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# EXTENDED SURVEY REPORT FROM THE JOINT NORWEGIAN/RUSSIAN ECOSYSTEM SURVEY IN THE BARENTS SEA AUGUST-OCTOBER 2004

## VOLUME 2

Institute of Marine Research - IMR

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# EXTENDED SURVEY REPORT FROM THE JOINT NORWEGIAN/RUSSIAN ECOSYSTEM SURVEY IN THE BARENTS SEA AUGUST-OCTOBER 2004

## Volume 2

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## Preface

The 2nd joint ecosystem survey was carried out during the period 1st of August to 4th of October 2004. This survey encompasses various surveys that previously have been carried out jointly or at national basis. Joint investigations include the 0-group survey, the acoustic survey for pelagic fish (previously known as the capelin survey), and the investigations on young Greenland Halibut north and east of Spitsbergen. Oceanographic investigations have always formed a part of these surveys, and studies on plankton have been included for many years. In recent years, observations of sea mammals, seabirds, bottom fishes, and benthos have been included. Consequently, from 2003, these surveys were called “ecosystem surveys”.

Presented material not only describes survey results from 2004, but summarizes some previous years investigations.

Major materials of these investigations were involved into 1st volume of the survey report. There were presented results of temperature condition in the Barents Sea, distribution and traditional abundance indices of 0-group fish, distribution and stock abundance of pelagic fish (capelin, polar cod, young atlanto-scandian herring, blue whiting). All other results were briefly mentioned based on very preliminary results.

The present volume 2 of the report covered rest part of the survey results after age readings of bottom fish and working up of other material in laboratories. In this volume main focus now is on the hydro chemical conditions in the Barents Sea, the results from the 0-group fish abundance indices based on new joint Norwegian-Russian method, the investigation on bottom fish (cod, haddock, and additionally on Greenland halibut, redfish, long rough dab, catfish). More detail materials on sea mammals and seabirds as well as results from plankton and benthos investigations are presented in 2nd volume of the report also.

The general charts with survey tracks, bottom and pelagic trawl stations, CTD, plankton and benthos grid stations are presented in Figures 1.1-1.4.

A list of the scientific members on all vessels (as in 1st volume of the survey report) also is given in Appendix I as well as following research vessels participated:

| Vessel | Institute | Cruise leader | Date |
|---|---|---|---|
| "Johan Hjort" | IMR | S. Aanes | 01.08 – 12.08 |
| | | A. Dommasnes | 13.08 – 20.08 |
| | | P. Fossum | 20.08 – 09.09 |
| | | H. Gjøsæter | 10.09 – 04.10 |
| ”Jan-Mayen” | IMR | M. Aschan | 04.08 – 12.08 |
| | | K. Sunnanå | 12.08 – 22.08 |
| | | T. de Lange Wenneck | 10.09 – 01.10 |
| “Smolensk” | PINRO | D. Prozorkevich | 06.08 – 02.10 |
| ”F. Nansen” | PINRO | I. Dolgolenko | 07.08 – 02.10 |

Besides, following specialists not taking part in the survey took part in preparing of single sections of the report:

Abundance indices of 0-group fish – V. Mamylov (PINRO);

Plankton – E. Orlova, V. Nesterova (PINRO) and P. Dalpadado, A. Hassel (IMR);

Sea mammals and birds – V. Tereshchenko, V. Zabavnikov, S. Egorov, S. Ziryanov (PINRO).

## Synopsis

The main aim of the ecosystem survey was to map the distribution and abundance of the young and adult stages of several demersal and pelagic fish species, and in addition to this gather information about hydrographical features, zooplankton, benthos, seabirds and sea mammals.

Depleted content of oxygen in the bottom layer of the southern Barents Sea that started in 1998 has continued in summer and autumn 2004. Phosphate content in the Barents Sea in summer was close to the long-term mean and reduced in autumn because of late termination of water blooming.

Total abundance indices of 0-group fish were estimated by new Norwegian-Russian method used two ways. The new indices show the same richness of year classes as was found by traditional indices.

Total cod numbers was estimated to be 1544 million individuals. Numbers of haddock was estimated near 791 million individuals.

Assessments of other species biomass were estimated correspondingly: Redfish *Sebastes marinus* – 12 thousand sp., *Sebastes mentella* – 317 thousand sp., long rough dab - 3096 million individuals, Greenland halibut – 139 thousand sp. In addition, three species of catfish were also estimated.

The highest values of plankton were found west and Northeast of Spitsbergen. A minimum was found in the cold water masses East of Spitsbergen. Relative homogenous and intermediate values were found in the central part of the sea.

Migrations of cetaceans in the Barents Sea became more prolonged both in time of presence in the sea and distance. It is probably a consequence of the influence of both warming (earlier spring migration) and decrease of food base (capelin).

Despite derived estimates being relative, it can be concluded that the abundance of two species of sea birds, black-legged kittiwake and northern fulmar, declined in the Barents Sea in 2004.

The benthos species occurring most often were bivalve molluscs, Polychaeta and Echinodermata. The clam *Astarte crenata* was the most abundant, followed by species of brittle stars and sea-anemones. Clear biogeographic changes in species composition, biodiversity and distribution were observed northwards in the Barents Sea.

# 1. Hydrochemical investigations (based on data from Russian vessels)

## *1.1. Material and method*

The hydrographical investigations consisted of measurements of temperature and salinity by CTD-sondes in depth profiles along sections and distributed over the total investigated area. Other hydrochemical parameters (oxygen, phosphates, nutrition and siliceous concentrations) were determined from water samples by special complex of test probe.

On Russian vessels concentrations of silicates, nitrates and nitrites were determined using Bran-Luebbe's autoanalyzer following methods recommended by the manufacturer. Methods basically used were as follows: for nitrites – Bendshnider and Robinson's method, for nitrates – reduction of nitrates to nitrites by passing the sample through a tube with coppered cadmium and subsequent estimation of a sum $NO_2$+$NO_3$ (in the form of $NO_2$), and for silicates – Koroleff's method.

Content of ammonia was estimated using Sagi–Solorzano's method; total nitrogen and phosphorus were combusted following the method given by Walderramma with subsequent determination in the form of phosphates and nitrates.

The basis for phosphate estimation was Morphy and Riley's method and when analyzing by spectrophotometer the method of Deniges-Atkins was also applied with the use of photocolorimeter.

Concentration of dissolved oxygen was defined using the Winkler's method.

## *1.2. Results of investigations (figs. 1.2.1-1.2.4)*

In the period from August to September hydrochemical conditions in the Barents Sea were governed by damping of photosynthesis processes, increase of heat advection in the system of currents of Atlantic origin, decrease of the effect of Arctic waters and warming-up of the surface layer due to solar radiation.

In the sections No. 29 (along 74°30'N to the east of the Bear Island), No. 6 (the Kola Section) and No. 37 (Kanin Section) concentrations of dissolved oxygen were registered to be close to the normal in waters of Arctic origin and reduced in the Atlantic waters down to 1.5 ml/l. Aeration of surface layers was close to the normal except for stations done in areas influenced by the Arctic waters where positive anomalies of water saturation with oxygen made up about 1-2% (Figure 1.2.1). Concentrations of mineral phosphorus in the surface 50-m layer were reduced which was caused by more prolonged period of photosynthesis (Figure 1.2.2).

Above pycnocline minimum concentrations of silicon and nitrites (less than 0,4 μM $SiO_3$ and 0,1 μM $NO_3$) were observed. Under such low concentrations of nitrates, products of primary oxidation of organic matter such as ammonia, concentrations of which were quite high in the photic layer (0,7 – 1,4 μM) became have an important role in supply of phytoplankton with nitrogen.

Under conditions of the observed termination of vegetative season (almost no nitrates, phosphates and silicates; surface waters were oversaturated with oxygen) high concentrations of ammonia nitrogen showed that production processes were based on recycling due to mineralization of organic matter. Considerable increase of ammonia concentrations in the pycnocline layer and under it indicated high primary production in the upper layer.

At station 12 (74°30'N and 31°20'E) of the section 29 in the surface layer concentration of dissolved oxygen decreased to 6.0 ml/l (long-term mean was 7.1-7.5 ml/l), which could be a result of upwelling formed under increased advection of waters by northern branch of the North Cape Current over the eastern slope of the Hope Island Deep. By the same reason in the bottom layer at stations 13-14 (74°30'N, 32°30'E – 74°30'N, 33°30'E) concentrations of dissolved oxygen were observed anomalously low. Also, zone of decreased aeration of waters was formed, where saturation with oxygen of surface layer declined to 93-93% (with the normal being 103%), and in the bottom layer it reduced to 10%. Besides, because of upwelling, mineralization at depths down to 125 m was recorded to be high, which suggested formation of a zone of high biological productivity in this area of the sea.

Horizontal distribution of dissolved oxygen on the surface in its structure followed distribution of water temperature and corresponded to position of the main water masses. Concentrations varied within the range of 6.3 ml/l in warm waters of the Murman Current to 8.0 ml/l and higher in polar areas in the northeastern Barents Sea. In the bottom layer considerably depleted concentrations of dissolved oxygen were registered. Comparative analysis with the long-term mean data also indicated negative anomalies of oxygen concentration in the Atlantic waters reaching 0.4 ml/l on the surface. In the bottom layer they were close to the normal. For the Arctic waters, negative anomalies remained at all depths, sometimes exceeding 1.0ml/l.

Variability in water saturation with oxygen in the surface layer varied in the range of 99% at the Kanin Peninsula to 110% in the area west of the Bear Island (Figure 1.2.3). In the eastern part of the sea its distribution was characterized by low background aeration of waters compared to its long-term mean values. In the Northern and Central branches of the North Cape Current and in the Main and Coastal branches of the Murman Current percentage of oxygen was close to the normal, while in the Spitsbergen and Bear Island currents it was by 3-5 % above the normal.

At the depth of 50 m at the Novaya Zemlya coast water saturation with oxygen was observed to be as high as 110%. Deeper, at the depths of 100 m and 200 m, this maximum was fuzzy and in the bottom layer, percentage of oxygen decreased to 75% (the normal is 86%).

Concentrations of biogenic elements in the surface layer were characteristic of vegetation period and were marginal almost over the whole area. They ranged within 0.00-0.15 µM for nitrates, 0.00 – 0.15 µM for phosphates, and 0,1 – 1,0 µM for silicates.

The exception was a small area adjacent to the western shore of the southern island of Novaya Zemlya, where concentrations of biogenic elements remained high.

Variability in the phosphate concentrations on the surface was not high and constituted 0.0 – 0.3 µM (Figure 1.2.4). Their background values were observed to decrease compared to the mean long-term data.

In the result of termination of photosynthesis process in the second half of September south of the Spitbergen there was no consumption of phosphates for phytoplankton reproduction; at the same time due to water exchange between the upper and lower layers their relatively high concentrations were formed. On the surface they reached 0.5 µM

At the end of September – beginning of October in the section No. 6 low concentrations of dissolved oxygen were observed; their minimum values were characteristic of waters of the Main and Coastal branches of the Murman Current and decreased in the midstream down to 6.00 ml/l. Negative anomalies varied within 0.10-0.60 ml/l range. The increased water temperature could explain such situation.

Water saturation with oxygen in all layers reduced approximately by 2-3% compared to the long-term mean values (Figure 1.2.1), while at station 8 (73°00'N, 33°30'E) in the lower part of water column (100 m – bottom) it was by 4-6% lower.

Phosphate concentrations were also below the long-term mean by 0.1-0.2 (μM)(Figure 1.2.2). Vertical structure of phosphate distribution corresponded to that of summer type, while for the long-term mean data it is characteristic that in this period waters begin to mix under the effect of autumn-winter convection.

Thus, hydrochemical investigations conducted in the Barents Sea showed the following:

On the whole background values of dissolved oxygen were low (by 0.3-1.5ml/l below the normal) and such situation was due to increased temperature of waters of the Atlantic origin and their flow to the upper layers of sea.

Zone of extreme values of hydrochemical characteristics observed in August allows suggesting upwelling at eastern stations of the section 29 and possible formation of the zone with increased biological productivity. In this area of the sea dense concentrations of zooplankton were observed.

A period characterized by depleted content of oxygen in the bottom layer of the southern Barents Sea that started in 1998 has continued in summer and autumn 2004. Phosphate content in the Barents Sea in summer was close to the long-term mean and reduced in autumn because of late termination of water blooming.

## 2. New abundance indices of 0-group fish based on real trawl catch (joint materials)

The standard trawling procedure consisted of tows at 3 depths, each of 0.5 nautical miles, with the headline of the trawl located at 0, 20 and 40 m. Additional tows at 60 and 80 m, also of 0.5 nm distance, were made when the 0-group fish layer was recorded deeper than 60 m or 80 m on the echo-sounder.

In addition to the traditional abundance indices, a new type of total 0-group fish abundance indices (Dingsør and Prozorkevich, in prep.) were calculated from the actual catches of the same trawl stations. These were used for the first time during the joint ecosystem survey 2004. This new method is considered to correspond better with total abundance, allows to calculate confidence limits, and makes better use of the total data than the indices used hitherto. To be able to present a time series with new indices, the survey data were reanalysed for the period 1980-2004 and the results presented in this report. The preparation of the data is explained and analysed in detail in (Dingsør, 2005). When new indices for the whole period have been recalculated, and the results have been carefully scrutinized and compared to previous traditional methods, this method is meant to replace the methods used up to now after a short period of overlap between the two methods.

### 2.1. Underlying principles and trawl capture efficiency

The 0-group survey in the Barents Sea has been carried out in late August - early September each year, using four to six Norwegian and Russian vessels. Since 1980, Norway, and 1981, Russia, the trawling procedure has been standardized by depth and distance (see above). Most trawl stations are spaced apart by 30-35 nm sailed distance, but the distance between cruise tracks are varying and the distance between stations are in some cases less than 30 nm.

The trawl used is a small-meshed mid-water trawl with 20 m vertical opening and 15 m wing spread (Godø et al., 1993). This sampling trawl has been used regularly since 1979 by Norwegian vessels and 1981 by Russian vessels. All Russian vessels in 1980 and one Russian vessel in 1982 - 1984 used a smaller sized (6 x 10 m) trawl. Assuming that the catches are proportional to the area of the trawl mouth, the catches of the smaller sized trawl were multiplied by a factor of 3.33 to even out the difference in vertical opening. In 1994, one Russian vessel used a non standard trawl with 30 m vertical opening and unknown wing spread, two steps were trawled to cover the usual three steps.

Due to the trawling procedure, the effective trawling distance is equal to the total distance towed divided by the number of depth steps (Stensholt and Nakken, 2001). Because of many errors in the datasets, the total distances were recalculated. The duration of a trawl haul was found by the start and stop time, duration was then multiplied by the speed and the total distance was found. If the start time, stop time, or speed was missing, then the total distance from the data was used. Even though there is developed a coding system for the number of depth steps, these codes were often lacking or in some cases erroneous. Thus, the number of depth steps were found by the duration and the following criteria: 1 step when duration < 16 minutes, 2 steps when duration is 16 – 25 min, 3 steps when duration is 26 – 35 min, 4 steps when duration is 36 – 45 min and 5 steps when duration is 46 – 55 min. If duration could not be calculated, the number of depth steps was found by total distance divided by 0.5 and rounded to the nearest integer. The effective distance, $d_s$, at station $s$ was then found by

$$d_s = \text{total distance / depth steps} \tag{1}$$

The common practice in the traditional old indices has been to use the effective distances of 1 nm for 2 steps and 1.5 nm for 3 or more steps (Havforskningsinstituttet, 1994). The reason for making the recalculations above even when values were not missing, is that the fewer links of human touch between input and output, the smaller is the chance of human error in terms of calculation and punching errors.

Godø et al. (1993) and Hylen et al. (1995) showed that the sampling trawl is highly selective for 0-group cod and haddock. Its capture efficiency of fish smaller than 65 mm was much lower than their experimental trawl and it is reasonable to assume that this applies to other species as well. The similar results were obtained by PINRO (Mamylov, 2003). Thus there is arisen the necessity to take in attention a special correction factor which would compensate the different trawl capture efficiency subject to fish length and species. This factor is named as *Keff*, and to estimate possible catch refer the trawl swept area (the trawl mouth) the catch quantity should be multiplied with this *Keff*.

One of the ways to estimate *Keff* might be the calculated method based on the trawl geometry and mesh size (Mamylov, 2003). This method concerns only passive objects being fished and excludes the effects of fish behaviour in the trawl operation zone. It was assumed that the small objects (4-7 cm and less in length, depending on the minimum mesh size in codend) are fished only by a cylindrical part of trawl codend with a small-meshed insertion, therefore, for them *Keff* is taken to be equivalent to the ratio of trawl mouth area and codend cross section area, that equal to 100 % -"straining" of small objects through a trawl netting.

For the sampling trawl 20x20 m this maximum *Keff* value is about 10. As for medium- and large-size marine organisms (above 10-15 cm), a fishing cross section for them is equal to trawl mouth area, i.e. *Keff* = 1, was taken and in this case, the trawl efficiency was determined only by the effective horizontal trawl opening. Values of *Keff* for the "intermediate" fish size (4-15 cm) were estimated as geometrical interpolation, corresponding to exponential dependence. Thus for this trawl with the minimum mesh size in codend a=4 mm, the dependence of *Keff* from $l$ for $l = 4.5 – 12.5$ cm was estimated as

$$Keff = 31.177*\exp(-0.2708l) \quad (2)$$

As a first approximation it is possible to adopt this theoretical value of *Keff*. But recently Prozorkevich has estimated the following correction functions for three species types according to regressions of acoustic and trawl data about fish densities received during trawling on the its relatively "pure" concentrations:

$$Keff_{gadoids} = 17.065* \exp(-0.1932*l) \quad (3)$$
$$Keff_{capelin} = 7.2075*\exp(-0.1688*l) \quad (4)$$
$$Keff_{herring} = 357.23*\exp(-0.6007*l) \quad (5),$$

where $l$ is the length in cm.

It is interesting that theoretical dependence *Keff (l)* is inside of confidence limits of these regressions. These correction functions can be applied directly to the observed length frequencies at each station. But since the functions above give unreasonably high numbers as $l$ decreases, it was decided to set for $l < 4$ cm $Keff_{gadoids}$ constant to 8, $Keff_{herring}$ constant to 30 and $Keff_{capelin}$ constant to 4.

The abundance indices estimated with these correction functions, *Keff*, were compared to other indices and the correlations were a little weaker than without the use of *Keff*. Thus, it is a problem what *Keff (l)* dependencies (including *Keff*=1 independently from fish species and length) should be used for concrete surveys. This question should be coordinated for future. Thereafter it is suggested that until better correction functions are available, the new indices estimated with no correction for catching efficiency (Keff is set to 1) are regarded as the official indices and corrected index with varied *Keff* should be used as "additional".

## 2.2. Stratified sample mean estimator (table 2.1& figs.2.2.1-2.2.2)

For new estimation of abundance it was decided to use an index based on the stratified sample mean method. The area covered by the survey was stratified by new strata system including 22 strata (fig. 2.2.1). Example of good coverage (2000) is presented in figure 2.2.2.

**Table 2.1 Area coverage coefficients and number of trawl stations**

| Year | Strata number | | | | | | | | | | | | | | | | | | | | | | | Total coverage area, $nm^2$ | Numbers Stations |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 01 | 02 | 03 | 04 | 05 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 20 | 21 | 22 | 23 | 24 | 25 | 27 | 37 | 39 | | |
| 1980 | 0.20 | 0.87 | 0.91 | 0.88 | 0.93 | 1.00 | 0.67 | 1.00 | 1.00 | 0.66 | 0.71 | | | | 1.00 | 0.91 | 0.22 | 0.29 | 0.08 | 0.48 | 0.89 | 0.96 | 0.99 | 351 949 | 326 |
| 1981 | 0.30 | 0.87 | 0.91 | 0.86 | 0.12 | 1.00 | 0.69 | 1.00 | 0.99 | 0.83 | 0.86 | 0.45 | | | 1.00 | 0.95 | 0.41 | 0.29 | 0.06 | 0.52 | 0.94 | 0.03 | 0.80 | 331 608 | 296 |
| 1982* | 0.05 | 0.94 | 1.00 | 0.88 | 0.28 | 1.00 | 0.07 | 1.00 | 0.97 | 0.05 | 0.86 | | | | 1.00 | 0.95 | 0.33 | 0.24 | 0.15 | 0.46 | 0.93 | 0.19 | 0.58 | 264 791 | 266 |
| 1983 | 0.43 | 0.84 | 0.99 | 0.93 | 0.31 | 1.00 | 0.90 | 1.00 | 1.00 | 0.75 | 1.00 | 0.16 | | | 1.00 | 0.94 | 0.38 | 0.30 | 0.15 | 0.63 | 0.93 | 0.10 | 0.43 | 336 604 | 268 |
| 1984* | 0.26 | 0.49 | 0.96 | 0.81 | 0.17 | 0.88 | 0.71 | 1.00 | 0.47 | 0.50 | 0.46 | | | | 1.00 | 0.95 | 0.36 | 0.26 | | 0.63 | 0.93 | 0.04 | 0.48 | 271 478 | 271 |
| 1985 | 0.22 | 0.92 | 0.97 | 0.77 | 0.28 | 1.00 | 0.89 | 1.00 | 1.00 | 0.91 | 1.00 | 0.09 | 0.02 | | 1.00 | 0.98 | 0.36 | 0.28 | 0.15 | 0.63 | 0.97 | 0.41 | 0.78 | 352 474 | 296 |
| 1986 | 0.23 | 0.82 | 1.00 | 0.87 | 0.15 | 1.00 | 0.84 | 1.00 | 1.00 | 0.79 | 1.00 | | | | 1.00 | 0.95 | 0.28 | 0.33 | 0.21 | 0.48 | 0.93 | | 0.47 | 314 537 | 275 |
| 1987 | 0.37 | 0.87 | 0.98 | 0.88 | 0.86 | 1.00 | 0.85 | 1.00 | 1.00 | 0.74 | 0.90 | | | | 1.00 | 0.95 | 0.26 | 0.29 | 0.10 | 0.38 | 0.78 | 0.34 | 0.38 | 324 558 | 281 |
| 1988 | 0.31 | 0.86 | 0.92 | 0.92 | 0.67 | 1.00 | 0.81 | 1.00 | 1.00 | 0.61 | 0.80 | 0.02 | | | 1.00 | 0.91 | 0.27 | 0.32 | 0.06 | 0.48 | 0.78 | 0.45 | 0.70 | 328 583 | 291 |
| 1989 | 0.49 | 0.93 | 0.89 | 0.91 | 0.36 | 1.00 | 0.92 | 1.00 | 1.00 | 0.98 | 1.00 | 0.91 | 0.25 | 0.23 | 1.00 | 0.82 | 0.46 | 0.57 | 0.41 | 0.45 | 0.75 | 0.12 | 0.57 | 405 007 | 422 |
| 1990 | 0.67 | 0.93 | 0.92 | 0.89 | 0.39 | 1.00 | 0.94 | 1.00 | 1.00 | 0.90 | 1.00 | 0.28 | 0.13 | | 1.00 | 0.87 | 0.36 | 0.35 | 0.25 | 0.43 | 0.73 | 0.08 | 0.54 | 358 862 | 396 |
| 1991 | 0.70 | 0.98 | 0.96 | 0.82 | 0.29 | 1.00 | 0.96 | 1.00 | 1.00 | 0.96 | 1.00 | 0.74 | 0.07 | | 1.00 | 0.94 | 0.39 | 0.55 | 0.33 | 0.40 | 0.77 | 0.08 | 0.55 | 384 610 | 403 |
| 1992 | 0.29 | 0.85 | 0.86 | 0.79 | 0.16 | 1.00 | 0.88 | 1.00 | 0.98 | 0.90 | 0.86 | 0.22 | | | 1.00 | 0.97 | 0.36 | 0.44 | 0.21 | 0.61 | 0.74 | | 0.33 | 322 792 | 301 |
| 1993 | 0.65 | 0.80 | 0.90 | 0.79 | 0.19 | 1.00 | 0.93 | 1.00 | 1.00 | 0.98 | 0.88 | | | | 1.00 | 0.91 | 0.19 | 0.29 | 0.15 | 0.62 | 0.85 | | 0.13 | 321 539 | 265 |
| 1994 | 0.47 | 0.87 | 0.92 | 0.56 | | 1.00 | 0.84 | 0.92 | 0.97 | 0.88 | 0.86 | 0.09 | | | 0.99 | 0.80 | 0.19 | 0.29 | 0.15 | 0.45 | 0.51 | | | 280 222 | 245 |
| 1995 | 0.19 | 0.69 | 0.95 | 0.84 | 0.13 | 1.00 | 0.50 | 1.00 | 1.00 | 0.57 | 0.90 | | | | 1.00 | 0.79 | | 0.26 | 0.11 | 0.37 | 0.53 | | 0.23 | 253 894 | 201 |
| 1996 | 0.53 | 1.00 | 0.90 | 0.79 | 0.11 | 1.00 | 0.92 | 1.00 | 1.00 | 0.94 | 1.00 | 0.78 | | | 1.00 | 0.87 | 0.20 | 0.19 | | 0.34 | 0.65 | 0.02 | 0.23 | 321 637 | 389 |
| 1997 | 0.47 | 0.88 | 0.86 | 0.62 | | 1.00 | 0.85 | 0.99 | 1.00 | 0.94 | 0.82 | 0.27 | | | 0.89 | 0.67 | 0.06 | 0.16 | | 0.41 | 0.64 | | 0.19 | 280 293 | 268 |
| 1998 | 0.54 | 0.99 | 0.74 | 0.68 | | 1.00 | 0.90 | 0.93 | 1.00 | 0.99 | 1.00 | 0.91 | 0.15 | | 1.00 | 0.97 | 0.23 | 0.23 | 0.20 | 0.11 | 0.60 | | | 320 802 | 356 |
| 1999 | 0.55 | 0.74 | 0.69 | 0.66 | 0.09 | 1.00 | 0.94 | 1.00 | 1.00 | 0.96 | 1.00 | 0.71 | | | 1.00 | 0.86 | 0.19 | 0.24 | 0.12 | 0.05 | 0.61 | | 0.08 | 304 759 | 229 |
| 2000 | 0.56 | 0.75 | 0.69 | 0.74 | 0.37 | 1.00 | 0.94 | 1.00 | 1.00 | 0.95 | 1.00 | 0.71 | | | 1.00 | 0.95 | 0.19 | 0.30 | 0.12 | 0.38 | 0.62 | 0.11 | 0.38 | 338 466 | 267 |
| 2001 | 0.59 | 0.79 | 0.73 | 0.74 | 0.41 | 1.00 | 0.96 | 1.00 | 1.00 | 0.96 | 1.00 | 0.71 | | | 1.00 | 0.96 | 0.20 | 0.29 | 0.12 | 0.42 | 0.81 | 0.13 | 0.34 | 348 248 | 275 |
| 2002 | 0.56 | 0.75 | 0.69 | 0.74 | 0.40 | 1.00 | 0.94 | 1.00 | 1.00 | 0.96 | 1.00 | 0.67 | | | 1.00 | 0.96 | 0.19 | 0.29 | 0.09 | 0.41 | 0.54 | 0.15 | 0.17 | 330 232 | 254 |
| 2003 | 0.65 | 0.96 | 0.83 | 0.78 | 0.14 | 1.00 | 0.98 | 1.00 | 1.00 | 0.96 | 1.00 | 0.70 | | | 0.99 | 0.95 | | 0.40 | 0.32 | 0.26 | 0.81 | 0.20 | 0.68 | 365 845 | 288 |
| 2004 | 0.51 | 0.94 | 0.73 | 0.66 | 0.10 | 1.00 | 0.94 | 0.98 | 1.00 | 0.93 | 1.00 | 0.92 | 0.22 | | 0.97 | 0.92 | 0.35 | 0.40 | 0.26 | 0.43 | 0.27 | | | 333 239 | 293 |
| ***Average*** | ***0.43*** | ***0.85*** | ***0.88*** | ***0.79*** | ***0.31*** | ***1.00*** | ***0.83*** | ***0.99*** | ***0.98*** | ***0.82*** | ***0.92*** | ***0.52*** | ***0.14*** | ***0.23*** | ***0.99*** | ***0.91*** | ***0.28*** | ***0.31*** | ***0.17*** | ***0.43*** | ***0.74*** | ***0.21*** | ***0.46*** | ***325 881*** | ***297*** |

**Missing data in the eastern areas.*

To find the coverage of a stratum, the station positions were loaded into a GIS software (Manifold system 6.00). The boundary stations were traced, a buffer zone of 20 nm was added, and the areas enclosed were calculated. The conic projection Albers equal-area, with centre latitude at 75°N, centre longitude at 30°E, and standard latitudes at 70° and 80°N, was used in this operation. The coverage varies to a large extent from year to year (Table 2.1). The low coverage in 1982 and 1984 is due to missing data.

