by expansion bolts drilled into the rock bottom. The stations are localised at the coast of North-Troms and Finnmark county (4 stations) and at Spitzbergen (2 stations). Photographs are taken annually. An experimental design, where at the start of the project in 1980 all organisms from half of the monitored area (half of the adjacent squares) were scraped off in order to study colonisation and succession of cleaned bottom, is implemented at some of the stations. Other variables obvious for investigation of the benthic biota here are species, abundance, growth, fluctuation in area-demanding species etc. Yet another element in studying the variations in diversity indexes is the close relation this issue may have to oscillations in climate indexes. Knowledge and understanding about the natural variation in biodiversity is necessary in order to quantify possible effects of human impact on the environment. The innovative, and challenging, elements regarding methods are especially related to the treatment and analysis of the underwater photographs using up-to-date scanning techniques, digital photography (from 2004), and statistical multivariate techniques.
Theme session II:
Development and improvement of new methods and models

N.A. Yaragina (PINRO), K.H. Nedreaas (IMR), V. Koloskova (PINRO), H. Mjanger (IMR),
H. Senneset (IMR), N. Zuykova (PINRO) & P. Ågotnes (IMR):

Fifteen years of annual Norwegian-Russian cod comparative age readings.

Fish age readings with great accuracy and precision are fundamental to any age-based fish stock assessments. Otolith samples for independent age reading by Russian and Norwegian specialists have routinely been exchanged twice a year since 1992. In all, 6386 pairs of otoliths were exchanged during 1992-2006, and 1411 of these were repeatedly read at the annual joint age readers’ meetings. Important lessons have been learned from these fifteen years of regular and systematic age reading cooperation. Differences in cod age reading between the two laboratories have apparently decreased. The scientific biological, and hence also the economic effect, of this work is obvious. There is a continuous need for regular meetings and tuning of age determination procedures.
A.K. Frie (IMR) & V. Svetochev (SevPINRO):

**Building time series from IMR and SevPINRO data sets on reproductive parameters of harp and hooded seals.**

Scientists from the IMR and SevPINRO have collected data on age specific reproductive parameters from the Northeast Atlantic stocks of harp seals (the Greenland sea and Barents Sea/White Sea stocks) and hooded seals (Greenland Sea stock) since the late 1950s. Collaboration and calibration of methods between the two institutes in this field goes back to the early 1960s, and is still ongoing. The collaboration has among other things resulted in publication of a joint comprehensive analysis of time series on age at maturity for Greenland Sea and Barents Sea/White Sea harp seals from the early 1960es to the early 1990s based on both Norwegian and Russian data. A similar study on hooded seal reproductive parameters is ongoing. Our two institutes have also cooperated on the organization of an international workshop on age determination of seals held in Bergen in 2006. Our presentation includes an overview of the results of the SevPINRO/IMR cooperation on collecting and analyzing age specific reproductive data on seals and some perspectives for our future cooperation.
The simulation of Norwegian spring spawning herring dynamics to evaluate various variants of the harvest control rule.

A simulation model was elaborated for imitation of Norwegian spring spawning herring (NSSH) dynamics to evaluate various harvest control rules. The model simulated herring dynamics within retrospective interval 1980-2004 and for the forecast time interval (2005-2012). The following HCRs (rules for determination fishing mortality coefficient $F(4-10)$) were examined:

1-4. $F(4-10)$ values by year are const and equal to 0.15, 0.2, 0.25 or 0.5;
5. a single step rule: $F(4-10) = 0$, if $SSB < 2500000$ t, else $F(4-10) = 0.15$
6. a double step rule: if $SSB < 2500000$ t, $F(4-10) = 0$, else:
   - if $SSB > 5000000$ t, $F(4-10) = 0.15$, else $F(4-10) = 0.125$.

The work was carried out with determinate and stochastic model versions. Determinate version showed that the increasing of $F(4-10)$ up to 0.15÷0.25 were not dangerous for herring stock status, at the same time catch =TAC was increasing; the step rules were permitted too.

In Stochastic version of the model stochastic noise was incorporated in the stock numbers by age in the start year (1980) and in the recruitment values by year. It allowed to perform risk analysis procedure. The risk probability depends on of reference point values chosen.
O.A. Bulatov, V.M. Borisov, B.N. Kotenev & G.S. Moiseenko (VNIRO, Moscow):

**The estimation of the Barents Sea cod stock by the GIS-methodology.**

The traditional approach to estimate the cod stock includes both the data on the counting trawling surveys and modeling of fishing biomass based on the fishery theory. Actually, the method proposed by the authors is a synthesis of the traditional area method and current information technologies allowing to get the results of the Russian fishery on-line. The daily vessel reports on which the estimate of fishing stock has been based have included the following information: coordinates of starting and ending of trawling, cod weight in catches, type of vessel and trawl, duration of trawling. The area of the effective catches was less than the area of cod distribution that resulted in the underestimation of the stock. For the period under investigation (2000-2006) 181,000 reports were treated, from which 89,000 reports were taken into account for the biomass estimate. The results showed that the interannual variability of biomass ranged from 1.9 mln t to 2.8 mln t (at the average of 2.3 mln t for the period). The dynamics of fishing stock in the recent years tended to increase. From 2005 to 2006 it increased from 2.0 to 2.6 mln t, i.e. the growth of biomass was 30%.

Basis of methodology of fisheries - ecological monitoring and new approaches to stock and estimation of living marine resources.

The work made within the framework of the Program of Comprehensive Resource Exploration in the high waters of the Northeast Atlantic (NEA), 2002-2006, helped us to formulate and to develop the methodological basis for the synoptic fishery and ecological monitoring for the study, including the effect of hydrophysical processes (natural synoptic periods and cycles) on the biological phases of the fish stock status; features of hydrometeorological processes and identification of essential phases of their development (in fact, the study of oceanic weather); peculiarities of hydrophysical, biological, and fisheries processes influencing on both the evolution and intermittent of hydrophysical structures, changes leading to formation and shifts of zones with the high biological and fish productivity; oceanological and biological importance of the ocean synoptic variability, which sometimes exceeded the seasonal variability. The paper points to necessity for development of the new line of the investigations, namely the complex synoptic monitoring of the natural-industrial system of "environment - marine living resources - fishery".

The environmental data on changes in SST and sea level were collected by ships, satellite and air surveillance. For the analysis purposes we also used the long-term data on the air temperature in the Northern Hemisphere.

The new approach to estimate the biomass, for example of cod (Cadus morhua L), based on satellite positioning of the fishing fleet including the individual trawl hauls, commercial fleet statistics, sea surface temperature (SST), and altitude describing the hydrodynamic status of the Barents Sea was applied. By our estimates, the cod biomass in June – August, 2003-2006 ranged from 2.1 to 2.6 million tons. The further development of the approach will include the size-weight composition of cod catches and acoustic data on the density and biomass of cod concentrations.
Cyclic changes of climate and major commercial stocks of Barents Sea.

The spectral analysis of 100-years time series of Arctic surface temperature (Arctic dT), mean temperature of 200-m water column on the Kola meridian, Index of zonal Atmospheric Circulation (ACI) and Global surface temperature anomaly (Global dT) was carried out. It was shown that climatic indices of Arctic region undergo long-term 50-70-year fluctuations similar to fluctuations of Global dT and Arctic dT for the last 1500-year reconstructed period and last 140 years of instrumental measurements.

A long-term changes of Norwegian spring-spawning herring and Arcto-Norwegian cod commercial stocks also undergo of 50-70 years fluctuations that is synchronous with fluctuations of climatic indices. A simple stochastic model is suggested that makes it possible to predict a probable trend of basic climatic indices and populations of major commercial fish species for 20-30 years ahead.
Applying the Bayesian approach in assessment of red king crab \((Paralithodes camtschaticus)\) and northern shrimp \((Pandalus borealis)\) stocks in the Barents Sea.