The number of fish per nm$^2$, $\rho_{s,l}$, at length, $l$, at each station, $s$, are estimated by the following equation:

$$\rho_{s,l} = \frac{f_{s,l} \cdot Keff}{a_s} \quad (6),$$

where $f_{s,l}$ is the calculated frequency of length $l$ at station $s$, $Keff$ is the correction functions defined above, and $a_s$ is the swept area found by

$$a_s = \frac{d_s \cdot ws}{1852} \quad (7),$$

where $ws$ is the wingspread of the trawl and is set to 15 m, $d_s$ is the effective trawl distance found as total trawl distance divided on depth steps.

The stratified swept area estimate, is given by

$$\bar{y}_{st} = \sum_{i=1}^{L} A_i \bar{y}_i \quad (8),$$

where $L$ is the number of strata, $A_i$ is the covered area in the $i$th stratum, and $\bar{y}_i$ is the average density in stratum $i$. The estimated variance of the stratified mean $\bar{y}_{st}$ is

$$\mathrm{var}(\bar{y}_{st}) = \sum_{i=1}^{L} A_i^2 \frac{s_i^2}{n_i} \quad (9),$$

where

$$s_i^2 = \frac{\sum_{s=1}^{n_i} (y_{i,s} - \bar{y}_i)^2}{n_i - 1} \quad (10).$$

The standard error of $\bar{y}_{st}$ is given by

$$\mathrm{se}(\bar{y}_{st}) = \sqrt{\mathrm{var}(\bar{y}_{st})} \quad (11)$$

and the confidence limits (CL) are found by

$$\mathrm{CL} = \bar{y}_{st} \pm 1.96 \cdot \mathrm{se}(\bar{y}_{st}) \quad (12).$$

### *2.3. New estimations of 0-group fish total abundance indices*

Based on methods described above the total abundance indices of 0-group fish were calculated with 95 % confidence limits. Following results are presented with correction for capture efficiency (Table 2.2) and without correction for capture efficiency (Table 2.3). As it was preliminary agreed the new indices with no correction for catching efficiency (Keff=1) will be used as the official indices and indices corrected by capture efficiency should use as "additional". Generally, the new 0-group indices show the same changing trends as the previous traditional indices, but variability in the new indices are more dynamic.

**Table 2.2 Abundance indices (in millions) with 95% confidence limits, corrected for catching efficiency**

| Year | Capelin | | | Cod | | | Haddock | | | Herring | | | Saithe | | | Polar cod (east) | | | Polar cod (west) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Abundance | Confidence | | Abundance | Confidence | | Abundance | Confidence | | Abundance | Confidence | | Abundance | Confidence | | Abundance | Confidence | | Abundance | Confidence | |
| 1980 | 1 078 218 | 737 682 | 1 418 753 | 417 | 219 | 616 | 411 | 253 | 569 | 124 | 33 | 215 | 28 | 0 | 62 | 0 | 0 | 0 | 168 932 | 0 | 410 222 |
| 1981 | 571 088 | 304 965 | 837 211 | 369 | 260 | 478 | 94 | 41 | 148 | 50 | 0 | 115 | 0 | 0 | 0 | 3 305 | 1 530 | 5 080 | 64 468 | 25 551 | 103 384 |
| 1982 | 815 597 | 203 572 | 1 427 623 | 3 442 | 2 524 | 4 359 | 3 062 | 2 254 | 3 869 | 1 065 | 292 | 1 837 | 354 | 0 | 886 | 4 | 0 | 7 | 3 668 | 0 | 8 093 |
| 1983 | 443 024 | 231 573 | 654 474 | 21 147 | 10 284 | 32 011 | 5 937 | 4 293 | 7 581 | 162 656 | 38 606 | 286 707 | 559 | 173 | 946 | 1 406 | 0 | 3 256 | 74 347 | 0 | 161 122 |
| 1984 | 224 880 | 137 399 | 312 360 | 27 123 | 7 586 | 46 661 | 5 004 | 3 429 | 6 578 | 24 257 | 1 735 | 46 778 | 1 342 | 443 | 2 240 | 164 | 0 | 417 | 35 625 | 8 634 | 62 616 |
| 1985 | 97 915 | 968 | 194 861 | 84 747 | 41 546 | 127 949 | 3 285 | 2 047 | 4 522 | 40 187 | 8 180 | 72 195 | 45 | 5 | 86 | 112 247 | 30 740 | 193 754 | 9 209 | 0 | 18 844 |
| 1986 | 75 297 | 6 625 | 143 968 | 12 900 | 8 872 | 16 927 | 2 762 | 1 637 | 3 886 | 149 | 41 | 258 | 5 | 0 | 12 | 85 547 | 29 287 | 141 807 | 24 552 | 0 | 49 632 |
| 1987 | 3 070 | 629 | 5 511 | 1 381 | 662 | 2 099 | 998 | 612 | 1 385 | 66 | 0 | 149 | 6 | 0 | 14 | 86 505 | 0 | 198 223 | 870 | 364 | 1 376 |
| 1988 | 122 766 | 22 343 | 223 190 | 3 558 | 2 063 | 5 052 | 2 249 | 821 | 3 677 | 83 138 | 28 337 | 137 939 | 41 | 15 | 67 | 3 628 | 75 | 7 181 | 55 880 | 0 | 121 347 |
| 1989 | 1 175 685 | 936 027 | 1 415 342 | 3 708 | 2 211 | 5 204 | 886 | 615 | 1 158 | 23 520 | 10 937 | 36 104 | 14 | 0 | 31 | 2 124 | 0 | 4 524 | 209 037 | 23 468 | 394 607 |
| 1990 | 153 597 | 103 466 | 203 728 | 31 479 | 17 739 | 45 220 | 4 109 | 3 037 | 5 180 | 10 566 | 828 | 20 304 | 37 | 4 | 71 | 3 699 | 890 | 6 507 | 333 996 | 0 | 744 122 |
| 1991 | 219 759 | 98 508 | 341 009 | 55 394 | 40 595 | 70 192 | 18 955 | 14 502 | 23 408 | 361 027 | 137 974 | 584 080 | 12 | 6 | 18 | 774 199 | 350 163 | 1 198 234 | 391 872 | 0 | 1 121 343 |
| 1992 | 465 | 0 | 991 | 226 092 | 122 932 | 329 252 | 6 518 | 4 457 | 8 579 | 118 159 | 68 004 | 168 315 | 443 | 214 | 672 | 62 894 | 0 | 126 267 | 109 034 | 17 006 | 201 063 |
| 1993 | 1 034 | 215 | 1 854 | 128 566 | 70 469 | 186 663 | 4 142 | 2 855 | 5 429 | 437 573 | 3 197 | 871 950 | 1 400 | 0 | 3 401 | 130 377 | 32 831 | 227 924 | 94 807 | 16 743 | 172 871 |
| 1994 | 27 983 | 2 590 | 53 376 | 115 923 | 61 246 | 170 600 | 6 921 | 3 897 | 9 945 | 174 920 | 0 | 365 301 | 8 | 0 | 18 | 1 616 827 | 731 033 | 2 502 621 | 66 016 | 0 | 146 621 |
| 1995 | 2 756 | 0 | 6 324 | 372 527 | 179 309 | 565 744 | 1 821 | 925 | 2 717 | 19 094 | 7 574 | 30 614 | 631 | 281 | 981 | 0 | 0 | 0 | 290 | 16 | 564 |
| 1996 | 191 767 | 98 491 | 285 044 | 370 935 | 246 723 | 495 148 | 3 491 | 2 640 | 4 343 | 758 043 | 359 092 | 1 156 994 | 629 | 263 | 994 | 815 216 | 511 037 | 1 119 394 | 62 511 | 0 | 155 320 |
| 1997 | 261 351 | 113 055 | 409 647 | 397 820 | 295 318 | 500 322 | 2 744 | 1 882 | 3 605 | 624 380 | 230 666 | 1 018 094 | 467 | 222 | 712 | 385 620 | 207 651 | 563 589 | 84 063 | 8 071 | 160 055 |
| 1998 | 117 380 | 64 377 | 170 384 | 32 088 | 21 040 | 43 136 | 18 880 | 12 572 | 25 188 | 632 685 | 365 795 | 899 574 | 219 | 106 | 331 | 22 927 | 11 728 | 34 127 | 127 410 | 0 | 294 535 |
| 1999 | 393 331 | 200 244 | 586 419 | 5 875 | 1 316 | 10 435 | 3 709 | 1 388 | 6 030 | 49 279 | 18 559 | 79 998 | 362 | 181 | 543 | 1 552 224 | 979 392 | 2 125 056 | 35 474 | 5 934 | 65 013 |
| 2000 | 186 841 | 7 492 | 366 191 | 144 970 | 77 486 | 212 454 | 14 670 | 9 218 | 20 123 | 626 908 | 30 754 | 1 223 062 | 1 151 | 608 | 1 693 | 1 186 355 | 679 308 | 1 693 403 | 274 315 | 188 173 | 360 457 |
| 2001 | 26 526 | 4 354 | 48 698 | 6 070 | 1 246 | 10 894 | 7 241 | 4 958 | 9 523 | 13 657 | 2 453 | 24 862 | 64 | 0 | 142 | 0 | 0 | 0 | 193 161 | 0 | 420 590 |
| 2002 | 29 182 | 16 813 | 41 552 | 45 252 | 29 031 | 61 472 | 5 840 | 3 925 | 7 754 | 124 280 | 18 213 | 230 346 | 689 | 400 | 979 | 129 539 | 76 206 | 182 871 | 312 272 | 63 566 | 560 979 |
| 2003 | 611 818 | 314 101 | 909 536 | 119 952 | 69 716 | 170 188 | 44 067 | 23 787 | 64 346 | 256 458 | 92 865 | 420 051 | 3 606 | 0 | 9 453 | 109 733 | 56 642 | 162 824 | 19 460 | 1 376 | 37 543 |
| 2004 | 74 158 | 16 665 | 131 651 | 103 650 | 74 911 | 132 389 | 55 529 | 37 521 | 73 536 | 1 065 883 | 728 730 | 1 403 037 | 6 492 | 3 715 | 9 269 | 345 598 | 151 681 | 539 514 | 3 249 | 890 | 5 608 |

**Table 2.3 Abundance indices (in millions) with 95% confidence limits, without correction for catching efficiency**

| Year | Capelin | | | Cod | | | Haddock | | | Herring | | | Redfish | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Abundance index | Confidence limit | | Abundance index | Confidence limit | | Abundance index | Confidence limit | | Abundance index | Confidence limit | | Abundance index | Confidence limit | |
| 1980 | 289 233 | 198 151 | 380 314 | 84 | 48 | 120 | 89 | 55 | 123 | 7 | 2 | 12 | 376 831 | 0 | 942 891 |
| 1981 | 146 857 | 79 240 | 214 473 | 65 | 45 | 86 | 19 | 9 | 29 | 5 | 0 | 11 | 208 676 | 0 | 495 518 |
| 1982 | 241 500 | 60 673 | 422 327 | 665 | 478 | 851 | 716 | 521 | 911 | 66 | 15 | 116 | 225 937 | 14 158 | 437 716 |
| 1983 | 134 397 | 72 378 | 196 416 | 5 302 | 2 324 | 8 280 | 1 816 | 1 193 | 2 440 | 43 773 | 16 434 | 71 112 | 71 452 | 35 908 | 106 997 |
| 1984 | 97 638 | 60 528 | 134 748 | 7 874 | 2 533 | 13 214 | 1 713 | 1 169 | 2 256 | 5 677 | 2 093 | 9 261 | 57 458 | 18 739 | 96 177 |
| 1985 | 32 255 | 0 | 65 111 | 20 151 | 10 163 | 30 139 | 923 | 530 | 1 316 | 10 478 | 1 852 | 19 104 | 425 744 | 159 729 | 691 758 |
| 1986 | 18 025 | 891 | 35 160 | 2 493 | 1 718 | 3 267 | 630 | 364 | 896 | 12 | 0 | 24 | 147 650 | 0 | 304 931 |
| 1987 | 799 | 178 | 1 421 | 223 | 113 | 333 | 170 | 102 | 239 | 3 | 0 | 6 | 32 904 | 17 801 | 48 007 |
| 1988 | 38 435 | 7 967 | 68 904 | 702 | 402 | 1 002 | 524 | 207 | 840 | 11 928 | 4 488 | 19 368 | 91 515 | 58 459 | 124 571 |
| 1989 | 344 987 | 273 551 | 416 424 | 957 | 549 | 1 365 | 234 | 160 | 307 | 5 484 | 1 876 | 9 092 | 21 354 | 10 223 | 32 485 |
| 1990 | 48 054 | 32 584 | 63 525 | 8 821 | 4 733 | 12 909 | 1 519 | 1 117 | 1 920 | 6 054 | 0 | 12 658 | 123 980 | 67 925 | 180 034 |
| 1991 | 74 506 | 33 789 | 115 223 | 14 776 | 10 663 | 18 889 | 5 281 | 3 954 | 6 608 | 105 890 | 55 508 | 156 271 | 51 494 | 0 | 104 059 |
| 1992 | 154 | 0 | 330 | 60 728 | 33 084 | 88 371 | 2 237 | 1 600 | 2 874 | 52 097 | 30 012 | 74 182 | 18 413 | 0 | 48 719 |
| 1993 | 343 | 96 | 590 | 35 890 | 19 228 | 52 552 | 1 623 | 1 098 | 2 148 | 90 769 | 5 517 | 176 021 | 7 623 | 0 | 18 569 |
| 1994 | 12 316 | 1 206 | 23 425 | 35 683 | 18 494 | 52 872 | 2 586 | 1 367 | 3 806 | 25 224 | 0 | 54 145 | 71 465 | 0 | 164 239 |
| 1995 | 819 | 0 | 1 882 | 119 472 | 60 293 | 178 651 | 720 | 366 | 1 074 | 2 267 | 814 | 3 720 | 22 022 | 4 497 | 39 546 |
| 1996 | 62 740 | 32 285 | 93 194 | 94 377 | 62 348 | 126 406 | 1 422 | 1 062 | 1 782 | 78 827 | 39 355 | 118 298 | 37 | 11 | 62 |
| 1997 | 76 780 | 32 845 | 120 714 | 90 747 | 66 917 | 114 576 | 834 | 576 | 1 093 | 62 444 | 28 017 | 96 870 | 196 | 0 | 395 |
| 1998 | 47 841 | 30 786 | 64 895 | 9 065 | 5 747 | 12 382 | 7 990 | 4 985 | 10 996 | 106 103 | 58 716 | 153 490 | 995 | 12 | 1 978 |
| 1999 | 118 474 | 64 831 | 172 117 | 1 819 | 201 | 3 436 | 1 539 | 503 | 2 575 | 22 033 | 2 821 | 41 245 | 54 | 20 | 88 |
| 2000 | 52 507 | 787 | 104 227 | 34 816 | 18 597 | 51 035 | 3 927 | 2 510 | 5 344 | 66 280 | 4 456 | 128 104 | 10 051 | 0 | 22 542 |
| 2001 | 6 950 | 852 | 13 047 | 1 309 | 250 | 2 367 | 2 688 | 1 724 | 3 652 | 1 136 | 202 | 2 070 | 8 | 2 | 14 |
| 2002 | 27 629 | 15 510 | 39 748 | 25 504 | 14 781 | 36 227 | 2 464 | 1 699 | 3 228 | 31 326 | 16 289 | 46 363 | 176 | 29 | 324 |
| 2003 | 174 219 | 90 750 | 257 687 | 25 464 | 14 899 | 36 028 | 11 524 | 5 974 | 17 073 | 41 866 | 23 187 | 60 546 | 257 | 0 | 549 |
| 2004 | 22 688 | 3 525 | 41 851 | 29 893 | 21 856 | 37 931 | 26 775 | 17 806 | 35 744 | 185 326 | 131 597 | 239 055 | 1 366 | 0 | 2 807 |

**End of Table 2.3**

| Year | Saithe | | | Halibut | | | LRD | | | Polar cod (east) | | | Polar cod (west) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Abundance index | Confidence limit | | Abundance index | Confidence limit | | Abundance index | Confidence limit | | Abundance index | Confidence limit | | Abundance index | Confidence limit | |
| 1980 | 3.32 | 0.00 | 6.90 | 58.30 | 18.27 | 98.32 | 1 468 | 1 077 | 1 860 | 0 | 0 | 0 | 19 689 | 0 | 47 858 |
| 1981 | 0.00 | 0.00 | 0.00 | 91.35 | 56.33 | 126.37 | 689 | 338 | 1 041 | 403 | 187 | 619 | 7 198 | 2 810 | 11 585 |
| 1982 | 182.56 | 0.00 | 485.38 | 53.52 | 14.31 | 92.74 | 1 148 | 769 | 1 527 | 0 | 0 | 1 | 411 | 0 | 906 |
| 1983 | 325.21 | 111.26 | 539.16 | 51.70 | 26.90 | 76.50 | 486 | 310 | 661 | 1 406 | 0 | 3 256 | 8 240 | 0 | 17 624 |
| 1984 | 1 013.54 | 294.94 | 1 732.14 | 41.47 | 23.44 | 59.49 | 60 | 41 | 79 | 164 | 0 | 417 | 4 315 | 1 051 | 7 579 |
| 1985 | 18.54 | 0.00 | 37.58 | 60.44 | 36.74 | 84.14 | 377 | 160 | 593 | 27 127 | 7 198 | 47 056 | 1 119 | 0 | 2 256 |
| 1986 | 1.06 | 0.00 | 2.31 | 152.81 | 83.13 | 222.48 | 9 625 | 6 865 | 12 384 | 11 320 | 3 830 | 18 809 | 2 817 | 172 | 5 461 |
| 1987 | 0.86 | 0.00 | 1.89 | 49.61 | 32.59 | 66.64 | 1 116 | 582 | 1 651 | 10 388 | 0 | 24 129 | 103 | 44 | 162 |
| 1988 | 22.34 | 5.99 | 38.70 | 10.23 | 3.54 | 16.92 | 264 | 148 | 381 | 537 | 11 | 1 064 | 6 296 | 0 | 13 472 |
| 1989 | 1.95 | 0.00 | 4.05 | 2.50 | 0.71 | 4.29 | 233 | 127 | 339 | 304 | 0 | 652 | 23 058 | 3 134 | 42 981 |
| 1990 | 13.98 | 1.90 | 26.05 | 3.43 | 0.31 | 6.55 | 72 | 34 | 110 | 512 | 129 | 895 | 43 204 | 0 | 96 647 |
| 1991 | 4.73 | 2.35 | 7.12 | 4.34 | 0.00 | 8.98 | 111 | 65 | 157 | 83 453 | 38 143 | 128 762 | 54 034 | 0 | 155 162 |
| 1992 | 216.54 | 117.37 | 315.72 | 11.91 | 0.33 | 23.48 | 173 | 27 | 319 | 9 537 | 0 | 19 162 | 13 444 | 2 057 | 24 832 |
| 1993 | 496.36 | 0.00 | 1 235.57 | 5.87 | 2.17 | 9.57 | 68 | 29 | 106 | 17 646 | 4 610 | 30 682 | 11 174 | 1 846 | 20 502 |
| 1994 | 3.34 | 0.00 | 6.88 | 52.04 | 0.00 | 123.95 | 2 430 | 1 540 | 3 320 | 253 318 | 133 494 | 373 142 | 7 313 | 0 | 16 120 |
| 1995 | 228.98 | 99.59 | 358.36 | 24.67 | 7.19 | 42.15 | 347 | 57 | 638 | 0 | 0 | 0 | 37 | 3 | 71 |
| 1996 | 194.35 | 84.58 | 304.12 | 8.06 | 3.72 | 12.39 | 57 | 2 | 112 | 99 094 | 61 972 | 136 217 | 6 567 | 0 | 16 338 |
| 1997 | 107.68 | 50.43 | 164.93 | 6.67 | 3.69 | 9.65 | 130 | 59 | 201 | 43 601 | 23 893 | 63 309 | 10 282 | 831 | 19 732 |
| 1998 | 104.13 | 44.29 | 163.97 | 10.27 | 4.35 | 16.19 | 37 | 17 | 56 | 16 590 | 9 781 | 23 398 | 13 743 | 0 | 31 142 |
| 1999 | 179.02 | 88.64 | 269.40 | 21.87 | 12.71 | 31.04 | 142 | 1 | 283 | 174 810 | 111 485 | 238 135 | 4 179 | 670 | 7 688 |
| 2000 | 278.68 | 151.41 | 405.96 | 52.54 | 18.63 | 86.44 | 288 | 140 | 435 | 150 033 | 86 494 | 213 573 | 32 702 | 21 023 | 44 381 |
| 2001 | 27.48 | 0.00 | 61.59 | 69.46 | 14.40 | 124.52 | 104 | 0 | 220 | 0 | 0 | 0 | 21 989 | 0 | 48 328 |
| 2002 | 429.09 | 248.26 | 609.92 | 81.87 | 0.00 | 188.77 | 1 007 | 470 | 1 545 | 129 539 | 76 206 | 182 871 | 40 156 | 7 440 | 72 872 |
| 2003 | 464.52 | 0.00 | 1 098.79 | 18.76 | 0.00 | 40.25 | 158 | 83 | 232 | 14 428 | 7 600 | 21 257 | 3 652 | 262 | 7 041 |
| 2004 | 1 901.13 | 1 145.27 | 2 657.00 | 108.65 | 30.38 | 186.92 | 49 | 25 | 73 | 44 368 | 19 790 | 68 947 | 423 | 118 | 728 |

### 2.4. Length distributions

To minimize the chance of including older age groups in the analysis, maximum lengths were defined for each year and species. This was done by going through the survey reports and finding the maximum lengths from the length frequency tables. Most length data are also coded with age codes and all data that were coded older than 0-group were excluded from the analysis. Erroneous coding and coding that includes both 0-group and older fish will cause bias when the length distributions of 0- and 1-group overlap. Minimum length was set to one centimeter.

Another objective of the 0-group survey is to estimate the length distributions of the juveniles of the year. One way to do this is to use a variation of the ratio estimator, $\hat{R}$, of the mean length given by Cochran (1977):

$$\hat{R} = \frac{\sum_{s=1}^{n} y_s \bar{x}_s}{\sum_{s=1}^{n} y_s} \tag{13}$$

where ys is the sum of the densities estimated by equation (8) at station s, $\bar{x}_s$ is an estimate of the average length of fish at station s, and n is the number of stations where fish of the species in question were caught.

An estimate of population variance, $\sigma_x^2$, of lengths can be found by modification of the grouped sample variance (Bhattacharyya & Johnson, 1977):

$$\hat{\sigma}_x^2 = \frac{\sum_{s=1}^{n} \sum_{l} \rho_{s,l} (l - \hat{R})^2}{\sum_{s=1}^{n} \sum_{l} \rho_{s,l}} \tag{14}$$

where $\rho_{s,l}$ is the density of fish of length l at station s.

Mean lengths for these purposes are given in table 2.4 below.

**Table 2.4 Mean lengths (cm), no correction for catching efficiency**

| Year | Capelin | Cod | Haddock | Herring | Gr. halibut | Redfish | Saithe | Polar cod | LRD |
|---|---|---|---|---|---|---|---|---|---|
| 1980 | 3.85 | 5.68 | 6.97 | 5.11 | 3.63 | 3.54 | 3.41 | 3.61 | 3.30 |
| 1981 | 3.79 | 5.82 | 6.59 | 5.84 | 6.41 | 4.18 | | 3.35 | 3.54 |
| 1982 | 4.62 | 6.22 | 7.33 | 5.41 | 5.96 | 3.99 | 11.66 | 3.30 | 3.43 |
| 1983 | 4.66 | 7.68 | 8.86 | 7.98 | 6.26 | 4.34 | 12.17 | 3.33 | 3.57 |
| 1984 | 5.19 | 7.55 | 8.51 | 8.11 | 6.61 | 3.39 | 13.41 | 3.75 | 4.05 |
| 1985 | 5.15 | 7.35 | 8.37 | 8.12 | 6.14 | 4.12 | 10.54 | 7.11 | 3.40 |
| 1986 | 3.22 | 6.20 | 7.21 | 5.67 | 6.43 | 3.85 | 6.35 | 3.92 | 3.83 |
| 1987 | 3.75 | 5.38 | 5.59 | 4.75 | 6.21 | 2.96 | 5.13 | 3.74 | 3.63 |
| 1988 | 4.97 | 6.47 | 7.63 | 6.72 | 5.98 | 4.04 | 12.03 | 3.47 | 3.39 |
| 1989 | 4.50 | 7.75 | 8.12 | 7.69 | 6.69 | 3.82 | 4.74 | 3.25 | 3.53 |
| 1990 | 4.82 | 8.26 | 9.94 | 9.18 | 7.34 | 4.42 | 9.89 | 4.13 | 3.57 |
| 1991 | 5.35 | 7.99 | 8.25 | 8.06 | 7.39 | 3.67 | 10.01 | 3.66 | 3.61 |
| 1992 | 5.13 | 7.99 | 9.47 | 8.85 | 6.71 | 4.31 | 11.20 | 4.18 | 3.84 |
| 1993 | 4.87 | 8.16 | 10.05 | 7.37 | 5.22 | 3.18 | 9.56 | 3.99 | 3.35 |
| 1994 | 6.76 | 8.67 | 9.84 | 6.63 | 6.18 | 4.29 | 9.95 | 3.83 | 3.24 |
| 1995 | 4.53 | 8.88 | 10.13 | 6.37 | 6.33 | 4.08 | 9.54 | 4.04 | 3.86 |
| 1996 | 5.15 | 7.69 | 10.28 | 6.20 | 5.44 | 4.12 | 8.82 | 3.69 | 3.54 |
| 1997 | 4.43 | 7.12 | 8.76 | 6.22 | 6.12 | 3.95 | 7.29 | 3.54 | 3.09 |
| 1998 | 4.29 | 8.19 | 10.42 | 7.04 | 6.56 | 3.67 | 10.97 | 3.18 | 3.25 |
| 1999 | 4.72 | 8.81 | 10.42 | 9.05 | 6.33 | 3.17 | 11.31 | 3.34 | 3.45 |
| 2000 | 4.20 | 7.42 | 8.08 | 6.28 | 6.24 | 3.70 | 7.61 | 3.98 | 3.35 |
| 2001 | 3.82 | 6.93 | 10.01 | 5.86 | 6.21 | 3.17 | 10.54 | 3.43 | 3.17 |
| 2002 | 6.55 | 8.03 | 10.50 | 8.12 | 6.05 | 3.45 | 11.05 | 4.13 | 3.66 |
| 2003 | 4.31 | 6.80 | 8.13 | 7.67 | 6.62 | 2.54 | 4.38 | 4.10 | 3.37 |
| 2004 | 4.83 | 8.37 | 11.09 | 7.66 | 6.01 | 3.57 | 8.56 | 4.12 | 4.10 |

## 3. Bottom fish survey (joint materials)

The weather and ice conditions were favourable during most parts of the survey, and consequently, an almost total coverage of the Barents Sea by a regular and dense grid of bottom trawl stations was achieved. The survey design has been used as for bottom fish survey in recent years, running east-west courses starting in the south.

The main distribution area of target species was surveyed with course lines 30-40 nautical miles apart. Bottom trawl hauls were executed every 35-40 miles. All participating vessels used a Campelen trawl. "Smolensk" and "F. Nansen" surveyed the eastern and central parts of the Barents Sea whereas "Johan Hjort" and "Jan Mayen" surveyed the western, north-western and central parts. Altogether, about 19000 nautical miles of survey tracks were made. This represents a 10% increase from 2003.

In total, the Norwegian vessels carried out 519 trawl hauls and the Russian vessels carried out 481 trawl hauls, so in total 1000 hauls were made during the survey.

### 3.1. Biological sampling of main bottom species during survey

(Length measurements include 0-group samples)

| Species | Norwegian vessels | Russian vessels | Sum |
|---|---|---|---|
| Cod | | | |
| No of samples | 446 | 324 | 770 |
| Nos. length measured | 16935 | 18233 | 35168 |
| Nos. aged | 1451 | 1308 | 2759 |
| Haddock | | | |
| No of samples | 324 | 113 | 437 |
| Nos. length measured | 12601 | 7857 | 20458 |
| Nos. aged | 390 | 391 | 782 |
| Redfish (Sebastes marinus) | | | |
| No of samples | 43 | 15 | 58 |
| Nos. length measured | 210 | 46 | 256 |
| Nos. taken for age | 109 | 12* | 121 |
| Redfish (Sebastes mentella) | | | |
| No of samples | 79 | 60 | 139 |
| Nos. length measured | 3057 | 1472 | 4529 |
| Nos. taken for age | 388 | 139* | 527 |
| Saithe | | | |
| No of samples | 119 | 119 | 238 |
| Nos. length measured | 1400 | 3151 | 4551 |
| Nos. taken for age | - | 23* | 23 |
| Greenland halibut | | | |
| No of samples | 377 | 157 | 534 |
| Nos. length measured | 7068 | 9414 | 16482 |
| Nos. taken for age | 719 | 600* | 1319 |
| Catfish (Anarhichas lupus) | | | |
| No of samples | 52 | 53 | 105 |
| Nos. length measured | 448 | 509 | 957 |
| Spotted catfish (Anarhichas minor) | | | |
| No of samples | 63 | 45 | 108 |
| Nos. length measured | 147 | 145 | 292 |
| Jelly catfish (Anarhichas denticulatus) | | | |
| No of samples | 33 | 18 | 51 |
| Nos. length measured | 46 | 28 | 74 |
| Long rough dab | | | |
| No of samples | 260 | 273 | 533 |
| Nos. length measured | 7736 | 19070 | 26806 |

**Age readings were not fulfilled until publishing of this report.*

### 3.2. Computations of stock sizes

The computations of individual's number and biomass per length- and age groups of cod, haddock and Greenland halibut were calculated from bottom trawl catches using the "swept-area" method with a strata system developed at IMR. For other bottom species (redfish, catfish and long rough dab) assessment of total numbers were made by length groups only.

Acoustic registrations of bottom fish carried out along all cruise tracks, with division of $s_A$-values by species based on trawl catches data. These results were additionally used for mapping of cod and haddock distribution.

### 3.3. Swept area analysis of bottom fishes

Length based indices for each sub area was estimated using the method of (Jakobsen *et al.* 1997). For each trawl station and length, fish density was estimated by:

$$P_{s,l} = \frac{f_{s,l}}{a_{s,l}}, \tag{15}$$

where $P_{s,l}$ is the number of fish/n.m.$^2$ observed at station $s$ (length $l$)

$f_{s,l}$ is the estimated frequency of length $l$

$a_{s,l}$ is swept area given by

$$a_{s,l} = \frac{d_s * EW_l}{1852} \tag{16}$$

$d_s$ is towed distance (n.m.)

and

$EW_l$ is the length dependent effective swept width.

For Greenland halibut, redfish, long rough dab and the catfishes, there is no available estimate of the length dependent effective swept width, so it was set to 25 m, independent of fish length and trawl depth.

Based on (Dickson 1993a; Dickson 1993b), length dependent effective fishing width for cod and haddock was included in the calculations where EW was:

$$EW_l = \alpha * l^{\beta} \quad \text{for} \quad l_{\min} < l < l_{\max} \tag{17}$$

$$EW_l = EW_{l_{\min}} = \alpha * l_{\min}^{\beta} \quad \text{for} \quad l \le l_{\min} \tag{18}$$

$$EW_l = EW_{l_{\max}} = \alpha * l_{\max}^{\beta} \quad \text{for} \quad l \ge l_{\max} \tag{19}$$

The parameters used for cod and haddock are given in the text table:

| Species | $\alpha$ | $\beta$ | $l_{\min}$ | $l_{\max}$ |
|---|---|---|---|---|
| Cod | 5.91 | 0.43 | 15 cm | 62 cm |
| Haddock | 2.08 | 0.75 | 15 cm | 48 cm |

Point observations for fish density based on length (*l)* was summed up in 5 cm length groups denoted by $p_{s,l}$. Stratified abundance indices for each length group and strata were generated using

$$L_{p,l} = \frac{A_p}{S_p} * \sum P_{s,l} \tag{20}$$

where $L_{p,l}$ is the index for stratum $p$, length group $l$

$A_p$ area (n.m.$^2$) of stratum $p$

$S_p$ is the number of stations in stratum $p$

For each subarea, the total number of fish in each 5cm length group was estimated by summing over all strata in the sub area, and the total number of fish in each age group in the area was estimated using an age/length key. Finally, the total index for each length and age class is the sum of the values for all sub areas.

For each year, an age/length key was estimated for each stratum. All age samples for a stratum were used. Age samples from a length group was weighted by the index of the number of fish in the 5 cm length group within a stratum divided by the number of age samples in the length group:

$$w_{p,l} = \frac{L_{p,l}}{n_{p,l}} , \qquad (21)$$

where $n_{p,l}$ is the number of age samples in stratum *p* and length group *l*.

The proportion of age *a* at length *l* was estimated using

$$P_a^{(l)} = \frac{\sum_p n_{p,a,l} * w_{p,l}}{\sum_p n_{p,l} * w_{p,l}} , \qquad (22)$$

where $P_a^{(l)}$ is the weighted proportion of age *a* in length group *l* in stratum *p*, and $n_{p,a,l}$ is the number of age samples of age *a* in length group *l*.

The sum of the weighted factors in a sub area is the abundance index for the total number of fish in the sub area. The number of fish at age was estimated by:

$$N_a = \sum_p \sum_l L_{p,l} * P_a^{(l)} \qquad (23)$$

Average length and weight at age was estimated using (only shown for weight):

$$W_a = \frac{\sum_p \sum_l \sum_j W_{p,a,l,j} * w_{p,l}}{\sum_p \sum_l \sum_j w_{p,l}} , \qquad (24)$$

where $W_{p,a,l,j}$ is the weight for sample *j* in length group *l* in stratum *p* and age *a*.

### *3.4. Distribution and abundance of bottom fish (joint materials)*

#### Swept area assessment of bottom fishes (figs.3.4.1-3.4.3)

A new strata system was constructed covering the whole Barents Sea to include the total survey area. The new geographic system is also depth stratified using GEBCO depth data. Since this is the first total coverage of bottom fishes during this period, it is not possible to compare the indices to corresponding indices in previous years. However, for the species cod, haddock and Greenland halibut, there are indices from approximately the same period in earlier years, at least for some regions of the Barents Sea.

The old strata system for the Norwegian summer/autumn survey covered the southern and western Barents Sea where only the Spitsbergen area was depth stratified. Due to unpredictability in getting access to the Russian EEZ for Norwegian research vessels only the areas west of the Median line were covered after 1999 and the swept area analyses were run for this area. When comparing the new survey with the earlier the swept area analyses were run using the old strata system, and only stations within this area were included. In the tables, area I corresponds to the westernmost part of ICES area I, or strata 11-13 and 16 in the figure, area IIa corresponds to strata 14 and 15 and area IIb is strata 1-10. The tables for cod and haddock were made using this strata system.

The juvenile Greenland halibut survey has been conducted since 1996 and has been a joint Russian – Norwegian survey since 2000. This survey covered the main juvenile area north and east of Spitsbergen and in the first two years the area E-Frans Josef was not included. This strata system was also depth stratified. When comparing the Greenland halibut results between years this system was used.

**Cod** (tables 3.1, 3.2 and figs. 3.4.4, 3.4.5)

Estimation of Northeast Arctic cod by aged groups and regions showed in tables 3.1, 3.2. Main part of cod (73 %) distributed in region I ICES. Young cod distributed mainly in the central of the Barents Sea and large cod were found in eastern part and in Spitsbergen region. Total stock was observed as 1544.39 millions individuals.

**Haddock** (tables 3.3, 3.4 and figs. 3.4.6, 3.4.7)

The northeast arctic haddock stock was distributed in the southern and central parts of the Barents Sea, the larger fish had a more coastal distribution than smaller fish. Total index was observed as 790.7 millions individuals.

**Greenland halibut** (tables 3.5, 3.6 and figs. 3.4.8, 3.4.9)

The Greenland halibut had a wide distribution except from the easternmost areas. The young fish (less than 20 cm) was mainly found in the areas to the north and east of Spitsbergen. The age groups 1-3 were most abundant in the part of region I belonging to REEZ, while older fish was mainly found in the other parts of region I and in region IIb. The total index was estimated at 139 thousand individuals. This index is the highest obtained during the period 1996-2004, but it must be kept in mind that during 1996 and 1997 the REEZ was not covered, and in 2003 the investigations were hindered by severe ice conditions. The main adult area for this species, which is located along the slope between Norway and Spitsbergen at depths of 500 – 900 m, is not covered by this survey.

**Redfish** *(Sebastes marinus)* (table 3.7, figs. 3.4.10, 3.4.11)

This species was found in very scattered concentrations in the southern and western parts of the area. The total index was 12 thousand specimens.

**Deepwater Redfish** *(Sebastes mentella)* (table 3.8, figs. 3.4.12, 3.4.13)

This redfish species was mainly found in the western parts of the Barents Sea. While the fish larger than 20 cm was concentrated in the southern areas, the smaller fish were also found to the north and east of Spitsbergen. The total index was 316 thousand individuals.

**Catfish** *(Anarhichas lupus)* (table3.9, fig. 3.4.14)

The catfish was found in scattered concentrations in the central and southeastern part of the area, and in addition to the west and north of Spitsbergen. The total index was 12.5 million specimens.

**Spotted catfish** *(Anarhichas minor)* (table 3.10, fig. 3.4.15)

The spotted catfish had a similar distribution to the catfish. A total index of 13.5 million was estimated.

**Jelly catfish** *(Anarhichas denticulatus)* (table 3.11, fig. 3.4.16)

This species was most frequently encountered along an axis from southeast to northwest, but the density was low everywhere. A total index of 2.9 million individuals was obtained for the total area.

**Long rough dab** (table 3.12, fig. 3.4.17)

This species has a wide distribution in the total covered area, except from the northeastern part. The densest concentrations are found to the east of the island Hopen and southeastwards towards Cape Kanin and the island Kolguev. In total, the highest index was obtained in the part of region I belonging to REEZ, but the smaller length groups were most frequent in the NEEZ and the Spitsbergen area. A total index of 3.1 billion individuals was obtained.

**Table 3.1. Northeast Arctic cod. Bottom trawl indices (million individuals) pr region and age group during the ecosystem survey in autumn 2004**

| **Region** | Age | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12+ | |
| | | | | | | **I (NEEZ + SVA)** | | | | | | | |
| 2004 | 151.93 | 69.70 | 30.93 | 34.40 | 14.37 | 19.32 | 12.23 | 4.71 | 1.14 | 0.40 | 0.06 | 0.08 | 339.27 |
| | | | | | | **I (REEZ)** | | | | | | | |
| 2004 | 87.12 | 204.23 | 38.45 | 273.62 | 115.72 | 40.97 | 18.37 | 3.75 | 0.23 | 0.23 | 0.03 | 0.08 | 782.80 |
| | | | | | | **IIa** | | | | | | | |
| 2004 | 10.57 | 5.72 | 1.74 | 6.45 | 2.01 | 2.41 | 0.49 | 0.32 | 0.12 | - | - | - | 29.83 |
| | | | | | | **IIb** | | | | | | | |
| 2004 | 142.84 | 62.13 | 38.28 | 104.57 | 19.31 | 15.04 | 8.29 | 1.54 | 0.33 | 0.03 | 0.00 | 0.13 | 392.49 |
| | | | | | | **Total** | | | | | | | |
| 2004 | 392.46 | 341.78 | 109.40 | 419.04 | 151.41 | 77.74 | 39.38 | 10.32 | 1.82 | 0.66 | 0.09 | 0.29 | 1544.39 |

**Table 3.2. Northeast Arctic cod. Abundance indices (million individuals) pr region and age group from Norwegian Bottom Trawl survey in the Svalbard area summer-autumn 1995-2004**

| Region | Age | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12+ | |
| **I** | | | | | | | | | | | | | |
| 1995 | 191.02 | 34.99 | 63.23 | 88.03 | 26.33 | 10.81 | 6.11 | 0.74 | 0.42 | 0.17 | 0.14 | 0.19 | 422.18 |
| 1996 | 545.22 | 218.06 | 37.16 | 34.53 | 22.03 | 8.27 | 5.32 | 1.42 | 0.52 | 0.02 | 0.05 | 0.01 | 872.61 |
| 1997 | 403.98 | 285.31 | 89.58 | 16.60 | 12.68 | 14.08 | 10.77 | 4.86 | 0.62 | 0.11 | 0.06 | 0.12 | 838.77 |
| 1998 | 357.55 | 126.39 | 91.54 | 19.38 | 3.74 | 2.58 | 3.28 | 2.03 | 0.33 | 0.05 | - | 0.02 | 606.89 |
| 1999 | 87.73 | 91.44 | 57.64 | 31.12 | 8.09 | 1.34 | 1.09 | 0.89 | 0.19 | 0.13 | - | - | 279.66 |
| 2000 | 26.36 | 50.06 | 73.27 | 27.90 | 15.25 | 5.58 | 0.87 | 0.53 | 0.33 | 0.10 | 0.02 | 0.03 | 200.30 |
| 2001 | 212.00 | 16.03 | 14.65 | 9.47 | 4.89 | 2.92 | 1.51 | - | - | - | 0.16 | - | 261.63 |
| 2002 | 12.91 | 57.76 | 15.93 | 11.56 | 11.00 | 7.43 | 8.52 | 1.13 | 0.35 | - | 0.08 | - | 126.67 |
| 2003 | 77.90 | 16.39 | 72.19 | 6.87 | 5.87 | 5.15 | 3.32 | 2.20 | 0.46 | - | 0.03 | 0.06 | 190.44 |
| 2004 | 152.15 | 62.70 | 28.38 | 22.16 | 5.91 | 7.22 | 5.98 | 2.98 | 0.77 | 0.30 | 0.06 | 0.06 | 288.67 |
| **IIa** | | | | | | | | | | | | | |
| 1995 | 82.16 | 14.80 | 5.16 | 9.15 | 12.25 | 4.04 | 1.02 | 0.41 | - | - | - | - | 128.99 |
| 1996 | 221.77 | 31.52 | 9.31 | 16.11 | 17.13 | 6.12 | 2.38 | 0.48 | 0.03 | 0.03 | - | - | 304.88 |
| 1997 | 102.53 | 40.65 | 19.03 | 4.13 | 4.48 | 5.46 | 2.56 | 0.56 | 0.41 | 0.09 | 0.12 | - | 180.02 |
| 1998 | 292.99 | 58.68 | 34.22 | 21.44 | 5.77 | 3.55 | 1.44 | 0.45 | 0.52 | - | 0.13 | - | 419.19 |
| 1999 | 7.43 | 3.93 | 1.44 | 8.37 | 6.36 | 1.40 | 0.17 | 0.33 | 0.17 | - | - | - | 29.60 |
| 2000 | 7.83 | 10.09 | 16.20 | 18.15 | 15.33 | 6.51 | 0.90 | 0.24 | 0.06 | 0.03 | 0.08 | 0.07 | 75.49 |
| 2001 | 31.23 | 5.55 | 8.31 | 11.78 | 8.87 | 2.99 | 1.42 | 0.12 | 0.08 | - | - | - | 70.35 |
| 2002 | 0.47 | 9.43 | 4.73 | 11.29 | 10.69 | 5.17 | 2.62 | 0.70 | 0.11 | - | - | 0.11 | 45.32 |
| 2003 | 8.94 | 2.39 | 13.47 | 7.66 | 8.81 | 7.14 | 2.92 | 1.41 | 0.66 | - | - | - | 53.40 |
| 2004 | 10.51 | 7.48 | 3.71 | 8.29 | 3.18 | 3.53 | 0.77 | 0.39 | 0.14 | - | - | - | 38.00 |
| **IIb** | | | | | | | | | | | | | |
| 1995 | 472.94 | 66.72 | 108.28 | 81.14 | 67.42 | 32.53 | 10.94 | 2.63 | 0.53 | 0.33 | 0.02 | 0.27 | 843.75 |
| 1996 | 547.82 | 191.34 | 58.43 | 37.20 | 34.21 | 31.18 | 17.32 | 2.27 | 0.38 | 0.09 | 0.15 | 0.2 | 920.59 |
| 1997 | 238.78 | 225.73 | 55.19 | 17.59 | 9.87 | 9.95 | 6.77 | 2.02 | 0.32 | 0.01 | 0.01 | 0.04 | 566.28 |
| 1998 | 190.41 | 238.16 | 173.49 | 64.05 | 17.64 | 8.48 | 5.83 | 2.79 | 0.53 | - | - | - | 701.38 |
| 1999 | 105.01 | 179.18 | 132.16 | 106.15 | 20.84 | 3.96 | 3.89 | 2.08 | 0.43 | - | - | 0.01 | 553.71 |
| 2000 | 30.28 | 121.30 | 130.94 | 52.47 | 43.46 | 9.62 | 0.91 | 1.37 | 0.28 | - | - | 0.04 | 390.67 |
| 2001 | 75.80 | 20.73 | 39.59 | 28.38 | 15.35 | 18.25 | 3.80 | 0.55 | 0.12 | - | - | 0.03 | 202.60 |
| 2002 | 6.64 | 80.49 | 28.56 | 18.54 | 17.20 | 6.81 | 3.39 | 0.52 | 0.03 | 0.05 | - | - | 162.23 |
| 2003 | 45.45 | 12.27 | 63.54 | 25.22 | 24.62 | 31.22 | 10.40 | 4.32 | 1.14 | 0.05 | - | - | 218.23 |
| 2004 | 122.54 | 71.81 | 35.24 | 82.57 | 15.73 | 11.97 | 5.61 | 0.76 | 0.49 | 0.05 | - | 0.1 | 346.87 |
| **Total** | | | | | | | | | | | | | |
| 1995 | 746.12 | 116.51 | 176.67 | 178.32 | 106.00 | 47.38 | 18.07 | 3.78 | 0.95 | 0.50 | 0.16 | 0.46 | 1394.92 |
| 1996 | 1314.81 | 440.92 | 104.90 | 87.84 | 73.37 | 45.57 | 25.02 | 4.17 | 0.93 | 0.14 | 0.20 | 0.21 | 2098.08 |
| 1997 | 745.29 | 551.69 | 163.80 | 38.32 | 27.03 | 29.49 | 20.10 | 7.44 | 1.35 | 0.21 | 0.19 | 0.16 | 1585.07 |
| 1998 | 840.95 | 423.23 | 299.25 | 104.87 | 27.15 | 14.61 | 10.55 | 5.27 | 1.38 | 0.05 | 0.13 | 0.02 | 1727.46 |
| 1999 | 200.17 | 274.55 | 191.24 | 145.64 | 35.29 | 6.70 | 5.15 | 3.30 | 0.79 | 0.13 | 0.00 | 0.01 | 862.97 |
| 2000 | 64.47 | 181.45 | 220.41 | 98.52 | 74.04 | 21.71 | 2.68 | 2.14 | 0.67 | 0.13 | 0.10 | 0.14 | 666.46 |
| 2001 | 319.03 | 42.31 | 62.55 | 49.63 | 29.11 | 24.16 | 6.73 | 0.67 | 0.20 | 0.00 | 0.16 | 0.03 | 534.58 |
| 2002 | 20.02 | 147.68 | 49.22 | 41.39 | 38.89 | 19.41 | 14.53 | 2.35 | 0.49 | 0.05 | 0.08 | 0.11 | 334.22 |
| 2003 | 132.29 | 31.05 | 149.20 | 39.75 | 39.30 | 43.51 | 16.64 | 7.93 | 2.26 | 0.05 | 0.03 | 0.06 | 462.07 |
| 2004 | 285.20 | 141.99 | 67.33 | 113.02 | 24.82 | 22.72 | 12.36 | 4.13 | 1.40 | 0.35 | 0.06 | 0.16 | 673.54 |

**Table 3.3. Northeast Arctic haddock. Bottom trawl indices (million individuals) pr region and age group during the ecosystem survey in autumn 2004**

| **Region** | Age | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12+ | Total |
| | | | | | | **I (NEEZ + SVA)** | | | | | | | |
| 2004 | 23.92 | 35.99 | 12.84 | 3.65 | 3.38 | 3.79 | 0.22 | 0.36 | - | - | - | - | 84.15 |
| | | | | | | **I (REEZ)** | | | | | | | |
| 2004 | 35.54 | 150.85 | 142.23 | 71.15 | 73.47 | 20.11 | 1.57 | 0.34 | 0.00 | 0.13 | - | 0.25 | 495.64 |
| | | | | | | **IIa** | | | | | | | |
| 2004 | 70.99 | 73.76 | 10.33 | 4.61 | 3.39 | 4.98 | 0.30 | 0.80 | - | - | - | 0.04 | 169.20 |
| | | | | | | **IIb** | | | | | | | |
| 2004 | 24.29 | 5.89 | 2.19 | 1.50 | 3.64 | 2.97 | 0.11 | 1.12 | - | - | - | - | 41.71 |
| | | | | | | **Total** | | | | | | | |
| 2004 | 154.74 | 266.49 | 167.59 | 80.91 | 83.88 | 31.85 | 2.20 | 2.62 | 0.00 | 0.13 | 0.00 | 0.29 | 790.70 |