A possibility of the use of stochastic analytical models and methods for assessment of northern shrimp and red king crab stocks in the Barents Sea is considered in the paper. Two types of equations to describe the biomass dynamics process are realized. The first type is based on the Shaffer’s production model and the second type on the cohort analysis of catches from surveys (CSA and LBA). The Bayesian approach was taken to construct the distribution of posterior probability of model parameter possible values.

We applied a logistic production model of the population growth having a discrete view and a stochastic version of CSA and LBA models based on the cohort analysis of size groups. The analysis of possibility of including different parameters as priors was carried out. The catchability function for different size groups of crabs was also included in the model. To a first approximation, the model diagnostics and comparative analysis with stochastic version of the CSA cohort model were performed.

The analysis of the red king crab input data showed that the dynamics of population parameters is extremely unstable. It is apparent that to apply mathematical models not only data of trawl surveys are requested but also some additional information such as data on catchability factors for age and size groups, fishing efforts, age and size composition of commercial catches and realistic value of yield. On the other hand, the occurrence of strong year-classes and their registration over a period of years make it possible to forecast the stock dynamics and do risk analysis of consequences of adopted management strategies.
II. Shafikov (PINRO):

Probabilistic approach to the estimation of marine biological objects by the data of aerial surveys.

One of the main methods for survey of marine biological objects dispersed throughout large water areas is aerial survey. Normally, the marine fauna are counted along parallel transects from board the ship or plane. Various methods are used in order to determine the number of biological objects being surveyed various methods are used largely based on the estimation of mean density of the marine fauna in area, which is subsequently extended to the to the entire area under study. Such methods fail to account for the pattern of the distribution of the marine fauna, which may large calculation error.

The accuracy of the assessment the numbers of marine biological objects, taking into account their distribution pattern, should be augmented. For this purpose, in is proposed using a probabilistic approach in assessment of the numbers of biological objects by aerial survey on the method of Monte Carlo.

The benchmark data for calculations are number densities over the of counted marine biological objects. This method consists in the use for extrapolation and interpolation throughout the entire assessment area of probabilistic fits in some particular interval classes of density data rather than the absolute benchmark density values. The selection of these classes is determined by the Monte Carlo method.

At present the first variant of the computer program and mathematical machinery of the probabilistic approach is developed. The method was tested in the mathematical model and shoved good results. Deviation from the “tree” value constituted 3%, that for the traditional methods was 15 to 25%.

The advantage of the proposed method of assessment of the numbers of biological objects consists in the following:
- General purpose application for calculation of abundance and biomass of marine biological objects (ichthyofauna, marine mammals, algae etc.);
- Good accuracy of determination of abundance of biological objects by data of aerial surveys;
- Absence of restraints associated with collection of primary data (parallel transects, regularity of the distribution of survey sites, etc);
- Possibility of taking into account the biological properties of the distribution of marine biological objects via weight coefficient;
- Selection of arbitrary boundaries of number assessments in the water area under study;
- Simplicity of usage of the method on practice.
Theme session III:
Long term changes in the Barents Sea

Ø. Skagseth (IMR), T. Furevik (UiB), R. Ingvaldsen (IMR), H. Loeng (IMR), K.A. Mork (IMR), K.A. Orvik (UiB) & V. Ozhigin (PINRO):

Transports and propagation of anomalies in the Norwegian and Barents Seas.

The main aim of this paper has been to present a holistic view of the Atlantic water flow along the Norwegian Coast and into the Barents Sea. It has focused on the period starting in the mid-1990s, with simultaneous arrays of moored current meters in the Svinøy section and the Barents Sea Opening. These detailed measurements have provided the bases for improved estimates of means and variations in fluxes, and their forcing mechanisms.

Mean volume and heat fluxes associated with Atlantic water in the Norwegian Atlantic Slope Current (NwASC) are 4.3 Sv and 126 TW respectively for the Svinøy section, showing no significant trends, and 1.8 Sv and 48 TW for the Barents Sea Opening, where positive trends have been found in both measures. These estimates are probably higher than the long-term mean, since hydrographic data along the Norwegian Coast show that the periods of direct current measurements are the prolongations of a period that started in the late 1970s, since when Atlantic water has become warmer and saltier.