**Table 3.4. Northeast Arctic haddock. Abundance indices (million individuals) pr region and age group from Norwegian Bottom trawl survey in the Svalbard area summer-autumn 1995-2004**

| Region | Age | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12+ | |
| **I** | | | | | | | | | | | | | |
| 1995 | 54.19 | 20.14 | 3.14 | 5.47 | 9.35 | 1.34 | 0.12 | - | - | - | 0.06 | 0.06 | 93.87 |
| 1996 | 5.82 | 12.27 | 3.90 | 1.24 | 1.61 | 1.09 | 0.27 | - | - | - | - | - | 26.20 |
| 1997 | 27.17 | 3.06 | 5.13 | 0.52 | 0.17 | 0.26 | 0.24 | 0.01 | - | - | - | - | 36.56 |
| 1998 | 20.66 | 12.48 | 0.42 | 0.95 | 0.09 | - | 0.21 | 0.10 | 0.14 | - | - | - | 35.05 |
| 1999 | 126.29 | 8.72 | 8.09 | 1.67 | 1.30 | 0.41 | 0.02 | 0.27 | 0.17 | - | - | - | 146.94 |
| 2000 | 297.75 | 58.36 | 4.20 | 4.00 | 1.15 | 0.70 | 0.20 | 0.20 | 0.18 | 0.13 | - | 0.02 | 366.89 |
| 2001 | 34.22 | 30.53 | 10.25 | 0.86 | 3.30 | 0.98 | 0.14 | - | - | - | - | - | 80.28 |
| 2002 | 36.82 | 16.05 | 5.83 | 1.05 | 0.41 | 0.72 | 0.15 | 0.05 | - | - | - | - | 61.08 |
| 2003 | 29.21 | 6.38 | 2.29 | 4.83 | 8.66 | 0.62 | 0.31 | - | - | - | - | - | 52.30 |
| 2004 | 22.96 | 31.81 | 11.77 | 3.09 | 3.02 | 2.66 | 0.09 | 0.25 | - | - | - | - | 75.65 |
| **IIa** | | | | | | | | | | | | | |
| 1995 | 298.24 | 100.29 | 14.20 | 9.60 | 14.22 | 2.59 | - | - | 0.05 | - | - | 0.07 | 439.26 |
| 1996 | 26.36 | 46.64 | 15.83 | 4.18 | 4.63 | 3.73 | 0.96 | 0.11 | 0.19 | - | 0.05 | - | 102.68 |
| 1997 | 324.80 | 36.11 | 39.99 | 13.85 | 2.12 | 2.18 | 7.40 | 0.70 | 0.03 | - | 0.36 | 0.07 | 427.61 |
| 1998 | 254.89 | 133.38 | 9.83 | 5.75 | 0.85 | 0.19 | 0.54 | 0.78 | 0.21 | - | 0.04 | - | 406.46 |
| 1999 | 66.36 | 4.09 | 1.06 | - | - | - | - | - | - | - | - | - | 71.51 |
| 2000 | 398.25 | 100.20 | 4.81 | 6.77 | 1.00 | 1.15 | 0.31 | 0.04 | 0.28 | 0.23 | 0.21 | 0.09 | 513.34 |
| 2001 | 150.25 | 60.86 | 22.90 | 2.33 | 3.00 | 0.78 | 0.28 | 0.03 | - | 0.07 | - | 0.03 | 240.53 |
| 2002 | 156.86 | 33.68 | 13.20 | 2.90 | 1.61 | 2.29 | - | 0.09 | - | 0.06 | 0.15 | - | 210.84 |
| 2003 | 282.28 | 33.72 | 21.71 | 20.20 | 11.61 | 2.35 | 2.81 | 0.42 | 0.35 | 0.02 | - | - | 375.47 |
| 2004 | 94.98 | 94.98 | 16.55 | 6.22 | 4.59 | 6.07 | 0.61 | 1.25 | - | - | - | 0.06 | 225.31 |
| **IIb** | | | | | | | | | | | | | |
| 1995 | 12.63 | 2.38 | 0.38 | 1.93 | 7.57 | 2.87 | 1.27 | - | 0.03 | - | - | - | 29.06 |
| 1996 | 3.04 | 1.95 | 0.47 | 0.37 | 1.11 | 1.12 | 0.07 | 0.05 | - | - | 0.01 | - | 8.19 |
| 1997 | 3.96 | - | 0.46 | 0.15 | 0.29 | 0.51 | 1.29 | 0.33 | 0.10 | 0.02 | - | 0.01 | 7.12 |
| 1998 | 6.28 | 1.79 | 0.12 | 0.15 | 0.10 | - | 0.19 | 0.24 | 0.04 | - | - | - | 8.91 |
| 1999 | 71.35 | 1.20 | 1.37 | 0.38 | 0.65 | 0.41 | - | 0.28 | 0.58 | - | - | 0.01 | 76.23 |
| 2000 | 73.51 | 12.16 | 0.59 | 3.96 | 1.11 | 1.02 | 0.28 | 0.55 | 0.21 | 0.16 | 0.07 | 0.02 | 93.64 |
| 2001 | 75.72 | 13.99 | 23.63 | 2.23 | 8.78 | 1.21 | 3.41 | 0.19 | 0.10 | 0.20 | 0.02 | - | 129.48 |
| 2002 | 52.43 | 21.60 | 1.39 | 2.14 | 0.47 | 1.71 | - | - | 0.02 | - | - | - | 79.76 |
| 2003 | 57.11 | 9.85 | 1.25 | 1.01 | 2.06 | 0.20 | 0.22 | - | 0.02 | - | - | - | 71.72 |
| 2004 | 24.71 | 8.93 | 2.14 | 1.25 | 2.95 | 2.51 | 0.09 | 0.90 | - | - | - | - | 43.48 |
| **Total** | | | | | | | | | | | | | |
| 1995 | 365.06 | 122.81 | 17.72 | 17.00 | 31.14 | 6.80 | 1.39 | - | 0.08 | - | 0.06 | 0.13 | 562.19 |
| 1996 | 35.22 | 60.86 | 20.20 | 5.79 | 7.35 | 5.94 | 1.30 | 0.16 | 0.19 | - | 0.06 | - | 137.07 |
| 1997 | 355.93 | 39.17 | 45.58 | 14.52 | 2.58 | 2.95 | 8.93 | 1.04 | 0.13 | 0.02 | 0.36 | 0.08 | 471.29 |
| 1998 | 281.83 | 147.65 | 10.37 | 6.85 | 1.04 | 0.19 | 0.94 | 1.12 | 0.39 | - | 0.04 | - | 450.42 |
| 1999 | 264.00 | 14.01 | 10.52 | 2.05 | 1.95 | 0.82 | 0.02 | 0.55 | 0.75 | - | - | 0.01 | 294.68 |
| 2000 | 769.51 | 170.72 | 9.60 | 14.73 | 3.26 | 2.87 | 0.79 | 0.79 | 0.67 | 0.52 | 0.28 | 0.13 | 973.87 |
| 2001 | 260.19 | 105.38 | 56.78 | 5.42 | 15.08 | 2.97 | 3.83 | 0.22 | 0.10 | 0.27 | 0.02 | 0.03 | 450.29 |
| 2002 | 246.11 | 71.33 | 20.42 | 6.09 | 2.49 | 4.72 | 0.15 | 0.14 | 0.02 | 0.06 | 0.15 | - | 351.68 |
| 2003 | 368.60 | 49.95 | 25.25 | 26.04 | 22.33 | 3.17 | 3.34 | 0.42 | 0.37 | 0.02 | 0.00 | - | 499.49 |
| 2004 | 142.65 | 135.72 | 30.46 | 10.56 | 10.56 | 11.24 | 0.79 | 2.40 | 0.00 | 0.00 | 0.00 | 0.06 | 344.44 |

**Table 3.5. Greenland halibut. Bottom trawl indices (thousand individuals) pr region and age group during the ecosystem survey in autumn 2004.**

| **Region** | Age | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12+ | |
| | | | | | | **I (NEEZ + SVA)** | | | | | | | |
| 2004 | 2 912 | 8 501 | 11 392 | 2 165 | 1 344 | 765 | 1 490 | - | 262 | 24 | 20 | 56 | 28 931 |
| | | | | | | **I (REEZ)** | | | | | | | |
| 2004 | 8 342 | 25 230 | 37 546 | 3 434 | 212 | 1 005 | 129 | 32 | 78 | 90 | 75 | 100 | 76 273 |
| | | | | | | **IIa** | | | | | | | |
| 2004 | - | - | - | 120 | 278 | 451 | 1 661 | 589 | 373 | 57 | 182 | 153 | 3 864 |
| | | | | | | **IIb** | | | | | | | |
| 2004 | 5 259 | 3 828 | 6 784 | 3 503 | 3 171 | 2 917 | 1 979 | 747 | 490 | 333 | 211 | 404 | 29 627 |
| | | | | | | **Total** | | | | | | | |
| 2004 | 16 513 | 37 559 | 55 722 | 9 221 | 5 005 | 5 138 | 5 259 | 1 368 | 1 203 | 505 | 488 | 714 | 138 695 |

**Table 3.6. Greenland halibut. Bottom trawl indices (thousand individuals) by age group during autumn in the period 1996-2004**

| | Age | | | | | | Total |
|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6+ | |
| 1996[*] | 15 655 | 14 510 | 10 025 | 3 487 | 1 593 | 3 349 | 48 619 |
| 1997[*] | 3 415 | 15 271 | 14 140 | 2 803 | 403 | 434 | 36 466 |
| 1998 | 10 210 | 28 020 | 17 186 | 6 380 | 1 551 | 932 | 64 279 |
| 1999 | 7 514 | 16 159 | 8 045 | 3 067 | 2 401 | 954 | 38 140 |
| 2000 | 17 087 | 10 320 | 7 460 | 5 855 | 1 629 | 476 | 42 827 |
| 2001 | 24 603 | 19 302 | 5 444 | 3 497 | 1 440 | 786 | 55 072 |
| 2002 | 53 037 | 32 571 | 17 402 | 3 912 | 1 386 | 596 | 108 904 |
| 2003[**] | 31 220 | 22 103 | 4 404 | 2 275 | 959 | 507 | 61 468 |
| 2004 | 17 146 | 40 770 | 59 578 | 11 223 | 3 207 | 1 239 | 133 165 |

**Table 3.7. Sebastes marinus. Bottom trawl indices (thousand individuals) pr region and length group during the ecosystem survey in autumn 2004**

| Region | Length group (cm) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 5.0-9.9 | 10.0-14.9 | 15.0-19.9 | 20.0-24.9 | 25.0-29.9 | 30.0-34.9 | 35.0-39.9 | 40.0-44.9 | 45.0-49.9 | 50.0-54.9 | 55.0-59.9 | 60.0 + | Total |
| **I (NEEZ + SVA)** | | | | | | | | | | | | | |
| 2004 | - | - | 303 | 499 | 344 | 529 | 694 | 252 | 86 | 118 | 81 | - | 2 905 |
| **I (REEZ)** | | | | | | | | | | | | | |
| 2004 | - | - | 187 | 88 | 274 | 841 | 184 | 48 | - | - | - | - | 1 621 |
| **IIa** | | | | | | | | | | | | | |
| 2004 | - | 102 | 228 | 324 | 573 | 790 | 806 | 1 132 | 682 | 110 | - | 264 | 5 010 |
| **IIb** | | | | | | | | | | | | | |
| 2004 | - | 4 | 7 | 67 | 537 | 761 | 528 | 428 | 115 | 12 | 5 | - | 2 464 |
| **Total** | | | | | | | | | | | | | |
| 2004 | 0 | 106 | 725 | 978 | 1 727 | 2 921 | 2 211 | 1 859 | 882 | 240 | 86 | 264 | 12 000 |

**Table 3.8. Sebastes mentella. Bottom trawl indices (thousand individuals ) pr region and length group during the ecosystem survey in autumn 2004**

| Region | Length group (cm) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 5.0-9.9 | 10.0-14.9 | 15.0-19.9 | 20.0-24.9 | 25.0-29.9 | 30.0-34.9 | 35.0-39.9 | 40.0-44.9 | 45.0-49.9 | 50.0-54.9 | 55.0-59.9 | 60.0 + | Total |
| **I (NEEZ + SVA)** | | | | | | | | | | | | | |
| 2004 | 320 | 2 677 | 2 669 | 6 047 | 4 356 | 3 525 | 1 842 | 200 | | | | | 21 637 |
| **I (REEZ)** | | | | | | | | | | | | | |
| 2004 | 99 | 6 843 | 2 933 | 89 | 60 | 0 | 68 | 57 | | | | | 10 148 |
| **IIa** | | | | | | | | | | | | | |
| 2004 | 320 | 2 672 | 1 947 | 4 887 | 18 938 | 117 894 | 47 773 | 1 613 | | | | | 196 045 |
| **IIb** | | | | | | | | | | | | | |
| 2004 | 1 707 | 7 024 | 8 256 | 3 468 | 7 809 | 32 137 | 27 168 | 1 329 | 18 | | | | 88 915 |
| **Total** | | | | | | | | | | | | | |
| 2004 | 2 446 | 19 216 | 15 805 | 14 491 | 31 163 | 153 556 | 76 851 | 3 199 | 18 | 0 | 0 | 0 | 316 745 |

**Table 3.9. Catfish. Bottom trawl indices (thousand individuals) pr region and length group during the ecosystem survey in autumn 2004**

| Region | Length group (cm) | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 10.0-14.9 | 15.0-19.9 | 20.0-24.9 | 25.0-29.9 | 30.0-34.9 | 35.0-39.9 | 40.0-44.9 | 45.0-49.9 | 50.0-54.9 | 55.0-59.9 | 60.0-64.9 | 65.0-69.9 | 70.0-74.9 | 75.0-79.9 | 80.0-84.9 | 85.0-89.9 | 90.0-94.9 | 95.0-99.9 | 100.0-104.9 | 105.0-109.9 | 110.0-114.9 | 115.0-119.9 | 120 + | Total |
| **I (NEEZ + SVA)** | | | | | | | | | | | | | | | | | | | | | | | | |
| 2004 | | | 24 | | | | | 116 | 27 | | | | 17 | | 17 | 30 | 30 | 41 | | | | | | 301 |
| **I (REEZ)** | | | | | | | | | | | | | | | | | | | | | | | | |
| 2004 | | | | | | | 60 | | 39 | 530 | 343 | 765 | 592 | 550 | 153 | 462 | 39 | | 160 | 51 | | | | 3 744 |
| **IIa** | | | | | | | | | | | | | | | | | | | | | | | | |
| 2004 | 958 | 350 | 124 | 243 | 247 | | | | | | 101 | 101 | | | | | | | | | | | | 2 124 |
| **IIb** | | | | | | | | | | | | | | | | | | | | | | | | |
| 2004 | 1 440 | 1 346 | 1 313 | 322 | 188 | 209 | 112 | 66 | 257 | 670 | 256 | 185 | | | | 4 | | | | | | | | 6 366 |
| **Total** | | | | | | | | | | | | | | | | | | | | | | | | |
| 2004 | 2 398 | 1 695 | 1 461 | 565 | 436 | 209 | 172 | 182 | 322 | 1 200 | 700 | 1 051 | 609 | 550 | 170 | 496 | 69 | 41 | 160 | 51 | | | | 12 536 |

**Table 3.10. Spotted catfish. Bottom trawl indices (thousand individuals) pr region and length group during the ecosystem survey in autumn 2004**

| Region | Length group (cm) | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 10.0-14.9 | 15.0-19.9 | 20.0-24.9 | 25.0-29.9 | 30.0-34.9 | 35.0-39.9 | 40.0-44.9 | 45.0-49.9 | 50.0-54.9 | 55.0-59.9 | 60.0-64.9 | 65.0-69.9 | 70.0-74.9 | 75.0-79.9 | 80.0-84.9 | 85.0-89.9 | 90.0-94.9 | 95.0-99.9 | 100.0-104.9 | 105.0-109.9 | 110.0-114.9 | 115.0-119.9 | 120 + | Total |
| **I (NEEZ + SVA)** | | | | | | | | | | | | | | | | | | | | | | | | |
| 2004 | 902 | 81 | 223 | 303 | | 240 | 370 | 303 | 594 | 220 | 403 | 323 | | 127 | 190 | | | 41 | 170 | 17 | | | | 4 507 |
| **I (REEZ)** | | | | | | | | | | | | | | | | | | | | | | | | |
| 2004 | 35 | | | 44 | 287 | 153 | 241 | 483 | 436 | 582 | 644 | 267 | 51 | | | | | | | | | | | 3 223 |
| **IIa** | | | | | | | | | | | | | | | | | | | | | | | | |
| 2004 | | | | | | | | | | | | | | | | | | | | 88 | | | | 88 |
| **IIb** | | | | | | | | | | | | | | | | | | | | | | | | |
| 2004 | 699 | 746 | 958 | 358 | 263 | 346 | 150 | 57 | 632 | 614 | 22 | 494 | 261 | 39 | 7 | 72 | | | | | | | | 5 718 |
| **Total** | | | | | | | | | | | | | | | | | | | | | | | | |
| 2004 | 1 635 | 828 | 1 181 | 705 | 551 | 739 | 761 | 843 | 1 663 | 1 416 | 1 068 | 1 084 | 311 | 167 | 197 | 72 | | 41 | 170 | 105 | | | | 13 535 |

**Table 3.11. Jelly catfish. Bottom trawl indices (thousand individuals) pr region and length group during the ecosystem survey in autumn 2004**

| **Region** | Length group (cm) | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 10.0-14.9 | 15.0-19.9 | 20.0-24.9 | 25.0-29.9 | 30.0-34.9 | 35.0-39.9 | 40.0-44.9 | 45.0-49.9 | 50.0-54.9 | 55.0-59.9 | 60.0-64.9 | 65.0-69.9 | 70.0-74.9 | 75.0-79.9 | 80.0-84.9 | 85.0-89.9 | 90.0-94.9 | 95.0-99.9 | 100.0-104.9 | 105.0-109.9 | 110.0-114.9 | 115.0-119.9 | 120 + | Total |
| **I (NEEZ + SVA)** | | | | | | | | | | | | | | | | | | | | | | | | |
| 2004 | | | | | | | | | | | 103 | | | 74 | 144 | | 81 | 127 | | | 40 | | | 570 |
| **I (REEZ)** | | | | | | | | | | | | | | | | | | | | | | | | |
| 2004 | | | | 48 | | | | | | | | 7 | 48 | 42 | 223 | 133 | 151 | 217 | 186 | 41 | | 48 | | 1 144 |
| **IIa** | | | | | | | | | | | | | | | | | | | | | | | | |
| 2004 | | | | | | | | | | | | | | 63 | | | | | | | | | | 63 |
| **IIb** | | | | | | | | | | | | | | | | | | | | | | | | |
| 2004 | | | | | | | | | | 11 | 24 | 149 | 68 | 83 | | 46 | 54 | 271 | 40 | 86 | | 288 | 18 | 1 136 |
| **Total** | | | | | | | | | | | | | | | | | | | | | | | | |
| 2004 | | | | 48 | | | | | | 11 | 127 | 156 | 116 | 262 | 367 | 180 | 286 | 615 | 226 | 128 | 40 | 335 | 18 | 2 913 |

**Table 3.12. Long rough dab. Bottom trawl indices (million individuals) pr region and length group during the ecosystem survey in autumn 2004**

| Region | Length group (cm) | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 5.0-9.9 | 10.0-14.9 | 15.0-19.9 | 20.0-24.9 | 25.0-29.9 | 30.0-34.9 | 35.0-39.9 | 40.0-44.9 | 45.0-49.9 | 50.0-54.9 | 55.0-59.9 | 60.0 + | |
| **I (NEEZ + SVA)** | | | | | | | | | | | | | |
| 2004 | 109.18 | 378.14 | 160.51 | 110.10 | 107.34 | 60.34 | 40.57 | 23.41 | 1.90 | | | | 991.49 |
| **I (REEZ)** | | | | | | | | | | | | | |
| 2004 | 64.06 | 277.57 | 396.11 | 306.93 | 182.10 | 86.03 | 61.81 | 30.64 | 4.57 | | | | 1 409.81 |
| **IIa** | | | | | | | | | | | | | |
| 2004 | 1.03 | 7.81 | 8.41 | 9.38 | 21.68 | 12.08 | 1.63 | 0.52 | | | | | 62.53 |
| **IIb** | | | | | | | | | | | | | |
| 2004 | 63.32 | 161.07 | 116.33 | 93.17 | 96.80 | 64.26 | 29.44 | 7.04 | 0.93 | | | | 632.36 |
| **Total** | | | | | | | | | | | | | |
| 2004 | 237.59 | 824.57 | 681.37 | 519.58 | 407.92 | 222.71 | 133.46 | 61.61 | 7.40 | 0.00 | 0.00 | 0.00 | 3 096.20 |

# 4. Zooplankton investigations (joint materials)

Regular Russian investigations of plankton in the main feeding areas of capelin in the northern Barents Sea were carried out in summer/autumn 1982-1993. Institute of Marine Research started regular sampling of zooplankton in the Barents Sea in August-September 1986, but had already since 1979 conducted several cruises with plankton investigations at different times of the year. Since 2002 PINRO and IMR have had joint cruises for monitoring zooplankton in the Barents Sea in autumn. The Russian vessels covered mostly the eastern part whereas the Norwegian cruises were in the central and western parts of the Barents Sea. In addition, the standard sections Bjørnøya-Fugløya and Vardø-N (since 1991) are covered on average 6 and 4 times a year respectively. Besides, PINRO conducted regular plankton investigations in spring/summer 1952-1993 in the way of drift of the commercial fishes larvae in 7 sections of the Barents Sea.

Complete processing of the most materials (1982-1985, 1987, 1989, 1992, 2002-2003) was done: species composition, age structure, spatial and vertical distribution, as well as dependence of plankton distribution on oceanographic factors were discovered.

These investigations have provided information on zooplankton e.g. annual and regional variations in abundance, biomass and species composition to different research groups at IMR and PINRO. The results are presented in the annual report at IMR and also at ICES Northern Pelagic and Blue Whiting Fisheries and Arctic Fisheries Working Group meetings. One of main aims in future is to incorporate zooplankton information in the prognosis of capelin growth and other important fish species.

## *4.1. Materials and Methods (fig. 1.3)*

***Russian plankton sampling***

The Russian research vessels "F. Nansen" and "Smolensk" sampled plankton during the survey in the southeast and northeast of the Barents Sea, as well as in some standard sections. On board the first vessel, plankton was sampled by a standard Juday net (the inlet aperture diameter was 0.1 $m^2$ and net mesh size – 180 μm) at depths intervals 50-0, 100-50 and bottom-100 m. A part of samples were collected by the WP-2 net (the inlet aperture diameter – 0.25 $m^2$ and the insertion mesh size – 180 µm) at the depth of 50-0 m. However, by technical reasons sampling on board the second vessel ("Smolensk") was done not at certain horizons, but in the water column (50-0, 100-0, 200-0 and 400-0). In total, more than 500 samples of zooplankton were collected. A scheme of sampling is shown in figure 1.3.

The primary processing of the major part of plankton materials differed from the standard method of PINRO. It was caused by the necessity of more rapid presentation of data for identification of plankton materials on the Barents Sea in the whole. Compared to the previous years, when weighing of samples was carried out as far as the samples were processed, in 2004 the weighing was done in a short time on the material fixed by the 10-% solution of formalin. Under such conditions, the problem of quick weighing is topical in spite of the fact that it seems to be simple.

Samples were identified for further analysis of plankton materials and comparison with the Norwegian data. For that purpose, the following work has been carried out.

Weighing of samples was done in laboratory to determine plankton biomass (wet weight mg/$m^3$) both by some groups of organisms (*Copepoda*, *Hyperiidae*, *Euphausiidae*, *Chaetognatha* etc.) and in total. To compare the obtained biomasses with the Norwegian data, they were converted into dry weight and diminished five times in accordance to advice of Norwegian scientists (Skjoldal etc., 1987).

Biomass values were recalculated per 1 $m^2$ (g/$m^2$ of dry weight); the volume of the filtered water and interval of depths of fishing were taken into consideration.

***Norwegian plankton sampling***

Plankton samples are obtained by using WP2 and MOCNESS (Multiple Opening and Closing Net and Environmental Sensing System) plankton nets with 180 µm mesh size. The sampling depths in the Barents Sea for the WP2 are from bottom to 0 m and 100 to 0m. At most stations the MOCNESS nets are towed in oblique hauls from 300-200, 200-150, 150-100, 100-50, 50-25, and 25-0 m. The number of nets varies from about 3 to 8 according to the bottom depth. The zooplankton samples are usually separated into two halves. One half preserved in 4% formaldehyde is used for species identification. The second half is size fractionated on 180 µm, 1000 µm and 2000 µm sieves for dry weight measurements.

For each MOCNESS and WP2 profile, the biomass (mg/$m^3$ and g/$m^2$) and abundance of individuals (nos.$m^3$, nos.$m^2$) is calculated by using the depth interval and the volume of water filtered.

### 4.2. Results (tables 4.1, 4.2 & figs.4.2.1-4.2.6)

Quantitative processing of plankton (density of concentrations, species and age composition with the account of vertical distribution during 24 hours) was carried out by materials of certain samples collected by Juday and WP-2 nets.

Maps of distribution of biomasses in the Russian sector of research were created by data of both R/V "F. Nansen" (collected by Juday net in horizons 50-0 and 100-50 m and by WP-2 net in the layer 50-0 m; 378 samples in total) and R/V "Smolensk" (collected by Juday net at the northern stations in water columns 50-0, 100-0, 200-0 and 400-0 m; 68 samples).

Biomass values obtained during the Russian investigations by Juday net (fig. 4.2.1) and WP-2 (fig. 4.2.2) were compared to those obtained during the Norwegian investigations by MOCNESS plankton sampler and WP-2 net together (fig. 4.2.6a).

As it is seen, biomass values differ by fishing gear and areas. By Russian data, the lowest values were obtained by WP-2 net in the 50-0 m layer (fig. 4.2.2). By catches taken by this net at stations more to the south (to 73ºN), mean values of biomass in dry weight did not exceed 0.9-1.6 g/m$^2$ at fluctuations from 0.04 to 4.98. At station more to the north, mean biomasses increased gradually from 2.7 g/m$^2$ (74-75ºN) to 5.4 g/m$^2$ (76-78ºN).

Higher values are registered when using Juday net; in some cases they are close to data obtained in the Norwegian investigations by MOCNESS trawl and WP-2 net. By Norwegian data, biomasses of 6 g/m$^2$ and higher were found over vast areas north-west and north-east of Spitsbergen. By Russian data, biomasses 6 g m$^2$ and higher were also widely distributed, predominantly north of 78ºN (figs. 4.2.3-4.2.5), and maximal biomasses (to 20-34 g/m$^2$) were observed in the water column from the surface to the bottom (fig. 4.2.5). However, big fluctuations of biomasses at different horizons, especially in the layer 50-0 and 100-0 m (maximal values exceeded minimal 10-12 times), were registered that was probably connected with the vertical migrations of zooplankton. The least fluctuations of biomasses correspond to data obtained in the water column 0-bottom.

As a ratio between the main groups of zooplankton (% of weight) shows, biomass values in most cases were formed by Copepoda. However, the portion of this group was inconstant (table 4.1), the lowest values were observed at the southernmost stations (not more than 55 %). North of 77º N the portion of copepods sharply increased, but decreased at 79ºN when the concentrations of the other numerous groups, the Arctic species of *Hyperiidae, Themisto libellula* and *Chaetognatha* increased. At the same time, it should be mentioned that the catchability of these large plankton organisms in Juday net is quite low, and their actual concentrations are higher. This is proved by unusually high density of euphausid concentrations at some northern stations (77-79º N), registered by bottom nets (2,200-6,800 ind./m$^3$ in 2004, while only small numbers were found in catches by Juday net (table 4.1).

The problem of catchability of different fishing gear is an important topic. One of the possible reasons for the higher biomasses obtained in the Norwegian investigations is the use of the MOCNESS trawl, which has advantages over other plankton gear when fishing organisms of the largest size fraction, more than 2 000 µm (Gjøsæter et al., 2000). According to these authors, WP-2 net is on the contrary better for catching of the smallest zooplankton organisms (180-1 000 µm). Thus, an assessed number of organisms depend on the fishing gear used, and higher biomasses can result from fishing by the above mentioned trawl.

We also compared in detail some samples taken by Juday and WP-2 nets in 2003 and 2004 (table 4.2). Although the obtained data are not sufficient for final conclusions, they justify the evident tendency of predomination of young and especially older copepodites of the species *Calanus finmarchicus* in catches taken by Juday net (in the southern areas). These data reflect also daily dynamics of crustaceans distribution: by data of the first sample, taken during a day in the 100-0 m, concentrations were somewhat higher, and in the second sample (early in the morning in the bottom layers) they were minimal. And on the contrary, in the northern areas (higher than 78º N) in the upper layer on 18-19 September, young copepodites *C. finmarchicus* occurred in high quantity; especially high concentrations were registered at night time in catches by Juday net. In the northern areas, the Arctic species *Calanus glacialis*, stages from I to V, was also registered in high quantity, but the bulk consisted of young copepodites. Ratios between two common species, *C. finmarchicus* and *C. glacialis*, in the compared fishing gear varied with time. The first species was caught in the upper layer approximately in equal numbers during day and night, whereas maximal quantity of the second one was taken at night.

Interpretation of the quantitative results of fishing for mass concentrations of small copepods (*Oithona similes, Pseudocalanus minutus*) were not so simple. However, the conclusion can be similar to that for young copepodites *C. glacialis*.

It should be mentioned that in most cases, when biomasses obtained by Juday net constituted in dry weight 10 g/m$^2$ and higher, their values in wet weight did not exceed 700-830 mg/m$^3$, and rarely more than 1 000 mg/m$^3$ in wet weight. Due to existing views (Bogorov, 1974; Degtyareva et al., 1990), such a level of biomasses for the Barents Sea is considered to be quite high. Even in the Far East seas (the Okhotsk Sea and Bering Sea) with higher bioproductivity, biomasses in summer do not exceed 1,400-1,800 mg/m$^3$ (Volkov, 1996). Usually 8-10 species dominates in the biomass, of which euphausids and copepods take the first place in the Okhotsk Sea and *Chaetognatha* in the Bering Sea.

The discussed materials permit to conclude on the following. The preliminary results of the comparative analysis of zooplankton biomasses show different values for different fishing gear, justifies to conclude that they have different catchability, when fishing for various size groups of plankton. Considering results of the other researchers one can at the given stage only report about more or less successful catching of this or that size fraction by this or that fishing gear. Larger fraction (more than 2,000 μm) is better caught by the MOCNESS trawl, whereas the small one (180-1,000 μm) – by WP-2 net (Gjøsæter et al., 2000). The middle fraction is better caught by Juday net compared to WP-2, and small fraction (180-1 000 μm) is well caught by both fishing gear (our data). Conclusions concerning the latter two cases for Juday net coincide with data of the other authors (Volkov et al., 1980; Vinogradov and Shushkina, 1987). They propose to introduce coefficients of catchability: 1.5 for small fraction and 2 – for middle one; and with the increase of plankton organisms the coefficients grow to 3-5. At the same time, A. F. Volkov (1996) argues that the determination of catchability as regards large movable plankton organisms (hyperiidae, euphausids, chaetognaths) is inevitably limited by the expert assessment. It is necessary also to take into account the period of the day, it especially concerns the large fraction and it's most numerous groups euphausids and copepods.

As it follows from the brief review, it is impossible to create a universal plankton sampling gear with absolute or adequate catchability for various species. It probably is necessary to carry out in the nearest future (2005) sampling of hydrobiological materials in the Barents and Norwegian Seas by the unified method (horizons and time of fishing, adequate weighing) with further complete processing of samples, results of which will permit to clear up mechanisms of formation of biomasses and food base of fishes.

The zooplankton biomass based on combined data from WP2 and MOCNESS gave an average dry weight of 7,8 g/m$^2$ . Distribution of its densities is shown in figure 4.2.6a. Total distribution of zooplankton biomass collected by WP-2 presented in figure 4.2.6b for comparison. The biomass in 2004 was higher compared to 2001 (5,9 g/m$^2$ ) and 2003 (6,5 g/m$^2$). Possible reasons for large variations are the differences in advective transport, temperature conditions and predation pressure. 2004 was one of the warmest years recorded and with very high salinity values. The high temperatures may have lead to increasing growth rates of zooplankton. In addition, increased advection may also have lead to high zooplankton abundance in the Barents Sea. Another explanation for the high biomass observed in 2004 could be the low predation pressure from capelin. The capelin stock size has declined from about 3.5 million tonnes in 2001 to a very low level (ca 0.5 million tonnes) in 2004.

Based on the biomass information we have from 2004, the zooplankton production in 2005 is expected to be comparatively higher, providing good feeding conditions for capelin.

### *4.3. Zooplankton and capelin interactions (figs.4.2.7)*

In the Barents Sea ecosystem, capelin plays a very important role, on one hand as a major predator and on the other hand as a major prey. Capelin is the main predator on zooplankton, feeding mainly on copepods, krill and amphipods. The investigations in the Barents Sea have demonstrated a several fold variation in zooplankton biomass among years in the period 1979-2004 (fig. 4.2.7). The observations of low zooplankton abundance when the capelin stock is large is not surprising as capelin is the most important predator on zooplankton in the Barents Sea ecosystem and probably exploits most of the secondary production, during its feeding season (fig. 4.2.7). During periods when the capelin stock was at very low levels, the predation pressure on zooplankton was at a minimum, thus causing an increase in the zooplankton biomass. These observations seem to indicate strong interactions between capelin and zooplankton in the Barents Sea.

The recent years materials prove a dense relationship between capelin distribution and food availability.

In warm years, the favourable conditions of large fish feeding are registered, when they reach the northern boundaries of the feeding area; capelin fatness can be 11-12 %.

The latter one is connected with the fact that capelin consume in addition to the Atlantic species *C. finmarchicus* the Arctic copepods and *C. glacialis*, in particular, which is characterized by the heightened content of lipids.

As it is shown (Table 4.2), the abundance of this species in high latitudes is quite large, they develop there even in September that supports high food potential of the northern areas.

**Table 4.1 Ratio between the main systematic groups of plankton from various areas of the Barents Sea, % by weight**

| Position | | Systematic group | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Latitude | Longitude | Copepods | Chaetognatha | Hyperiids | Euphausids | Ctenophora | Jellyfish | Pteropoda *Clione limacina* | Pteropoda *Limacina helicina* | Other |
| 74º30-75º53 | 29º10-42º24 | 54.5 | 4.8 | 2.8 | 1.5 | 3.8 | 4.8 | 10.2 | 17.6 | 0.0 |
| 77º00-78º43 | 33º01-41º44 | 84.9 | 4.7 | 2.0 | 0.6 | 2.5 | 2.4 | 0.9 | 2.0 | 0.0 |
| 79º15-79º44 | 28º00-39º47 | 70.3 | 5.5 | 8.3 | 1.3 | 6.3 | 5.2 | 0.0 | 0.5 | 2.6 |
| 80º00-80º45 | 15º25-17º15 | 86.5 | 10.0 | 0.2 | 0.0 | 2.3 | 1.0 | 0.0 | 0.0 | 0.0 |
| 80º15-80º44 | 39º43-44º52 | 72.2 | 9.6 | 1.9 | 0.4 | 2.4 | 4.4 | 5.4 | 1.4 | 2.3 |
| 81º14-81º46 | 36º20-42º40 | 78.2 | 8.6 | 2.5 | 0.6 | 1.2 | 2.9 | 1.6 | 4.5 | 0.0 |

**Table 4.2 Composition of mass species of zooplankton in various fishing gear (Juday and WP-2 nets) in August/September 2003 and 2004, individuals per m$^3$**

| Species | 69°23′N, 34°32′E 0-100 m | | 72°15′N, 36°52′E 0-224 m | | 78°05′N, 48°00′E 0-52 m | | 78°30′N, 50°00′E 0-50 m | | 78°02′N, 50°58′E 0-50 m | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 26.08.2003 $13^{20}$ | | 10.09.2003 $05^{48}$ | | 18.09.2004 $01^{05}$ | | 19.09.2004 $14^{45}$ | | 18.09.2004 $10^{20}$ | |
| | WP-2 | Juday | WP-2 | Juday | WP-2 | Juday | WP-2 | Juday | WP-2 | Juday |
| *Nauplii Calanus* | 24 | 4 | 3 | 24 | 0 | 717 | 1105 | 1233 | 211 | 596 |
| *Calanus finmarchicus* | | | | | | | | | | |
| I | 39 | 5 | 3 | 25 | 250 | 1248 | 252 | 233 | 138 | 251 |
| II | 14 | 60 | 8 | 27 | 383 | 1173 | 350 | 204 | 57 | 158 |
| III | 6 | 14 | 3 | 27 | 125 | 438 | 3 | 58 | 49 | 37 |
| IV | 22 | 112 | 3 | 14 | 39 | 93 | 0.2 | 1.2 | 2 | 2 |
| V | 61 | 126 | 3 | 3 | 0 | 9 | 0 | 0 | 0.2 | 0.2 |
| VI♀ | 0 | 1 | 0.1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Calanus glacialis* | | | | | | | | | | |
| I | 0 | 0 | 0 | 0 | 512 | 1713 | 569 | 893 | 244 | 456 |
| II | 0 | 0 | 0 | 0 | 738 | 3073 | 1545 | 981 | 439 | 754 |
| III | 0 | 0 | 0 | 0 | 43 | 671 | 146 | 68 | 33 | 112 |
| IV | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| V | 0 | 0 | 0.5 | 1 | 6 | 1.5 | 0 | 0 | 0 | 0.6 |
| VI♀ | 0 | 0 | 0 | 0 | 0.2 | 0 | 0 | 0 | 0.2 | 0.4 |
| *Calanus hyperboreus* | | | | | | | | | | |
| *IV* | 0 | 0 | 0.1 | 1 | 0.2 | 0.4 | 0 | 0 | 0 | 0.4 |
| V | 0 | 0 | 0.2 | 0.1 | 0 | 0 | 0 | 0 | 0 | 0 |
| ♀ | 0 | 0 | 0.02 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pseudocalanus elongatus* | | | | | | | | | | |
| I-III | 6 | 9 | 13 | 129 | 469 | 1862 | 813 | 126 | 33 | 223 |
| IV-V | 43 | 1 | 45 | 33 | 781 | 3724 | 236 | 835 | 8 | 56 |
| ♀ | 0 | 0 | 0.01 | 0.1 | 1 | 19 | 0 | 0 | 0 | 0 |
| *Temora longicornis* | | | | | | | | | | |
| I-V | 18 | 28 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Acartia longiremis* | | | | | | | | | | |
| I-V | 106 | 56 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Species | 69°23′N, 34°32′E 0-100 m | | 72°15′N, 36°52′E 0-224 m | | 78°05′N, 48°00′E 0-52 m | | 78°30′N, 50°00′E 0-50 m | | 78°02′N, 50°58′E 0-50 m | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 26.08.2003 $13^{20}$ | | 10.09.2003 $05^{48}$ | | 18.09.2004 $01^{05}$ | | 19.09.2004 $14^{45}$ | | 18.09.2004 $10^{20}$ | |
| | WP-2 | Juday | WP-2 | Juday | WP-2 | Juday | WP-2 | Juday | WP-2 | Juday |
| ♀ | 14 | 33 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Oithona similis* | | | | | | | | | | |
| I-V | 751 | 512 | 345 | 436 | 0 | 0 | | 0 | 0 | 0 |
| ♀ | 386 | 186 | 145 | 170 | 0 | 0 | 610* | 485 | 0 | 0 |
| ♂ | 20 | 46 | 18 | 20 | 0 | 0 | | 97 | 0 | 0 |
| *Metridia Nauplii* | 0 | | 0 | 0 | 109 | 37 | 89 | 359 | 89 | 74 |
| I-II | 0 | 0 | 11 | 62 | 0 | 0 | 0 | 0 | 0 | 0 |
| III-IV | 0 | 0 | 5 | 25 | 125 | 242 | 0 | 0 | 0 | 0 |
| V-VI | 0 | 0 | 0 | 0 | 23 | 411 | 0 | 0 | 0 | 0 |
| *Limacina helicina* | 0 | 28 | 292 | 415 | 766 | 4022 | 235 | 359 | 122 | 326 |

*for all Stages.

### 4.4. Focus on future zooplankton investigations

Main aim in future is to incorporate zooplankton information in the prognosis of capelin growth and other important fish species. In order to achieve this, it is need to include the following tasks:

Coordination of Norwegian and Russian plankton investigations and exchange of data (common gear, sampling and a data base).

Analyze plankton samples from the Bjørnøya-Fugløya transect to species level. Starting up with 2004, but also historical samples should be worked up. Note that only very few samples are worked up at species levels in the Barents Sea except for krill and amphipods.

Consider possibilities of taking samples at other time of the year than autumn.

Use of other types of gear (e.g. krill trawl) for sampling of larger organisms as e.g larger krill, amphipods, shrimps) in addition to WP2 and MOCNESS.

The nearest tasks of joint research of PINRO and IMR are as follows:

- Continuation of works on unification of the used fishing gear. It is expedient for scientific groups of PINRO and IMR to use Juday and WP-2 nets, as well as their calibration, assessment of catchability relating to organisms of different size groups; weighing of plankton material with the use of more operative way of drying.

- Collection of materials on capelin feeding within the boundaries of survey zones of the Norwegian and Russian vessels with the subsequent processing of stomachs in PINRO by the agreed method.

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## 5. Sea mammals observations (joint and aircraft materials)

During summer/autumn 2004 the vessels' observations were carried out of sea mammals and birds on board of R/V "F. Nansen" (PINRO) and Norwegian R/V "J. Hjort" and of some Russian fishing vessels leased for expeditions. Parallel with vessels investigations, the complex aircraft study (transect airborne survey) of distribution of sea mammals and birds in the Barents Sea was performed onboard of the aircraft-laboratory AN-26 "Arktika". The aim of investigations was to study the distribution pattern of main studied species of sea mammals and birds over the Barents Sea in the investigated period, to determine a mechanism and reasons of distribution, and, if possible, to give qualitative assessment of sea mammals and birds number in the studied areas of the Barents Sea.

Total volume of performed airborne investigations is presented in table 5.1.

**Table 5.1. Total volume of works performed by PINRO during airborne surveys of sea mammals and birds in summer and autumn 2004**

| Flight periods | Flight areas | Transects length, $km^2$ | Accounted area | Total surveyed area, $km^2$ |
|---|---|---|---|---|
| 22.08-03.09.04 | Central and southern part of the Barents Sea and White Sea | 7440 | 2980 | 416 500 |
| 17.09-30.09.04 | North and northeast of the Barents Sea | 4900 | 1950 | 239 000 |
| Total | The Barents and White Seas | 12 340 | 4930 | 655 500 |

Complex fisheries/oceanographic airborne investigations in the central, southern and eastern parts of the Barents Sea carried out within the framework of the annual Russian-Norwegian vessels ecosystem survey of pelagic fish of the Barents Sea were performed in the period from 22.08.2004 to 03.09.2004. Total duration of research and applied air works constituted about 56 hours, during which the count and studying of distribution of sea mammals and birds were performed.

Similar investigations were continued in the period 17.09.2004-30.09.2004, and they covered northern and western areas of the Barents Sea, including the area adjacent to Spitsbergen archipelago and ice-edge zone. Total duration of airborne works constituted 26 hours.

Total area surveyed onboard of the aircraft in 2004 turned out to be somewhat less than the area surveyed during the similar works in 2003.

## 5.1. Methods of investigations

All the discussed airborne surveys were carried out by the basic transects oriented mostly in the latitude direction with not more than 30 nautical miles. Airborne investigations were being carried out at the altitude from 100 to 500 m in dependence on the lower border of nebulosity, presence and intensity of precipitations, as well as regime of the air sounding etc.

Visual survey was carried out by not less than two experienced, specially trained observers from starboard and port side through the convex blisters permitted to observe a wide vision range. Observers registered sea mammals and birds in the visual range of their boards, data were transmitted by means of the internal communication to the computer operator (of the board automated system), who registered them in the flight report with the note of time, flight altitude and position of each point of observation.

Observers of research vessels participating in the survey collected materials on distribution of sea mammals and birds parallel with airborne investigations. Vessels observations of sea mammals and birds were performed by the standard method. Only processed materials are briefly presented in the given chapter.

To get more qualitative and representative materials on distribution of sea mammals, data obtained during airborne works were combined with results of vessels observations carried out at the same time. Materials were also used, which were obtained during expeditions. Besides, the dependence between distribution of sea mammals and localization of food objects was being revealed on the basis of analysis of 0-fish survey in 2004 reflected in the report of R/V “Smolensk” on the cruise No. 54 from 06 August to 02 October.

## 5.2. Sea mammals observation results *(table 5.2 & figs.5.2.1-5.2.2)*

During the ecosystem survey, the species composition of sea mammals of the Barents Sea was determined concerning those species, which observers succeeded to identify quite certainly, by data of the vessel and aircraft and additional coastal observations (table 5.2).

**Table 5.2 Species composition of sea mammals of the Barents Sea in summer/autumn 2004, by data of the ecosystem survey**

| | |
|---|---|
| **Order of cetaceans *Cetacea*** | |
| Fin Whale | *Balaenoptera physalus* |
| Sei Whale | *Balaenoptera borealis* |
| Minke Whale | *Balaenoptera acutorostrata* |
| HumpbackWhale | *Megaptera novaeangliae* |
| Sperm Whale | *Physeter macrocephalus* |
| Killer Whale | *Orcinus orca* |
| Bottle-Nose Dolphin* | *Tursiops truncatus* |
| White-Beaked Dolphin | *Lagenorhynchus albirostris* |
| Common Dolphin | *Delphinus delphis* |
| Harbour Porpoise | *Phocona phocoena* |
| Pilot Whale | *Globicephala melaena* |
| White Whale | *Delphinapterus leucas* |
| **Order Pinnipedia**** | |
| Harp Seal | *Phoca groenlandica* |
| Ringed Seal | *Phoca hispida* |
| Bearded Seal | *Erignatus barbatus* |
| Grey Seal | *Halichoerus grypus* |
| Walrus | *Odobenus rosmarus* |
| **Order carnivores *Carnivora*** | |
| Polar Bear | U*rsus maritimus* |

** Registered only once during shore observations off the East Murman coast.*

*** Common seal Phoca vitulina, dwelling off the shore, was not revealed by the observers.*

Minke whale is the most frequent species of the large cetaceans; it is easily identified and, as a rule, the most frequent species in the Barents Sea. As for the frequency of occurrence, humpback whale is comparable with minke whale at present.

White-beaked dolphin is the most frequently occurred in the Barents Sea species among small cetaceans. White-beaked dolphins became the usual and, sometimes, mass species in the Barents Sea.

In August 2004, the dispersed concentrations of harp seal, and not so often more concentrated groups, were observed in the surveyed area of the Barents Sea. Seals were distributed mainly sporadically, as single individuals or small groups (2-4, sometime to 10 individuals). Big numbers of harp seal occurred in the area from 34ºE to 46ºE (the area of the Central Trench), where their presence in the zone 36º-41ºE and 44º-46ºE coincided partly with the food concentrations of dolphins. Animals in that area, under later obtained information, fed presumably on polar cod. Besides, two quite dense concentrations of harp seal were registered in the area of the West Trench (73º-74ºN and 75º-76ºN)(fig. 5.2.1).

In August, two dense concentrations of dolphins were observed in the Barents Sea: one of them was registered in the eastern part of the Central Trench and northern part of the Novaya Zemlya Shoal and the second one located in the Kopytov and Nordkyn Banks. Three more relatively dense concentrations of dolphins were in the area of the Central Bank, northwestern part of the Eastern Basin and more to the south, coinciding with similar groups of whales (fig. 5.2.1). The species composition of the registered concentrations consisted of white-beaked and common dolphins and harbor porpoises. It should be mentioned that white-beaked dolphin occurred over the entire surveyed area, whereas common dolphin was predominantly registered in the western part. Both species were registered as small groups, 3-10 animals mainly, sometimes up to 35 animals.

Several average groups of harbor porpoises were observed. Based on trawl-acoustic data once can assume that in the eastern part of the Barents Sea the registered dolphins were apparently feeding on polar cod, and in the western part – on herring.

Two quite dense concentrations of large cetaceans (minke whale and humpback whale, predominantly) were revealed in August: one was distributed on the Southern Slope of the Bear Bank (on capelin and herring), the second one in the area of the Kopytov and Nordkyn Banks (on herring). Minke whale species was presented by single individuals, and humpback whale – by single individuals or groups of to 10 animals. In the given period the presence of fin whales (2 records) and sperm whale (1 record) was registered in the surveyed area of the Barents Sea.

In September 2004 (period 17-30.09), a wide area of the northwestern Barents Sea (to 50º E) with spacious areas of ice with different density was surveyed from aboard the aircraft. Flight carried out in September over the northern and northwestern areas of the Barents Sea, as well as results of vessels' observations in the same period permitted to reveal the main concentrations of various species of sea mammals (fig. 5.2.2).

In the surveyed area, two large concentrations of dolphins (white-beaked dolphin, sometimes – common dolphin) were observed: one of them located in the area of the Franz Josef Land, the second one – on the Great Perseus Bank and Western Slope of the Bear Bank. One could say that white-beaked dolphin is at present the frequently occurred species in the Barents Sea.

Both concentrations of dolphins were probably connected with polar cod schools as showed information, which were got from vessels later. The schools consisted mainly of groups of to 10 animals. However, larger aggregations of dolphins (to 40-60 and even 200 animals) were registered as well (79.10º N 37.30º E). Besides, single individuals of white-beaked dolphins or small groups to 10 animals occurred over the entire area of the northern and northwestern areas of the Barents Sea.

Large concentrations of white whale of about 2 thousand individuals were registered in the northern part of the Great Perseus Bank. Large schools of white whales followed polar cod. In the Franz Josef Land area white whales were mainly occurring as single individuals or in groups from 2 to 5 animals.

In the northern part of the Barents Sea, in the area of ice edge, groups of migrating harp seals were registered. The main concentrations were observed in the area of the Great Perseus Bank and Franz Josef Land on the edge of drifting ice with groups from 2-5 to 40-90 animals. Single individuals and groups to 10-20 animals were revealed in the area of the Cape Zhelaniya and the Admiralty Peninsula (the Novaya Zemlya archipelago). Together with harp seal in the area of the Cape Zhelaniya, bearded seal was observed. Along with seals in the area of the ice edge two polar bears were registered.

According to observations, cetaceans and pinnipeds were widely distributed in the current year over the entire surveyed area. Concentrating of sea mammals (humpback whales and dolphins) at sites of food objects aggregation was more dense and prolonged than in 2003. Against the background of low capelin abundance and absence of their dense schools, large groups of sea mammals concentrated mainly at schools of polar cod and herring. Some rare species for this area (pilot whale, sei whale, fin whale, sperm whale and bottle-nose dolphin), were registered more frequently than before.

An increase in the number of registered minke whales was found. The most interesting feature is the availability of large summer concentrations of minke whale in the coastal zone of the Murman coast and a rare fact of minke whales entering into the White Sea (the Kandalaksha Bay). Humpback whales are being observed for a series of years approximately in the same areas of the Barents Sea (in the area of the Cape Zhelaniya and on the Great Perseus Bank). There are reasons to suppose that this species number will increase.

Some attempts to quantify the number of sea mammals based on the observations must be considered preliminary. The reason is both imperfect mathematical methods and insufficient density of transects of fulfilled aircraft surveys.

A character of the revealed distribution of sea mammals in summer/autumn in the Barents Sea is probably a consequence of the influence of both warming (earlier spring migration) and decrease of food base (capelin). It should be mentioned that in 2004, there was the first time recording of early-spring (April) grouping of white-beaked dolphins (total number is 4-5 individuals) in the central part of the Barents Sea above the areas of wintering concentrations of capelin. Migrations of cetaceans in the Barents Sea became more prolonged both in time of presence in the sea and distance.

# 6. Sea birds investigations

Main species in the studies of distribution and abundance of sea birds undertaken from research aircraft An-26 “Arktika” were the two most numerous and widely spread – black-legged kittiwake (*Rissa tridactyla*) and northern fulmar (*Fulmarus glacialis*). A large number of these birds in the area and a rather small percent of underestimated by the aerial survey allow to derive relatively accurate estimates of abundance of these species. Nearly permanent occurrence of these birds along transects during aerial surveys makes it possible to build their distribution fields suitable for deriving averaged estimates of their abundance.

## *6.1. Methodology for estimating the abundance of birds on the basis of data from aerial surveys (fig.6.1.1)*

In surveys of marine mammals and sea birds flights are performed along pre-agreed parallel tracks with the spacing of 15 to 30 miles between them. In this connection the question arises of how the survey data can be converted to be suitable for estimating the abundance in a given area. This is achieved by averaging the counts from both aircrafts. To this end a special processing module was developed on the basis of GIS ArcView 3.1. The intention with this module was to derive density estimates for some sea bird species most plentiful in a given area. The following factors were taken into consideration in estimating the density:

1. flight altitude, which, in the first place, influences the width of a visual strip and hence coverage at a given point;
2. distance between consecutive counts, which depends on the speed of an aircraft and also impacts on the coverage in an aerial survey;
3. observing aircraft, it is either a concrete observation aircraft, which is selected (in case when there are no data available from another aircraft or they are for some reasons unrepresentative), or both observation aircrafts;

4. area of data averaging (1 $km^2$ or 10 $km^2$);
5. surveyed species (most plentiful species of sea birds).