The close resemblance, throughout the record, between temperature variations in the Kola section and the AMO-index back to the early 20th century illustrates the importance of large-scale long-term variations in the Barents Sea system. Although the magnitudes of these variations are relatively small in comparison with inter-annual variations, other studies have shown them to be of major importance for ecosystem changes (ACIA, 2005).

The different forcing effects of the NwASC and the Atlantic inflow to the Barents Sea to similar atmospheric systems are noted. The results strongly suggest that the relative distribution of the Norwegian Atlantic Current entering the Barents Sea and passing through the Fram Strait is very sensitive to storm tracks. Thus, changes in the predominant storm tracks may trigger major changes, including feedback mechanisms, for the Barents Sea climate and the heat budget of the Arctic Ocean.
Climate variations and state of zooplankton in the Barents Sea.

The data on zooplankton biomass distribution in August-September 2005-2006 obtained in the integrated ecosystem system survey for the Barents Sea by Russian and Norwegian vessels are presented. The data were obtained using Norwegian methods with drying samples immediately in the field conditions that favoured the operative presentation of data on plankton. To establish the general regularities of plankton biomass forming the data collected in the central latitudinal zone of the Barents Sea in different years (cold 1987, moderate warm 1989, anomalous warm 2002, 2004, 2005) were analyzed. Considerable year-to-year differences in species and age structure of plankton community in water masses of different origin depending on dynamics of the ice cover in that part of the sea were found.

They were studied best of all in the northeastern part of the sea, in the arctic waters. In 2002, owing to the north position of the ice edge in summer, plankton community was characterized by mixed composition (Atlantic and Arctic species) and high abundance. In 2005, as the advective processes were weak and the eastern areas became free from ice later a considerable reduction in abundance of warm-water species was observed. When the position of the ice edge was the most southward in 2004 the bulk of plankton community was made up by arctic species and the lack of warm-water species was recorded. In 1987 and 1989, high horizontal gradients of water temperature in the areas of Atlantic and Arctic water masses interaction were, together with anomalous ice distribution, the main factors influencing the state of zooplankton.
S. Falk-Petersen (NPI):

**Climate swings and ecosystem effects.**

Through the study of three related species of zooplankton it is demonstrated how the ecosystem is acting as a dynamic structure that can respond to historical climatic swings. An overview of current activity and sampling strategy will also be given.
H. Gjøsæter, B. Bogstad & S. Tjelmeland (IMR):

**Why did the three capelin stock collapses in the Barents Sea during the three last decades affect the ecosystem differently?**

In 1984, an almost total recruitment failure was evident in the Barents Sea capelin stock, which collapsed due to lack of recruits from 1985. From a level of 4-7 million tonnes maintained during the 1970s, the stock was reduced to below 200 thousand tonnes. The stock was rebuilt to pre-collapse levels in 1990, only to collapse once more in 1993, due to a new period of recruitment failure. In 2000, the stock was rebuilt to above 4 million tonnes, but collapsed for the third time from 2003.

Up to now, the causes and the underlying mechanisms have been at the centre of the research, but another interesting question is: what are the effects on the ecosystem when one of its key elements, the capelin, fluctuates to the extent seen during the last thirty years? The first collapse seemingly caused much more severe effects for the ecosystem than did the two later collapses. The present paper tries to elucidate the reasons for this difference, focusing on cod growth and survival, and changes in distribution and mortality of seals and sea birds.
V.L. Tretyak (PINRO):

**Long-term variation and adaptive relationships between the life cycle parameters of the north-east Atlantic cod *Gadus morhua*.**

A long-term variation of the basic biological population parameters of the North-East Atlantic cod, which represent a strategy of the cod life cycle and show the population development – growth and maturation rates of the individuals belonging to different year-classes, recruitment of the fishery stock and a theoretic life span is analyzed. It was found that after the mid of 1970s there was a variation in numerical characteristics of these parameters in the cod population. The mathematical expectation of growth and maturation rates increased, life span and recruitment decreased. Variance in the growth rate and the life span increased, rate of maturation and recruitment decreased. The adaptive relationship between the basic element of the population reproductive strategy, the maturation rate of individuals and other biological parameters of the life cycle is shown. The variation of maturation rate provides with the population adaptation to historically made high intensity of the stock exploitation and variable oceanographic conditions in the Barents Sea. The hypothesis on the population mechanism regulating the cod abundance under intensive exploitation was developed and statistically proved.
K. Drevetnyak (PINRO) & K.H. Nedreaas (IMR):