Figure 6.1.1 presents an outline of primary data collection in an aerial survey, summing up and averaging the data by area based on the conditions specified above.

Then, estimates of the density distribution of sea birds can be derived in the following way:

$$S_i = D_i \times L_i \text{ - a single area surveyed;} \qquad (25)$$

if we introduce $N_i$ to denote the number of sea birds observed per time unit in area $S_i$, the distribution density per unit area or area of averaging for estimating the density (1 $km^2$ or 10 $km^2$) can be expressed as follows:

$$S_{Pi} = \sum_{i=1}^{P} S_i \, ; \qquad (26)$$

Then after averaging by area $S_{Pi}$ the distribution density of the surveyed species, e.g. density of sea birds in the averaging area less than established (1 $km^2$ or 10 $km^2$) is:

$$N_{Pi} = \sum_{i=1}^{P} S_i \times N_i \, ; \qquad (27)$$

To estimate densities along survey transects, corresponding to the averaging interval, $N_{Pi}$ should be multiplied by $J_k$:

$$J_k = \frac{S_{Pi}}{S_B} \, , \qquad (28)$$

where: $S_B$ – the area of data averaging;

$N_k = N_{Pi} \, x \, J_k$ – distribution density of a concrete species of sea birds in the area of averaging.

In preliminary tests of this method assessment of sea bird abundance, results of calculations for different averaging areas, 1 $km^2$ or 10 $km^2$, were tested. The results have shown that averaging by 1 $km^2$ provides abundance estimates of poorer quality as the distribution of density points along flight transects is less even because of a rather large distance between survey tacks. Therefore we decided to use the area of 10 $km^2$ for averaging the data from aerial surveys. When doing this way data from aerial survey are found at regular grid points owing to a constant distance between tacks and averaging of data along the flight transects, which is required for interpolation of data by computer methods. Distribution density data for a concrete species from all flights performed within a limited time interval in a given area are interpolated into GIS by IWD (Inversely Weighted Distances) method using an additional in-built module Spatial Analyst. In doing this, the area is delineated so that interpolation is applicable only to the inside of its limits.

Further, to build a field of distribution density of a species the area of each stratum is estimated and total abundance within each stratum is calculated as follows:

$$N_{Ri} = S_{Ri} \, x \, N_{kj} \, , \qquad (29)$$

where: $N_{Ri}$ – abundance of the species in stratum, and $S_{Ri}$ – stratum area.

It should be noted that in interpolating the density data and estimating the stratum area it should be remembered that the initial map projection should be chosen.

Grand total abundance of a sea bird species is derived by summing up abundance estimates for all strata:

$$N = \sum_{j=1}^{G} N_{Rj} \quad (30)$$

After computations by this method data on the abundance of sea birds, two most plentiful species in the Barents Sea - black-legged kittiwake and northern fulmar, were summarized in the tables given in the results of this report.

### *6.2. Results of sea birds observation (tables 6.1-6.8 & figs. 6.2.1-6.2.9)*

Based on aerial surveys of black-legged kittiwake and northern fulmar densitiy distribution maps of these species in surveyed areas were drawn. The abundance of birds was estimated by direct extrapolation method using average density of birds in each density gradation from the map, which provided rather accurate estimates comparable with those for 2003. For comparison of abundance estimates we have also undertaken calculations to use data from aerial surveys of sea birds in a similar period of 2003. Not included in these calculations were followers from bird groups that follow fishing vessels.

Aerial survey of black-legged kittiwake in the southern part of the Barents Sea conducted in August-September 2004 provided an average estimate of density at 46.18 birds per 100 km$^2$, which was somewhat less than in the same period of 2003 – 76.67 birds per 100 km$^2$ (table 6.1, 6.2; fig. 6.2.1, 6.2.2). A comparison of average densities for the northern part of the Barents Sea (table 6.3, 6.4; fig. 6.2.3, 6.2.4) has shown a larger reduction in average density in 2004 - 121.13 birds per 100 km$^2$ compared to 2003 - 979.22 birds per 100 km$^2$. A lower abundance estimate for black-legged kittiwake as shown by calculations could be a result of differing aerial survey areas, however, a general conclusion could be made of a slightly decreased abundance of black-legged kittiwake population in the Barents Sea. The reason for this could be both a changed distribution pattern of birds in the area due to changed availability of food, and poorer production for the same reason.

To establish a general trend in the variation of abundance of mass bird species in the Barents Sea similar calculations were undertaken for another species, northern fulmar. The average density of birds in the area surveyed in 2003, primarily in the southern part of the Barents Sea (table 6.5, fig. 6.2.5), was 1265.36 birds per 100 km$^2$, compared to 995.59 birds per 100 km$^2$ in 2004 (table 6.6, fig. 6.2.6). The largest reduction of abundance was noted for the northern part of the Barents Sea (table 6.7, 6.8; fig. 6.2.7, 6.2.8): 2536.22 birds per 100 km$^2$ in 2003 compared to 98.12 birds per 100 km$^2$ in 2004.

Despite derived estimates being relative it can be concluded that the abundance of two mass species of sea birds, black-legged kittiwake and northern fulmar, in the Barents Sea declined in 2004. We are not presently able to precisely identify the reasons behind this phenomenon. Unfortunately, data available for other bird species are insufficient for undertaking similar assessment.

**Table 6.1 Abundance of black-legged kittiwake in the Barents Sea (southern part) in the period from 20 August till 5 September 2003**

| Species: black-legged kittiwake | Year (survey dates): 20 August till 05 September 2003 | | | | |
|---|---|---|---|---|---|
| Gradation of density birds/10 km² | S km² extrapol. | Average density in gradation for extrapolation, birds/10 km² | Number in gradation | Min. number in gradation | Max. number in gradation |
| 0-1 | 332812.81 | 0.5 | 16 641 | 0 | 33 281 |
| 1-5 | 110141.64 | 3 | 33 042 | 11 014 | 55 071 |
| 5-10 | 11544.46 | 7.5 | 8 658 | 5 772 | 11 544 |
| 10-50 | 9740.84 | 30 | 29 223 | 9 741 | 48 704 |
| 50-500 | 9056.12 | 275 | 249 043 | 45 281 | 452 806 |
| 50-723 | 434.61 | 611.5 | 26 577 | 21 731 | 31 422 |
| **Total:** | **473730.49** | | **363 184** | **93 538** | **632 829** |

**Table 6.2 Abundance of black-legged kittiwake in the Barents Sea (southern part) in the period from 22 August till 3 September 2004**

| Species: black-legged kittiwake | Year (survey dates): 22 August till 03 September 2004 | | | | |
|---|---|---|---|---|---|
| Gradation of density birds/10 km² | S km² extrapol. | Average density in gradation for extrapolation, birds/10 km² | Number in gradation | Min. number in gradation | Max. number in gradation |
| 0-1 | 303336.29 | 0.5 | 15 167 | 0 | 30 334 |
| 1-5 | 92772.57 | 3 | 27 832 | 9 277 | 46 386 |
| 5-10 | 10269.90 | 7.5 | 7 702 | 5 135 | 10 270 |
| 10-50 | 21198.69 | 30 | 63 596 | 21 199 | 105 993 |
| 50-208 | 5566.14 | 154 | 85 719 | 27 831 | 115 776 |
| **Total:** | **433143.60** | | **200 016** | **63 442** | **308 759** |

**Table 6.3 Abundance of black-legged kittiwake in the Barents Sea (northern part) in the period from 16 September till 1 October 2003**

| Species: black-legged kittiwake | Year (survey dates): 16 September till 1 October 2003 | | | | |
|---|---|---|---|---|---|
| Gradation of density birds/10 km² | S km² extrapol. | Average density in gradation for extrapolation, birds/10 km² | Number in gradation | Min. number in gradation | Max. number in gradation |
| 0-1 | 113680.88 | 0.5 | 5 684 | 0 | 11 368 |
| 1-5 | 64759.45 | 3 | 19 428 | 6 476 | 32 380 |
| 5-10 | 48024.39 | 7.5 | 36 018 | 24 012 | 48 024 |
| 10-50 | 48734.74 | 30 | 146 204 | 48 735 | 243 674 |
| 50-500 | 36419.42 | 275 | 1 001 534 | 182 097 | 1 820 971 |
| 500-4964 | 6995.08 | 2732 | 1 911 055 | 349 754 | 3 472 356 |
| **Total:** | **318613.97** | | **3 119 924** | **611 074** | **5 628 773** |

**Table 6.4 Abundance of black-legged kittiwake in the Barents Sea (northern part) in the period from 17 till 30 September 2004**

| Species: black-legged kittiwake | | Year (survey dates): 17 till 30 September 2004 | | | |
|---|---|---|---|---|---|
| Gradation of density birds/10 km² | S km² extrapol. | Average density in gradation for extrapolation, birds/10 km² | Number in gradation | Min. number in gradation | Max. number in gradation |
| 0-1 | 99534.78 | 0.5 | 4 977 | 0 | 9 953 |
| 1-5 | 80672.77 | 3 | 24 202 | 8 067 | 40 336 |
| 5-10 | 52309.35 | 7.5 | 39 232 | 26 155 | 52 309 |
| 10-50 | 3701.29 | 30 | 11 104 | 3 701 | 18 506 |
| 50-359 | 10739.50 | 204.5 | 219 623 | 53 698 | 385 548 |
| **Total:** | **246957.69** | | **299 137** | **91 621** | **506 654** |

**Table 6.5 Abundance of northern fulmar in the Barents Sea (southern part predominantly) in the period from 20 August till 5 September 2003**

| Species: northern fulmar | | Year (survey dates): 20 August till 5 September 2003 | | | |
|---|---|---|---|---|---|
| Gradation of density birds/10 km² | S km² extrapol. | Average density in gradation for extrapolation, birds/10 km² | Number in gradation | Min. number in gradation | Max. number in gradation |
| 0-1 | 35016.65 | 0.5 | 1 751 | 0 | 3 502 |
| 1-5 | 60396.27 | 3 | 18 119 | 6 040 | 30 198 |
| 5-10 | 52264.04 | 7.5 | 39 198 | 26 132 | 52 264 |
| 10-50 | 195322.72 | 30 | 585 968 | 195 323 | 976 614 |
| 50-500 | 113605.58 | 275 | 3 124 153 | 568 028 | 5 680 279 |
| 500-2097 | 17138.16 | 1298.5 | 2 225 390 | 856 908 | 3 593 872 |
| **Total:** | **473743.41** | | **5 994 579** | **1 652 430** | **10 336 728** |

**Table 6.6 Abundance of northern fulmar in the Barents Sea (southern part predominantly) in the period from 22 August till 3 September 2004**

| Species: northern fulmar | | Year (survey dates): 22 August till 3 September 2004 | | | |
|---|---|---|---|---|---|
| Gradation of density birds/10 km² | S km² extrapol. | Average density in gradation for extrapolation, birds/10 km² | Number in gradation | Min. number in gradation | Max. number in gradation |
| 0-1 | 76668.47 | 0.5 | 3 833 | 0 | 7 667 |
| 1-5 | 84416.73 | 3 | 25 325 | 8 442 | 42 208 |
| 5-10 | 78439.48 | 7.5 | 58 830 | 39 220 | 78 439 |
| 10-50 | 113626.74 | 30 | 340 880 | 113 627 | 568 134 |
| 50-871 | 79987.82 | 485.5 | 3 883 408 | 399 939 | 6 966 939 |
| **Total:** | **433139.23** | | **4 312 277** | **561 227** | **7 663 387** |

**Table 6.7 Abundance of northern fulmar in the Barents Sea (northern part) in the period from 16 September till 1 October 2003**

| Species: northern fulmar | | Year (survey dates): 16 September till 1 October 2003 | | | |
|---|---|---|---|---|---|
| Gradation of density birds/10 km² | S km² extrapol. | Average density in gradation for extrapolation, birds/10 km² | Number in gradation | Min. number in gradation | Max. number in gradation |
| 0-1 | 82594.99 | 0.5 | 20 649 | 0 | 41 297 |
| 1-5 | 69341.45 | 3 | 104 012 | 6 934 | 173 354 |
| 5-10 | 75068.17 | 7.5 | 281 506 | 37 534 | 375 341 |
| 10-50 | 57730.72 | 30 | 865 961 | 57 731 | 1 443 268 |
| 50-500 | 29096.60 | 275 | 4 000 782 | 145 483 | 7 274 149 |
| 500-1871 | 4734.95 | 1185.5 | 2 806 644 | 236 748 | 4 429 549 |
| **Total:** | **318566.88** | | **8 079 553** | **484 430** | **13 736 958** |

**Table 6.8 Abundance of northern fulmar in the Barents Sea (northern part) in the period from 17 till 30 September 2004**

| Species: northern fulmar | | Year (survey dates): 17 till 30 September 2004 | | | |
|---|---|---|---|---|---|
| Gradation of density birds/10 km² | S km² extrapol. | Average density in gradation for extrapolation, birds/10 km² | Number in gradation | Min. number in gradation | Max. number in gradation |
| 0-1 | 45247.20 | 0.5 | 2 262 | 0 | 4 525 |
| 1-5 | 103044.73 | 3 | 30 913 | 10 304 | 51 522 |
| 5-10 | 43630.56 | 7.5 | 32 723 | 21 815 | 43 631 |
| 10-50 | 52467.12 | 30 | 157 401 | 52 467 | 262 336 |
| 50-85.8 | 2838.23 | 67.9 | 19 275 | 14 191 | 24 359 |
| **Total:** | **247227.82** | | **242 575** | **98 778** | **386 373** |

## 7. Benthos observations (fig.1.4)

PINRO has over many years sampled the benthic fauna in the Barents Sea, but this has not been done on previous Norwegian cruises. Given the increased focus on the health of the whole ecosystem, and the ecosystem aspect of the survey, a pilot scheme for sampling benthic macro-fauna from bottom-trawl catches was carried out on the RV “Johan Hjort” from 20. August to 10. September. This was in addition to the regular sampling of benthos carried out by the RV “F.Nansen” using grab and Sigsby trawl (20.08.04 - 19.09.04), and by RV “Smolensk” using bottom trawl and grab, from 5 to 20 August. Total benthos sampling stations are shown in fig.1.4.

## *7.1. Method of benthos observations on Russian vessels*

Study of benthic communities' state is an integral part of research in a marine ecosystem. Due to data on bottom biocenosis, food supply of such important commercial benthophagous fish species as haddock, halibut and american plaice can be estimated.

The main purpose of benthic studies during survey on the Russian vessels was sampling of bottom invertebrates in the Eastern Barents Sea. These works have been started by PINRO scientists since 2003 and are continuation of investigations into the current state of the Barents Sea bottom biocenosis under the influence of climatic, biotic and anthropogenic factors. For that purpose, the following tasks have been carried out:

– quantitative zoobenthos sampling;
– qualitative zoobenthos sampling;
– zoobenthos bycatch analysis of ichthyological bottom trawlings;
– photographing of alive bottom invertebrates.

Quantitative collecting of macro-zoobenthos was carried out by a 0.1 $m^2$ Van Veen grab with five replicate samples at each station. The work with the grab was conducted by a cargo winch with the rope diameter of 9 mm.

Filling rate of the grab and type of bottom sediments of every sampling were examined visually and registered in an observation log. The taken sampling was washed in flowing seawater by a wash sieve with the mesh size of 0.75 mm. Washed bottom organisms with remains of ground were fixed in 4% neutralized solution of formaldehyde in hermetically covered plastic reservoirs. Tetraborate natrium was used as a buffer. During the washing and fixing the main occurring species and forms of macro-zoobenthos were examined visually and registered in the observation log.

Qualitative sampling of zoobenthos was carried out by a moderate Sigsby trawl with the frame of 1 x 0.35 m and with a 10 mm mesh size of inner cover in the bag. The codend part of the inner cover was sewed by a 5 mm mesh size knitting knotless netting.

The work with the Sigsby trawl was done using standard trawl winches. Trawlings with duration of 5-10 min were made at the vessel speed of 1-2 knots. Washing of trawl catches was done on the washing table using 2 washing sieves with the mesh size of 10 and 3 mm. As a rule, marine animals were taken from the upper sieve on the deck. Sampling of animals from the lower sieve and sorting of catch into taxonomic groups were done in the vessel laboratory. When processing the trawl catch, abundant bottom species of invertebrates were counted and measured. Organisms required further taxonomic processing were fixed in 75% ethyl alcohol and 4% formalin.

Bycatch analysis of bottom invertebrates in catches made with the bottom ichthyological trawl of Campelen system was carried out selectively when some rare species of bottom fauna occurred or in the cases of especially large benthos bycatch. To determine taxonomic composition of bycatch a certain part or the whole bycatch was divided into species and taxonomic groups. Sorted organisms were weighted on electronic scales to within 0.1 g. for total biomass and part of group determination in bycatch.

Photographing of bottom invertebrates was carried out by 2 digital cameras: Minolta Dimage A1 and Canon G5 with 5.2 megapixel resolution of ultrasensitive matrix. For further processing digital photos were saved in TIF and JPG formats in a computer. Photographing was made with the use of state camera and lighting of 2 incondescent lamps of 60W. Exposure and aperture values were set both automatically and manually. To render natural color of photographed organisms, gamma correction of white color was done before session. To photograph small objects a special macro photographing mode was used.

### 7.2. Results on materials of Russian vessels (figs. 7.2.1.-7.2.5)

Altogether by Russian vessels 98 benthos stations were made (fig.7.2.1), 465 qualitative and 85 quantitative macrobenthos samplings were taken during the research expedition. Bycatches of 35 bottom ichthyological trawls were analysed.

During the benthos works invertebrates of 12 types occurred in trawl and grab samplings: Spongia, Priapulida, Sipuncula, Nemertini, Coelenterata, Annelida, Arthropoda, Molluska, Bryozoa, Brachiopoda, Echinodermata, Tunicata. Among the most frequently occurring and abundant forms in catches were animals of such classes as: Bivalvia, Crustacea, Polychaeta, Asteroidea, Ophiuroidea. Aside from these groups, 16 classes of other animals were found as well: Hydrozoa, Antozoa, Pantopoda, Loricata, Gastropoda, Scaphopoda, Cephalopoda, Crinoidea, Echoidea, Holothuroidea, Priapulida, Sipunculidea, Bryozoa, Brachiopoda, Ascidiacea.

In the observed area the most occurring species were bivalves molluscs: Macoma calcarea, Ciliatocardium ciliatum, Nuculana pernula; polychaetes Pectinaria hyperborea, Spiochetopterus typicus and Echinodermata Ctenodiscus crispatus, Ophiura sarsii, Ophianacanta bidentata, Strongylocentrotus droebachiensis, S. pallidus.

Strongylocentrotus droebachiensis, S. pallidus inhabit often jointly and are used to form numerous communities, and make up sometimes more than 90% of catch taken with the Sigsby trawl. Most abundant catches of these species were taken at station 48. This biocenosis occurs on a very stony ground. 1/20 of catch consisted of 75 individuals of sea-urchins. Mass measurements of individuals enabled to determine the size structure of this local settlement (fig.7.2.2). The diameter of carapace varied from 21 to 59 mm, the mean diameter of carapace made up 36.8 mm.

Two size groups can be pointed out in this frequency. The first size group, from 21 to 33 mm in diameter, forms 52% of population, the second part of size group, from 37 to 54 mm in diameter, constitutes 45.33% of sampling.

Specimens of Crustacea predominated in catches made by the Sigsby trawl in the southern part of the research area. The most frequently found species of this group were: Pagurus pubescens, Hyas araneus, Sclerocrangon boreas, Balanus balanus, Balanus crenatus. Apart from these species, bivalves mollusks: Serripes groenlandica, Arctica islandica, Mytilis edulis occurred in the southern Barents Sea as well.

In the north the percentage of Crustaceans in catches decreased, and Echinodermata became to be predominant invertebrates group in catches. Among the specimens of this type Ophiuroidea were the most abundant: Gorgonocephalus arcticus, Ophiopleura borealis and Crinoidea: Heliometra glacialis. Pteraster sp, Ophioscolex glacialis occurred in trawl catches much rarer. Among the other groups of invertebrates such species as Sclerocrangon ferox (instead of S.boreas, which were observed to occur in the southern part), Bathyarca glacialis, Pandora glacialis were found.

The analysis of bottom invertebrates bycatches in bottom ichthyological trawl “Campelen” system was done onboard the R/V “Frodtjof Nansen” from 31.08.04 to 19.09.04.

Altogether, 35 bycatches of zoobenthos in the north-eastern Barents Sea near to the northern island of the Novaya Zemlya (fig.7.2.3) were analysed.

There was no benthos in 4 bottom trawls. The mass of zoobenthos bycatch in other catches by the bottom trawl varied from 0.5 kg (0.4 kg/1-hour trawling) to 209.5 kg (419.1 kg/1-hour trawling). The average mass of zoobenthos bycatch amounted to 72.7 kg/h per a trawling.

When making conversion of bycatch per unit area, the benthos biomass varied from 0.5 to 209 g/m2 at average biomass of 33 g/m2 in the research area on the data of bottom trawlings.

The largest catches, up to 1.0 t per 1-hour trawling taken and analysed from ichthyological bottom trawls were observed in the southern part of the research area near the Kanin Nos and the Kolguev island due to catch of such commercial important fish species as Gadus morhua (cod) and Melannogrammus aeglefinus (haddock). The percentage of zoobenthos in catches of these trawlings was not large and hardly amounted to 12.5% of the total mass of catch, the weight of bycatch varied from 0.4 kg per 1-hour trawling to 130 kg per 1-hour trawling.

The taxonomical analysis showed that on the average in the southern part of the research area in zoobenthos bycatches crustaceans prevail by weight and make up about 81% of bycatch and in some trawlings their percentage reaches up to 100% (fig. 7.2.4).

Paralithodes camtchatica, Hyas araneus, Pandalus borealis, Sclerocrangon boreas were the most predominating species of this taxonomical group. P. camtchatica occurred in one trawl in number of 31 specimens with the total weight of 126.5 kg, it made up 99% of zoobenthos bycatch. All crabs were males in the 2-3 molt stage. The minimal width of carapace was 116 mm, the maximal length – 233 mm.

H. araneus occurred rather frequently, the maximum catch of this species was amounted 0.5 kg and made up 100% of bycatch. H. araneus – 40%, P. borealis and S. boreas by 30% of total bycatch mass occured.

The second place of occurrence was presented by Echinodermata. Their portion in bycatch averages 10% but it can reach up to 14%, as well. This group was presented in the southern part of the research area by individuals of such classes as Echinoidea, Ophiuroidea, Asteroidea. Such species of Crustaceans as Strongilocentrotus (S. droebahiensis, S. palidus), Ophiura sarsi, Ophiocanta bidentat,Ctenodiscus crispatus, Solaster endeca, Crossaster papposus were the most predominating.

Another situation was observed in the northern part of research area. The maximum total catch of ichthyological bottom trawl was not more than 520 kg per 1-hour trawling, the maximum total catch of fish made up altogether 176 kg/1-hour trawling. Among fish, the greatest portion of catches carried out by bottom trawls constituted of such commercial species as B. saida (Polar cod), which catches reached up to 159 kg/1-hour trawling. Thus, zoobenthos organisms predominated in catches of ichthyological bottom trawl generally in the northern part of the research area (fig.7.2.3).

Species diversity in zoobenthos bycatches taken in the northern part of the research area was much higher than in bycatches taken in the southern part.Individuals of Echinodermata (fig.7.2.5) prevailed in the main part of bycatches.

Among species of this group, sea urchins from genus Strongilocentrotus occurred just as in the southern part of the research area, their percentage reached by weight up to 99% and made up 20% in bycatch in average over the area.

However, individuals from class Ophiuroidea occurred in bycatches most frequently and their percentage made up 35% in average over the area. Gorgonocephalus arcticus prevailed by weight among class Ophiura. Crustaceans took in bycatches the second place by weight, it made up 18% on average over the area.

Pandalus borealis occurred in bycatches both in the southern as in the northern part, catches of this species reached up to 53 kg/1-hour trawling. S. ferox started to occur instead of S.boreas among Crangonidae shrimps.Nevertheless, catches of this species were not high and not more than 8 kg/1-hour trawling.

During the cruise about 40 objects of bottom fauna were photographed. This material can be used for making of a quick atlas-guide to identification of bottom organisms. This atlas could be very helpful to research observers in their work onboard research-fishing vessels on trawl catches and analysis description of demersal fish feeding.

Thus, a great area of the Eastern Barents Sea was observed during the research expedition. A large volume of quantitative and qualitative zoobenthos samples was gathered which will allow to estimate changes taken place in bottom communities in the given research area since the last survey conducted by PINRO, to make conclusions about the food supply state of benthophage fishes.

The analysis of ichthyological trawl catches revealed a great number of benthos bycatch, it points out that bottom trawlings are very harmful to benthos communities. The wide photographic material on bottom organisms, which was gathered, is a major step toward a creation of an atlas-guide to identification of bottom organisms to help research observers in their work onboard research-fishing vessels.

### *7.3. Method of benthos observations on Norwegian vessels*

Benthos samples were taken from the bottom-trawl catches after the fish had been sorted out of the catch. A subsample of ~3 kg was taken out and sorted to species level if possible. For each species group the number and total weight was recorded, except for some colonial organism like Poriphera and certain species of Polychaeta where only weight was recorded. Species that were unidentifiable were tagged and frozen at –23ºC for later identification on shore. For each station the relative contribution by weight and numbers for each species was calculated.

### *7.4. Results on materials of Norwegian vessels*
***(tables 7.1 and figs. 7.4.1, 7.4.5)***

A total of 87 species groups were found, although 37 of these were not identified to species level. To clarify the analysis, these were only carried out on the 35 species that were present at more than 25% of the stations sampled (Table 7.1).