**Spatial migration pattern of deep-water redfish** (*Sebastes mentella* Travin) **in the Barents Sea as inferred from long-term research survey series.**

Study of redfish migration by traditional tagging-methods faces great difficulties. The redfish taken onboard a vessel usually prove to be nonviable. A sharp hydrostatic pressure differential is lethal for the redfish having a closed swim bladder.

The main purpose of the present paper is to determine migration pattern of the deep-water redfish juveniles. To study the data from Russian and Norwegian scientific trawl surveys conducted during autumn and winter of 1982-1995 were used.

The Petersen method was applied to analyse size composition of the deep-water redfish catches taken during the above trawl surveys. The conclusion made from prior researches that the deep-sea redfish year classes of 1982 and 1988 were strong compared to their neighbouring ones was confirmed.

On the assumption that "peaks" in the length distributions of survey catches displayed strong yearclasses, the annual corresponding lengths were defined for the 1982 and 1988 year classes at different age (from 0 to 7 years). Subsequently, using the database from trawl surveys and knowing the length of the deep-sea redfish from strong yearclasses at different age, the distribution of these yearclasses by year was mapped. Based on the analysis of these maps, migration patterns of the deep-sea redfish juveniles in the Barents and Norwegian Seas were plotted.
M-A. Svenning (NINA), A. Zubchenko (PINRO), S. Prusov (PINRO), B. Dempson (DFO-Canada), E. Niemele (RKTL-Finland), R. Borgstrøm (UMB) & J. Erkinaro (RKTL-Finland):

**Where do all the northern Atlantic salmon feed during their sea residence?**

Salmon in Tana river (Norway) and four Russian rivers on the Murman coast are studied in a joint Norwegian-Russian project. The feeding habits and whereabouts of the salmon during their stay in the sea is particularly focussed.
Marine mammals distribution and numbers in the Barents Sea in modern stage with connection of climatic changes.

To the last time considered that about 24 marine mammals species regularly occur in the Barents Sea, comprising 7 species of pinnipeds, 12 of large cetaceans, and 5 of small cetaceans species. The most met frequently of marine mammals species are harp seal (*Phoca groenlandica*), white-beaked dolphin (*Lagenorhynchus albirostris*), walrus (*Odobenus rosmarus*), and minke whale (*Balaenoptera acutorostrata*). Some of marine mammals species observe in the Barents Sea area all year around and some of them can be occur in certain time their life or time of year.

In carrying out of annual Russian-Norwegian ecosystem surveys in the Barents Sea (August-September) during 3 last years were discovered some evident changes in distribution, numbers and marine mammals staying in the Barents Sea area among animals who traditionally registered here (area expansion, numbers, and time duration staying increasing). Also here were observed some marine mammals species who did not discover earlier. This fact is closely associated with considerable the Barents Sea water warming which was registered in the last years.

This circumstance it is necessary to take into account in rational management by fisheries, including development and improvement ecosystem models, as it is known that marine mammals are top predators and they are significant of the Barents Sea ecosystem component, where they have annual food consumption in assume of marine fisheries organisms (prey) in several times more than total catch by commercial marine fisheries. For example, minke whales and harp seals consume 1.8 million and 3.5 million tones of prey per year, respectively, where prevail crustaceans, capelin, herring, polar cod, and gadoid fish, dependent on area and time of year. Functional relationship between marine mammals and their prey seem closely related to fluctuations in the marine ecosystems.
Polar bears and other ice-associated sea mammals in the Barents Sea.