**Table 7.1 Weight of total benthic sample (including abiotic components), weight of biotic components and number of species at bottom-trawl from "*Johan Hjort*"**

| Serial no. | Total weight | Biota sampled | No. Species | Serial no. | Total weight | Biota sampled | No. Species |
|---|---|---|---|---|---|---|---|
| 2369 | - | 2.3 | 5 | 2430 | 31.3 | 2.9 | 18 |
| 2370 | - | 1.9 | 10 | 2433 | 99.1 | 1.7 | 19 |
| 2373 | - | 23.5 | 6 | 2434 | 322.7 | 2.2 | 26 |
| 2374 | - | 5.2 | 16 | 2441 | 516.0 | 2.6 | 24 |
| 2377 | - | 1.3 | 11 | 2442 | 682.5 | 1.8 | 25 |
| 2378 | - | 2.6 | 13 | 2445 | 4.4 | 3.0 | 30 |
| 2381 | - | 0.3 | 14 | 2446 | 79.6 | 2.0 | 30 |
| 2382 | - | 3.0 | 14 | 2449 | 94.2 | 0.5 | 28 |
| 2385 | - | 3.2 | 11 | 2450 | 46.4 | 0.7 | 23 |
| 2386 | - | 0.4 | 13 | 2453 | 120.0 | 1.3 | 16 |
| 2389 | - | 1.0 | 9 | 2454 | 38.5 | 0.6 | 17 |
| 2390 | - | 1.4 | 14 | 2457 | 67.4 | 1.0 | 22 |
| 2393 | - | 0.7 | 20 | 2458 | 97.6 | 1.1 | 23 |
| 2394 | - | 3.4 | 15 | 2461 | 109.3 | 0.8 | 29 |
| 2397 | - | 2.9 | 23 | 2462 | 27.4 | 1.0 | 26 |
| 2398 | - | 0.5 | 17 | 2465 | 161.7 | 1.3 | 24 |
| 2401 | - | 1.9 | 22 | 2466 | 321.6 | 1.9 | 15 |
| 2402 | - | 0.9 | 24 | 2469 | 148.9 | 1.6 | 32 |
| 2405 | - | 2.9 | 24 | 2470 | 102.9 | 2.0 | 24 |
| 2406 | - | 1.8 | 25 | 2473 | 230.0 | 1.0 | 20 |
| 2409 | - | 1.9 | 27 | 2474 | 73.2 | 0.5 | 27 |
| 2413 | - | 3.8 | 24 | 2477 | 62.3 | 1.2 | 31 |
| 2414 | - | 2.7 | 32 | 2480 | 120.1 | 1.3 | 26 |
| 2417 | - | 2.6 | 31 | 2484 | 62.5 | 0.9 | 19 |
| 2418 | - | 0.7 | 25 | 2485 | 40.4 | 1.2 | 28 |
| 2421 | 27.7 | 1.1 | 25 | 2488 | 96.3 | 7.7 | 25 |
| 2422 | 34.5 | 2.2 | 27 | 2492 | 35.3 | 1.3 | 31 |
| 2425 | 40.0 | 1.7 | 30 | 2493 | 15.4 | 1.1 | 28 |
| 2426 | 79.3 | 1.9 | 22 | 2496 | 47.8 | 0.6 | 19 |
| 2429 | 190.7 | 5.3 | 17 | | | | |

Not recorded.

In terms of numbers the clam Astarte crenata, sea stars, brittle stars and sea-anemones were the most dominant (fig. 7.4.1). The number of species increased towards the north and east of the Barents Sea (fig. 7.4.2).

When species numbers was expressed as Hill's biodiversity index the same increase was also apparent (fig. 7.4.3).

To understand which species were occurring together, excluding each other, or showed no pattern in co-occurrence we carried out a Principal Component Analyses (PCA) on both biomass and numbers data (both as proportions of species A in relation to sample size/weight at a station).

The PCA plot (fig. 7.4.4) of the biomass data show that the species form three major groups in terms of coocurrence. The most abundant species, the clam Astarte crenata is positively correlated to the large isopod Saduria sabini, the snail Colus sabini, the clam Bathyarca glacialis and the sea-cucumber Molpadia borealis. The large crustacean Sabinea septemcarinata, is positively correlated (shows coocurrence) with a large number of species, most notably the sea-star Usterias lineki, the brittle star Ophipholis aculeate. This group is quite broad but consists of several known arctic species, like the Sabinea shrimp.The third groups is tighter linked and consists of the two sea-stars Ceramaster granularis and Hippasterias phrygiana, hermite crabs Pagurus sp., species with a more boreal distribution.

The PCA analysis based on numbers data (fig. 7.4.5) show much the same pattern.

Clear biogeographic changes in species composition, biodiversity and distribution were observed northwards in the Barents sea. The analysis are not finished in terms of relation to depth, hydrographic parameters, etc., but the initial multivariate analysis indicate that there are at least three separate species assemblages in the survey region.

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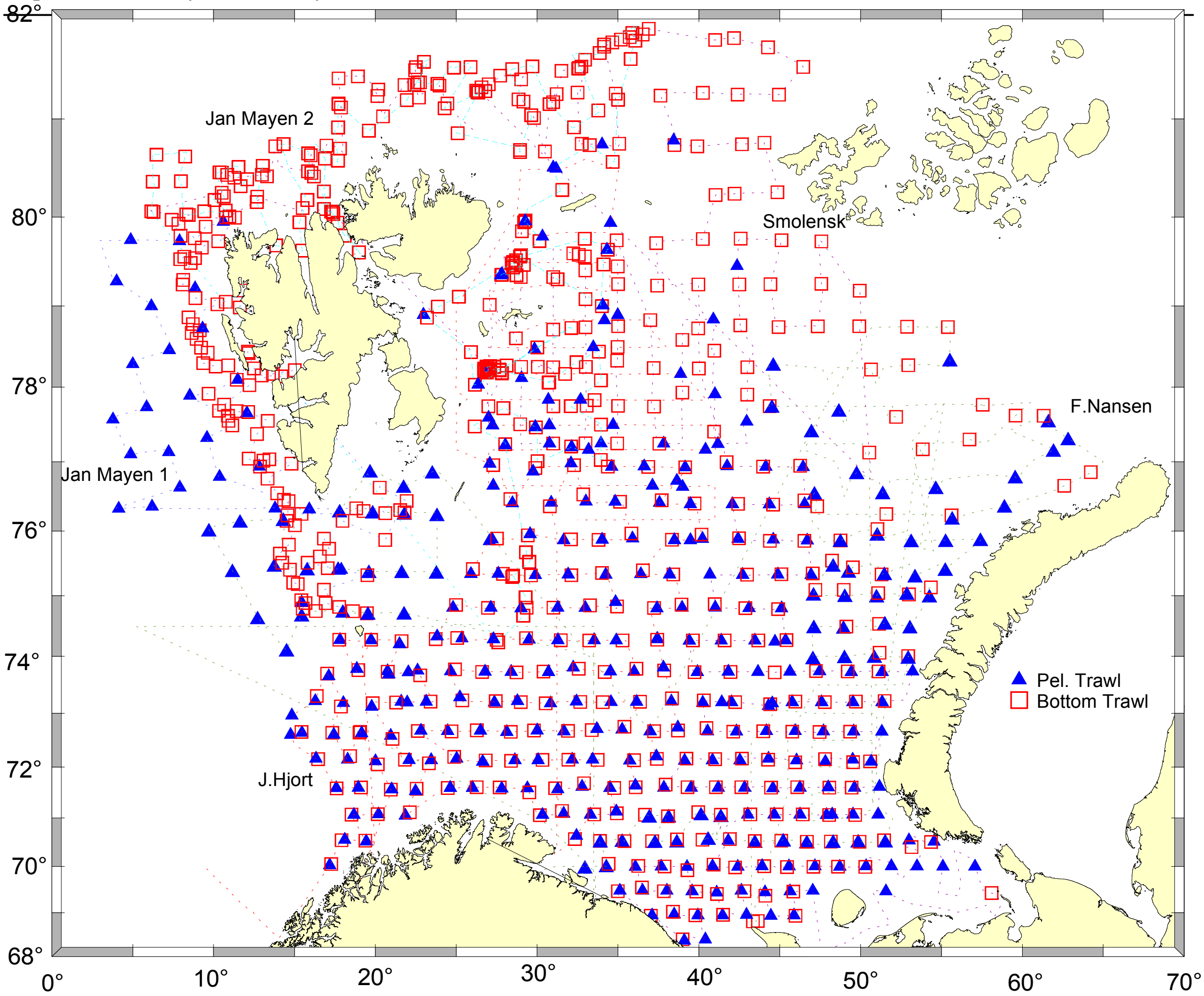


**Figure 1.1. Survey routes and trawl stations for "Johan Hjort", "Jan Mayen", "Nansen" and "Smolensk" August-October 2004**

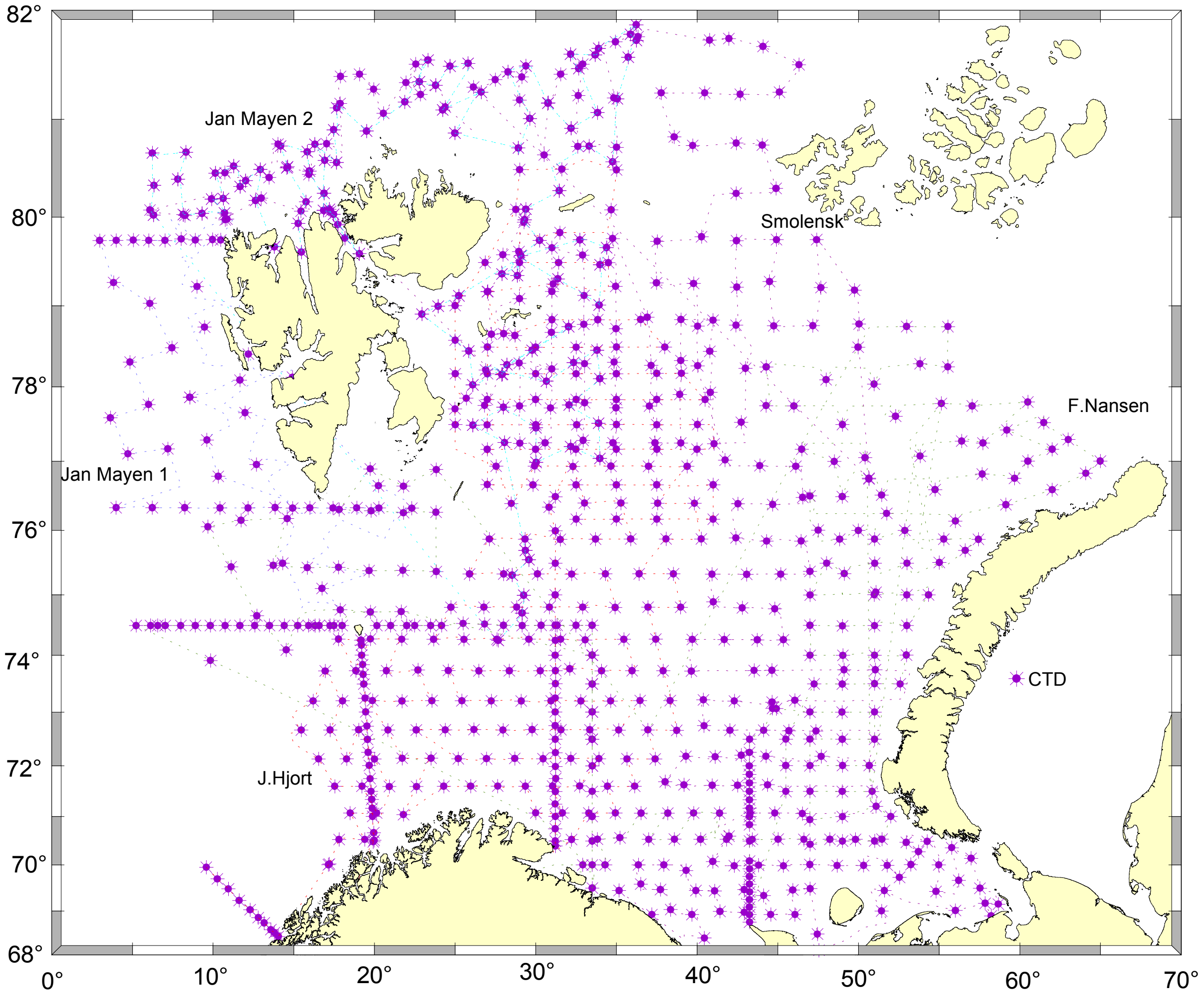


**Figure 1.2. Survey routes and hydrographic stations for "Johan Hjort", "Jan Mayen", "Nansen", and "Smolensk", August-October 2004**

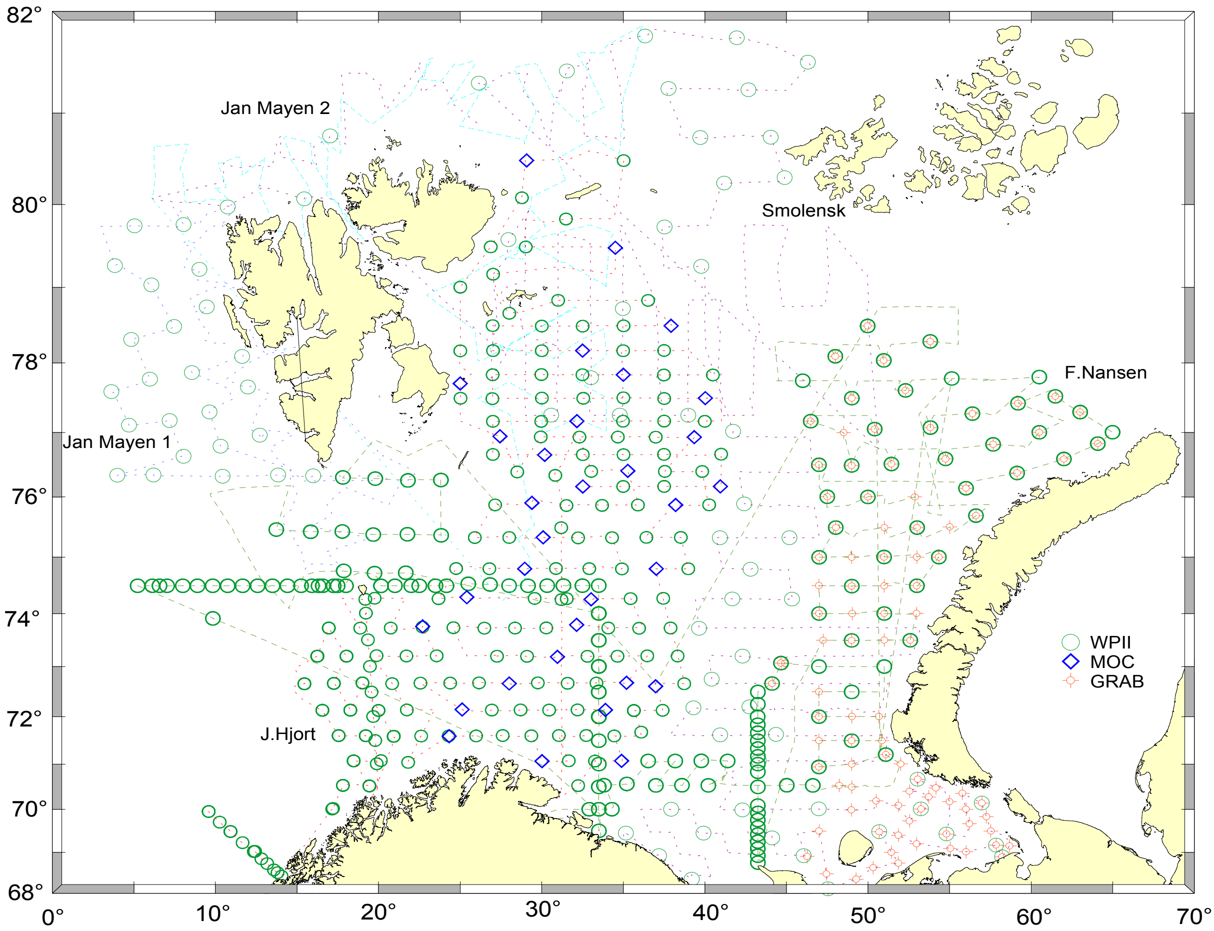


**Figure 1.3. Survey routes and plankton stations for "Johan Hjort", “Jan Mayen”, " Nansen” and "Smolensk", August-October 2004**

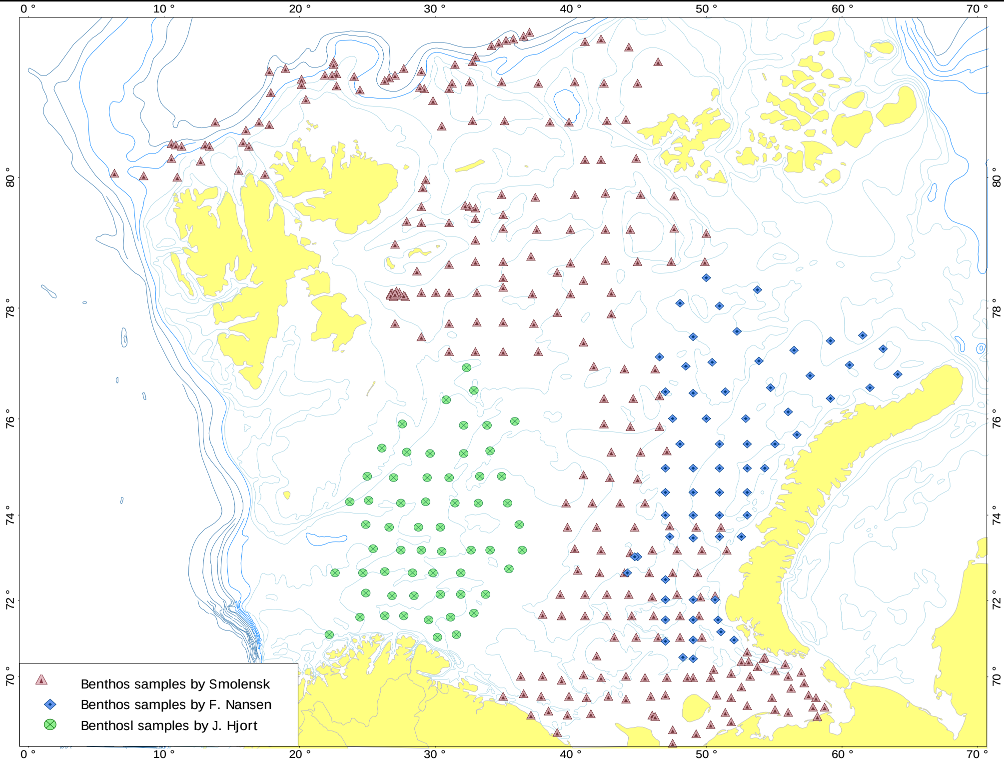


**Figure 1.4. Stations of macro-benthos sampled by bottom trawl (RV "*J.Hjort*"), bottom trawl and grab (RV "*Smolensk*"), or grab and Sigsby trawl (RV *"F. Nansen"*)**

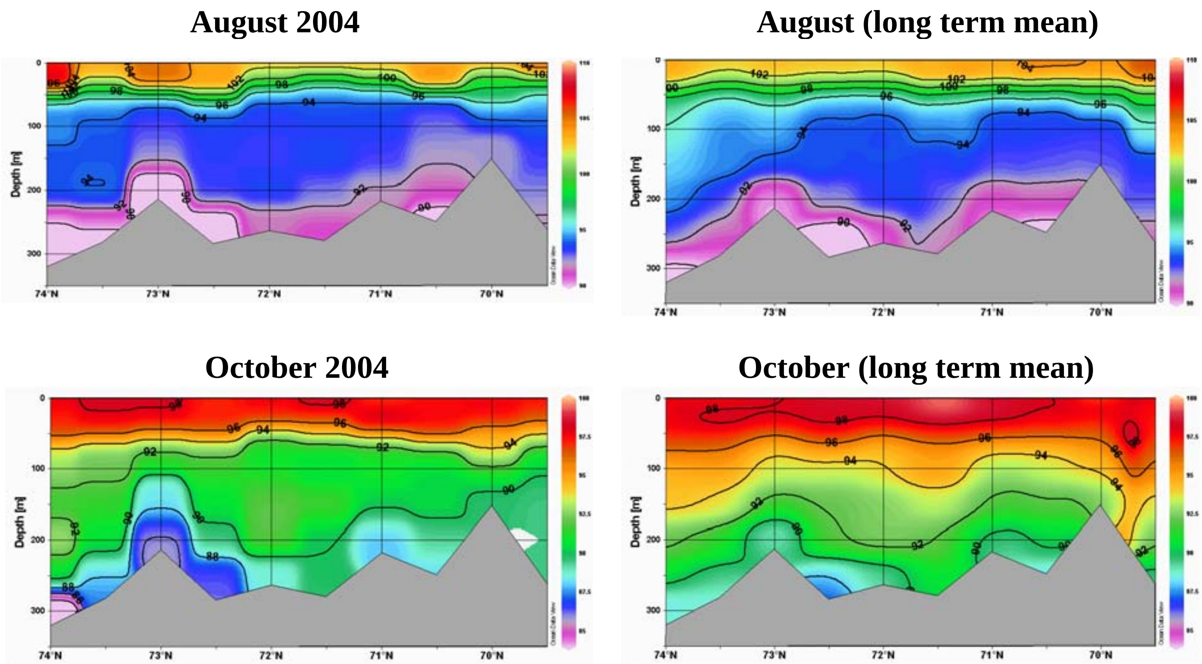


**Figure 1.2.1. Distribution of oxygen content (% of saturation) in the Kola Section and its long-term mean values**

**August 2004** **August (long term mean)**

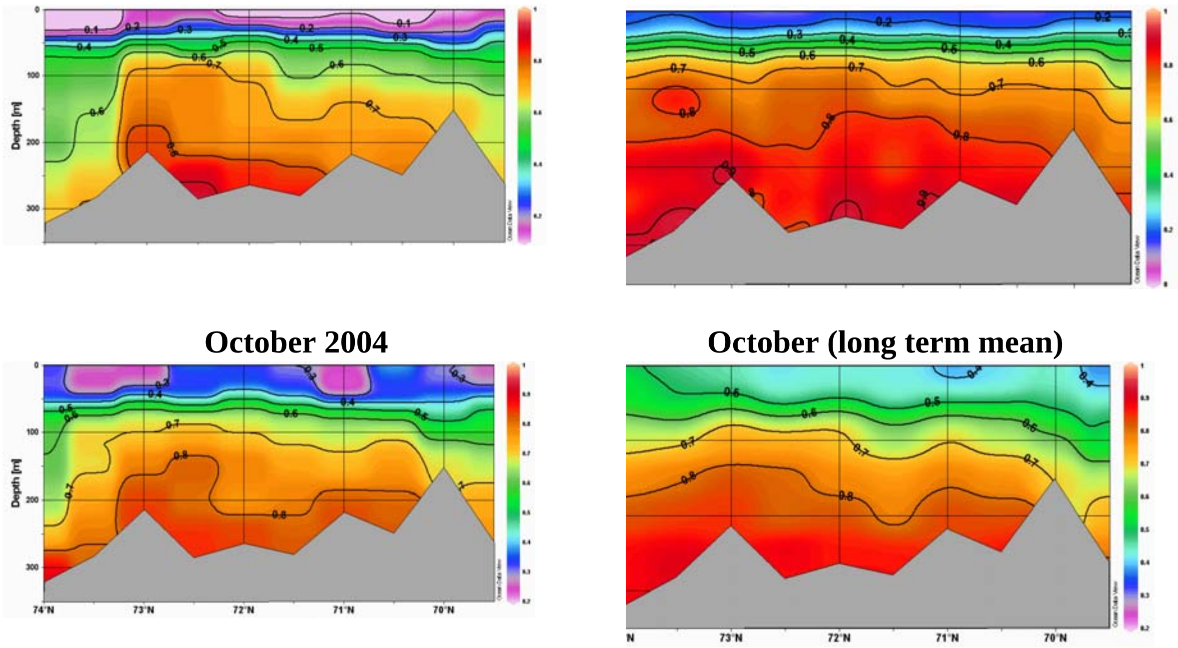


**Figure 1.2.2. Distribution of phosphate content (μM) in the Kola Section and their long-term mean values**

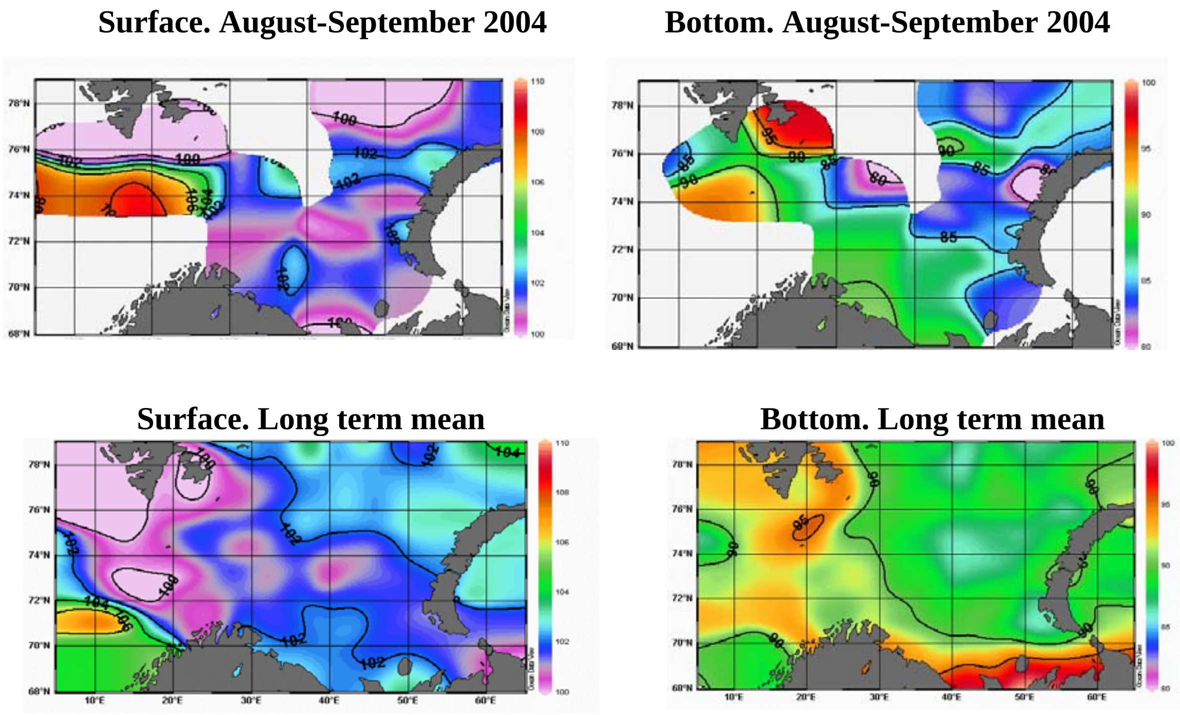


**Figure 1.2.3. Oxygen content (% of saturation) in the surface and bottom layers of the Barents Sea and its long-term mean values**