The polar bears in the Barents Sea area belong to a one out of 19 subpopulations in the Arctic. The subpopulation is shared between Russia and Norway, as individuals frequently migrate between Svalbard and the islands of Franz Josef Land. In a joint Norwegian-Russian project in 2004, it was estimated that the size of the subpopulation was about 3000. The main prey of the polar bears in the area are ice associated seals, mainly ringed seals, bearded seals and harp seals.
Oil hydrocarbons and PAH in the Barents Sea sediments.

PAH and oil contaminants in sediments in the Norwegian and Russian parts of the Barents Sea are being monitored by several institutions, including IMR (Norway) and PINRO (Russia). Results from analyses of samples taken in 2003-2005 will be compared with similar samples from the mid 1990s. The work is done as part of the AMAP project.
How does ice cover affect the benthic fauna in the Barents Sea?

Sea ice is a major factor governing the marine ecosystem in the Barents Sea. The extent and thickness of the ice cover determines the timing of the spring bloom, and consequently also influences food supply to the benthos. We investigate the hypothesis that ice cover affects the benthic fauna, and that intermittent ice conditions give rise to enhanced benthic production. In August 2003, we carried out a joint Norwegian-Russian expedition to the central and northern parts of the Barents Sea, comprising 47 sampling stations, extending across ?? km². We collected samples of benthic fauna, sediments, phyto- and zooplankton for a range of biological and geo-physical analyses. We investigated the relationships between ice influence and faunal characteristics, comparing areas predominantly, intermittently and almost never ice covered. Our results show a belt of increased benthic faunal biomass and abundance to occur in areas subjected to intermittent ice cover during a 2-3 year period prior to sampling. We discuss our findings in the context of current concern over ecosystem impacts of climate-induced changes in the extent of sea ice.
An. Filin (PINRO), S. Tjelmeland (IMR) & J.E. Stiansen (IMR):

**Ecosystem dynamics and fisheries management in the Barents Sea.**

Changes in marine ecosystems, caused by variations of the climate and trophic relations, affect strongly stock development that leads to changes in catches and so may have serious consequences for the fishery. Abrupt changes in the ecosystem could produce stronger effects on the stocks than regulated fisheries. On the other hand, the large-scale fisheries are one of the main factors determining the state and dynamics of the marine ecosystems. Therefore, the need of ecosystem approach to fisheries management is widely recognized now.

The Barents Sea is shared between Norway and Russia and the two countries have a mutual interest in a rational management of the fish stocks in this area. For this reason the major studies on development of ecosystem approach to fisheries management in the Barents Sea are realized through joint projects of Institute of Marine Researches in Norway (IMR) and Polar Research Institute of Marine Fisheries and Oceanography in Russia (PINRO). The fishery management in the Barents Sea is conducted through the Joint Russian-Norwegian Fishery Commission, which is a political body at the governmental level and which acts based on advice from the International Council for Exploration of the Sea (ICES). Currently the stocks from the Barents Sea are treated in several assessment working groups at the ICES, however the AFWG is considered as the main body of the ICES in regard to implementation of ecosystem considerations into stock assessments and to the fishery management in the Barents Sea. The current and expected state of the Barents Sea ecosystem has been considered routinely at the AFWG since 2002. Last years the informational basis for this is the joint IMR/PINRO report on the state of the Barents Sea ecosystem. This report is summarized and analyzed ecosystem monitoring information for evaluation of the current situation, making projections and putting the knowledge into operational use that is aimed to improve management advice for sustainable fisheries.

Apart from ICES the joint IMR/PINRO study on development of ecosystem approach to the fisheries management in the Barents Sea are conducted at the request from Norwegian - Russian Fishery Commission. In 2003 the Commission requested IMR and PINRO to evaluate the prospects for long-term yield of commercial species in the Barents Sea taking into account species interactions and the influence from the environment. According to this request a joint IMR/PINRO project on evaluation of optimal long-term harvest in the Barents Sea Ecosystem was initiated. Current state and future work on this project are represented.

Implementation of ecosystem approach to fishery management in the Barents Sea is a great challenge and presently we are taking the first step only in this direction. The current joint IMR-PINRO researches on implications of ecosystem considerations for the management advice are preparing a scientific background for this.