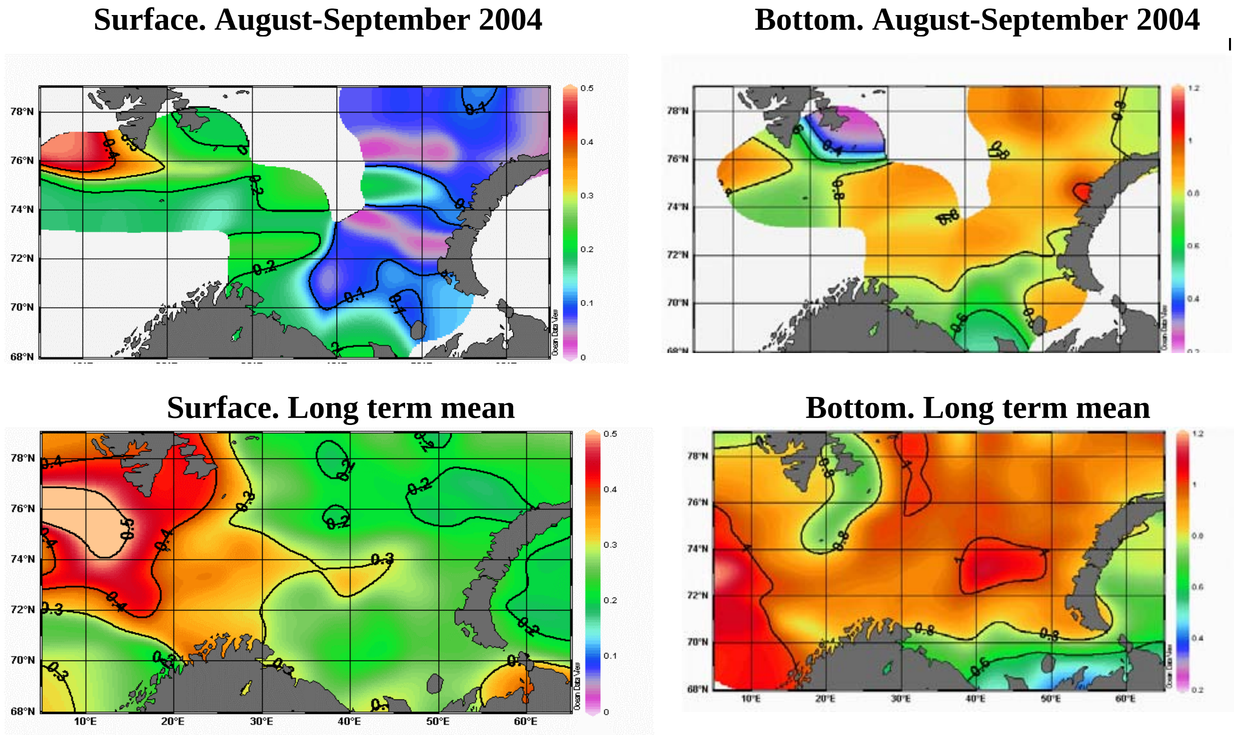


**Figure 1.2.4. Phosphate content (μM) in the surface and bottom layers of the Barents Sea and its long-term mean values**

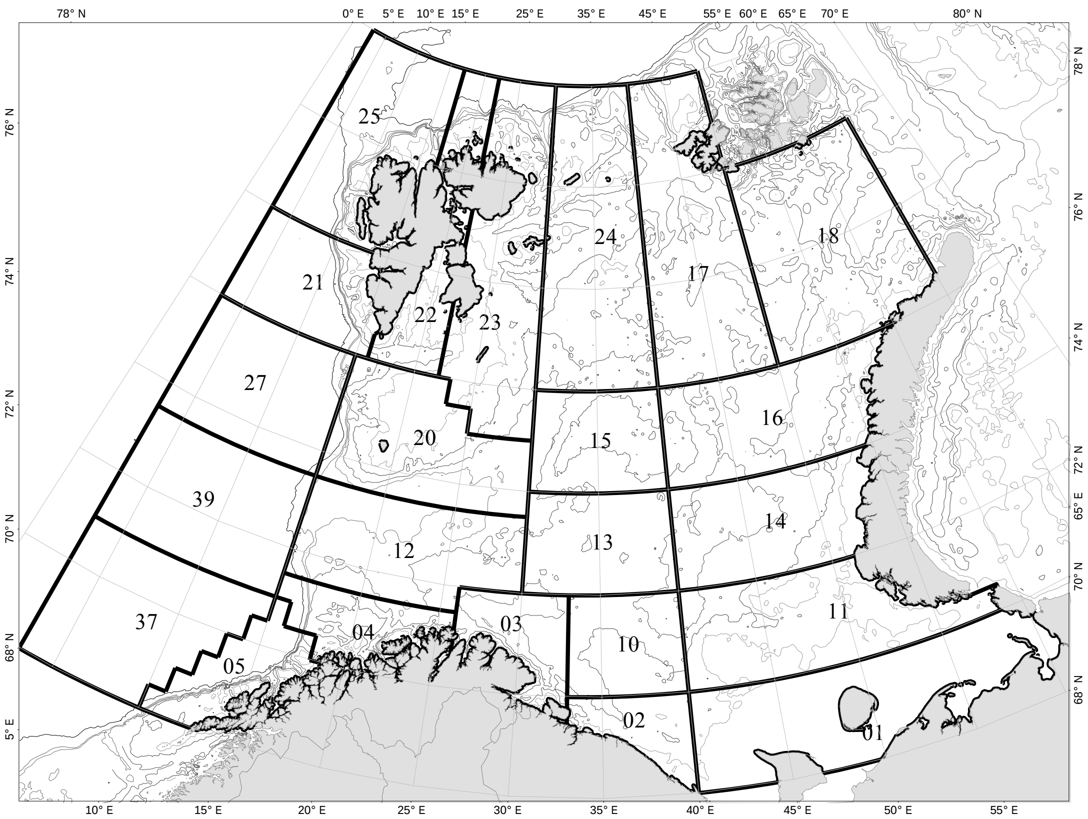


**Figure 2.2.1. The Barents Sea divided into 22 strata**

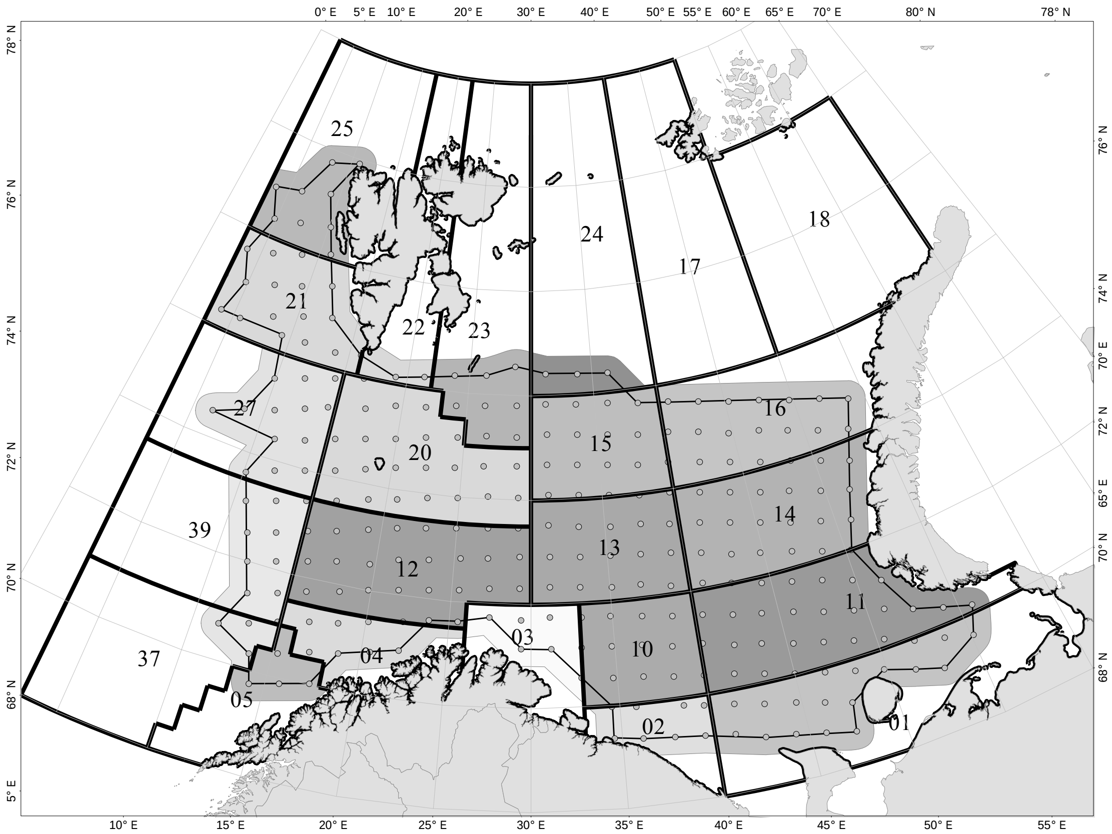


**Figure 2.2.2. Example of good coverage, year 2000. Gray areas are used in the 0-group abundance estimations**

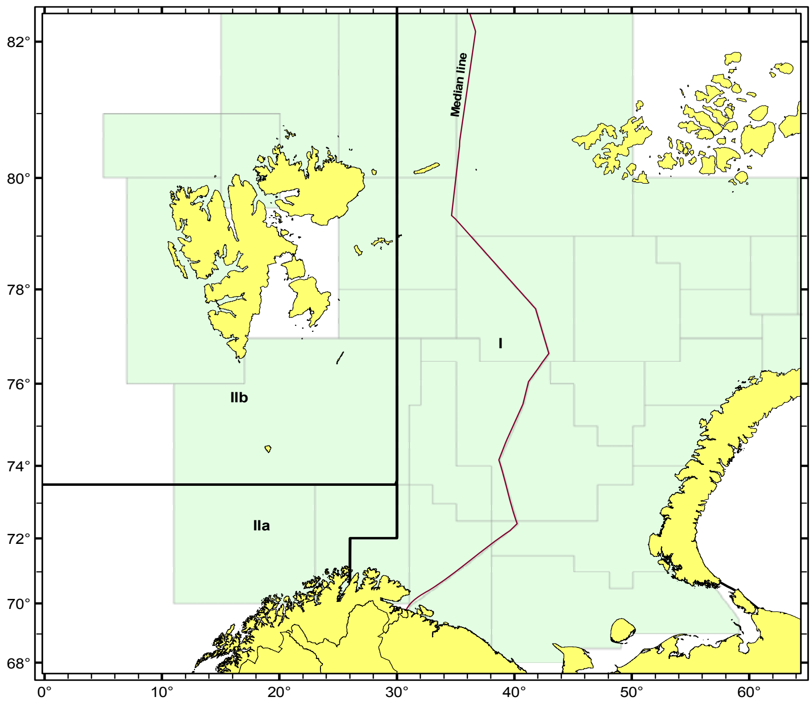


**Figure 3.4.1. Geographic outline of the new depth stratified system used in the swept area analyses for the ecosystem survey**

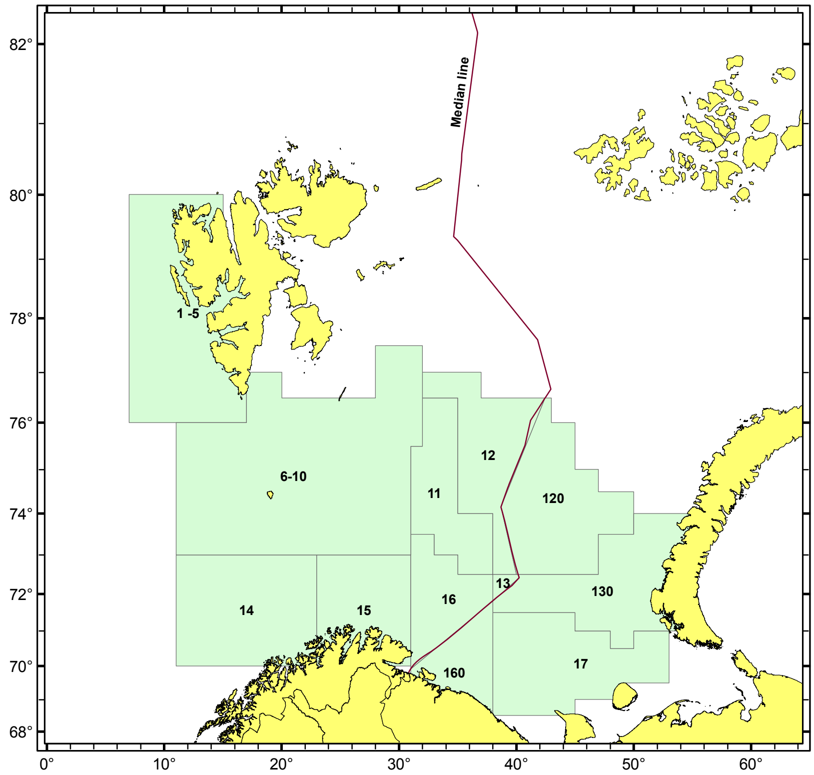


**Figure 3.4.2. The old strata system used for the Norwegian summer/autumn survey. Used when comparing results for cod and haddock with earlier years**

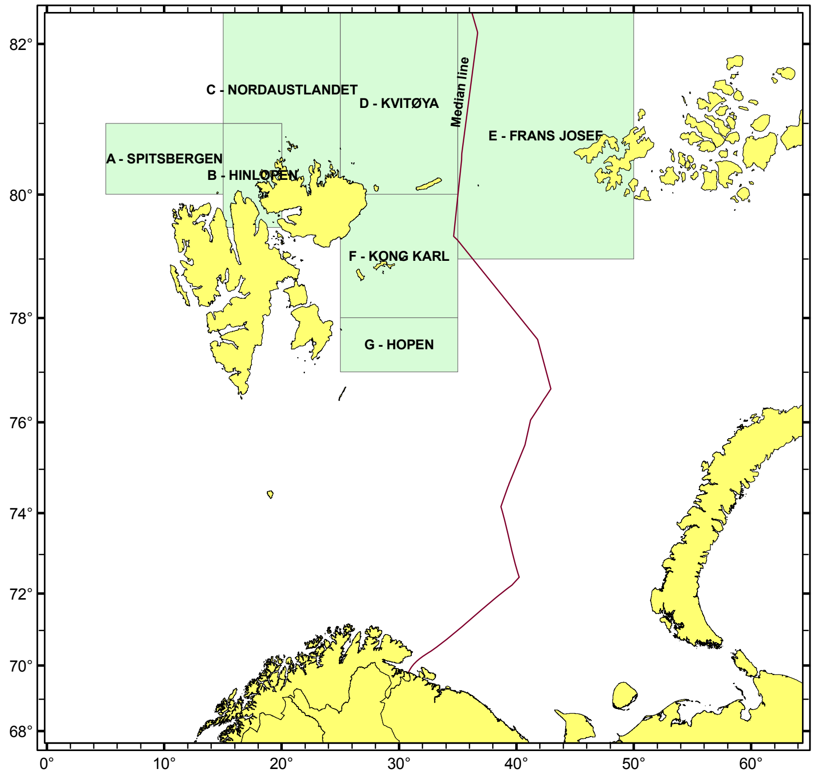


**Figure 3.4.3. The northern strata system used for the juvenile Greenland halibut survey. Used when comparing results for Greenland halibut with earlier years**

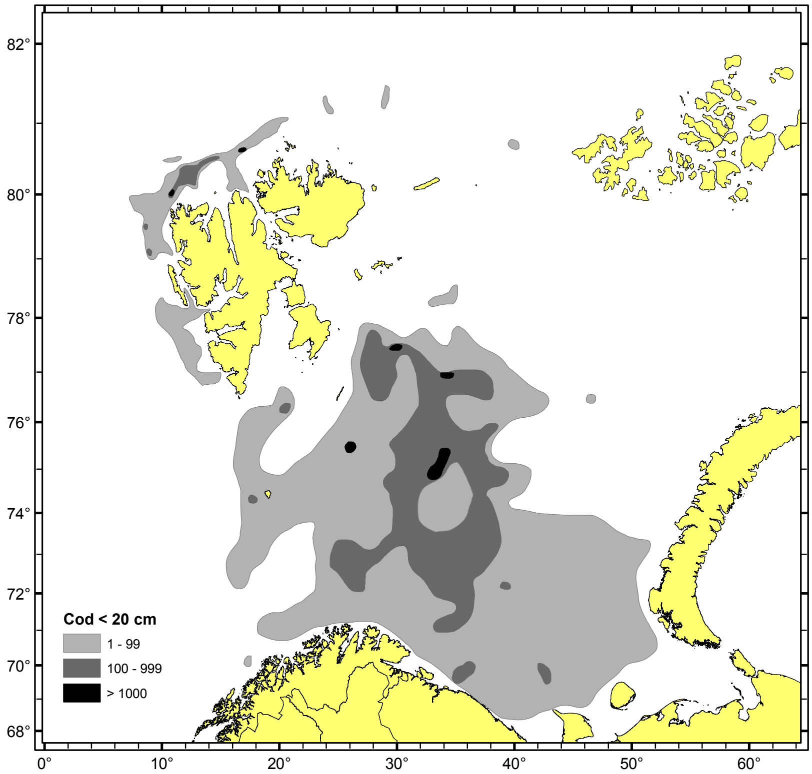


**Figure 3.4.4. Northeast Arctic cod less than 20 cm. Geographical distribution (catch in numbers per hour of trawling) during the ecosystem survey in autumn 2004**

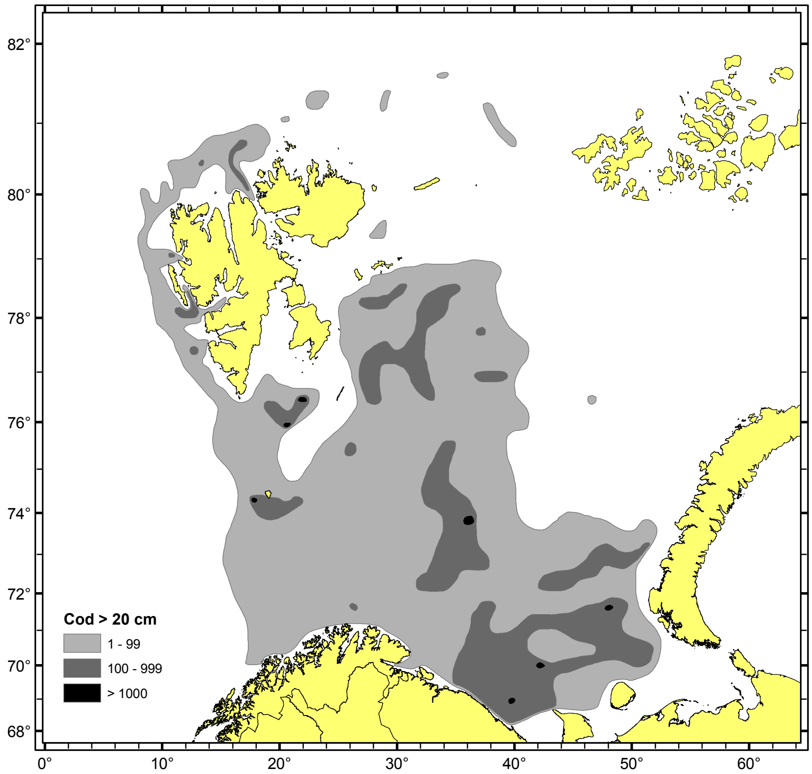


**Figure 3.4.5. Northeast Arctic cod larger than 20 cm. Geographical distribution (catch in numbers per hour of trawling) during the ecosystem survey in autumn 2004**

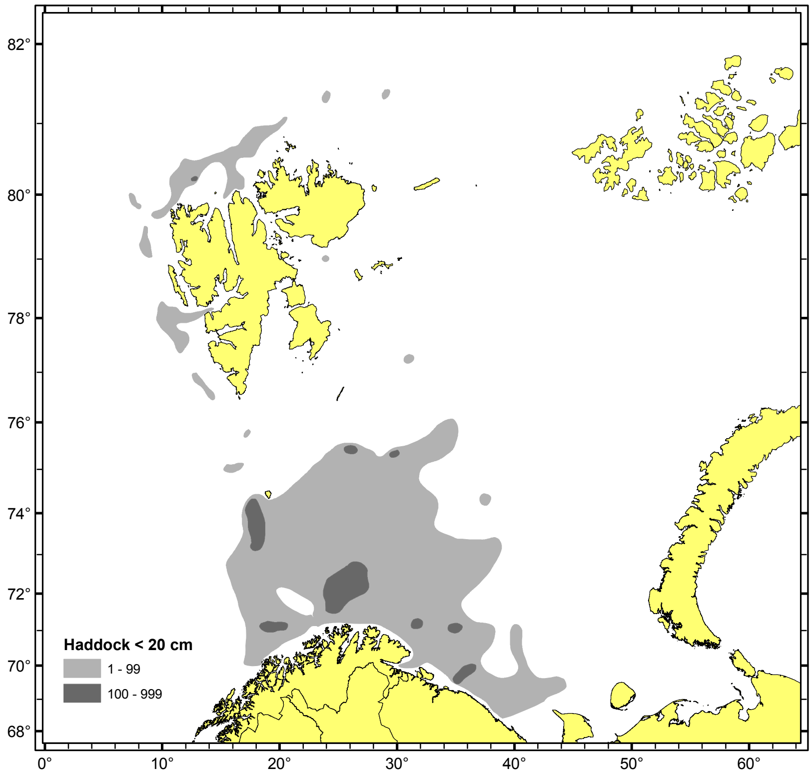


**Figure 3.4.6. Northeast Arctic haddock less than 20 cm. Geographical distribution (catch in numbers per hour of trawling) during the ecosystem survey in autumn 2004**

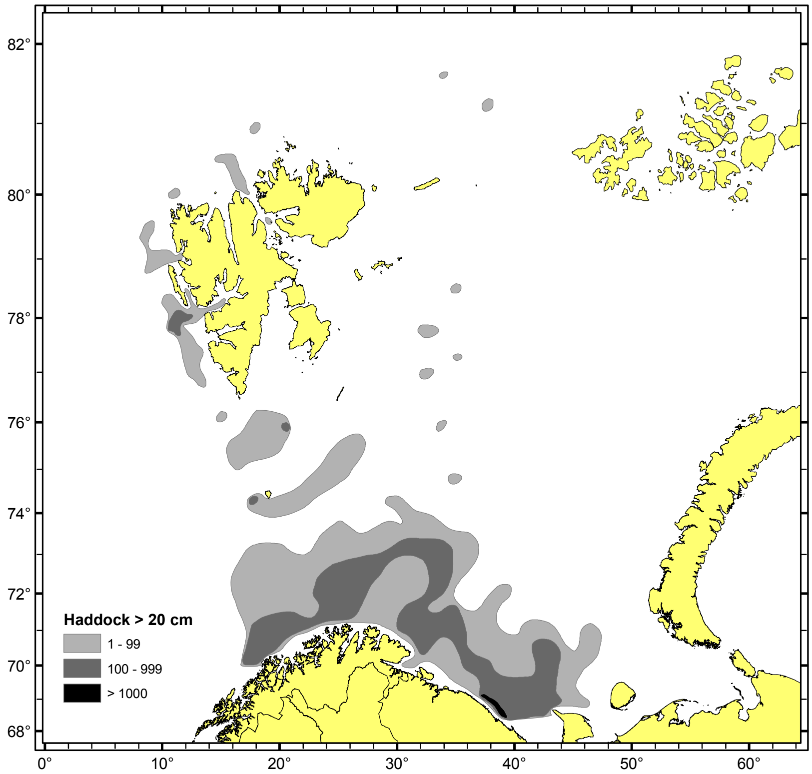


**Figure 3.4.7. Northeast Arctic haddock larger than 20 cm. Geographical distribution (catch in numbers per hour of trawling) during the ecosystem survey in autumn 2004**

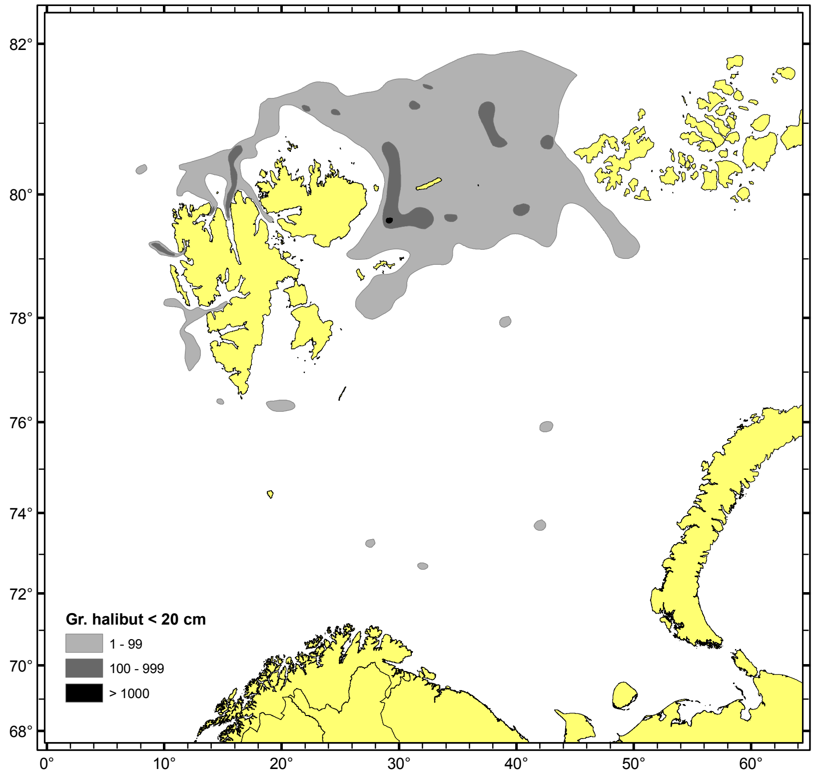


**Figure 3.4.8. Greenland halibut less than 20 cm. Geographical distribution (catch in numbers per hour of trawling) during the ecosystem survey in autumn 2004**

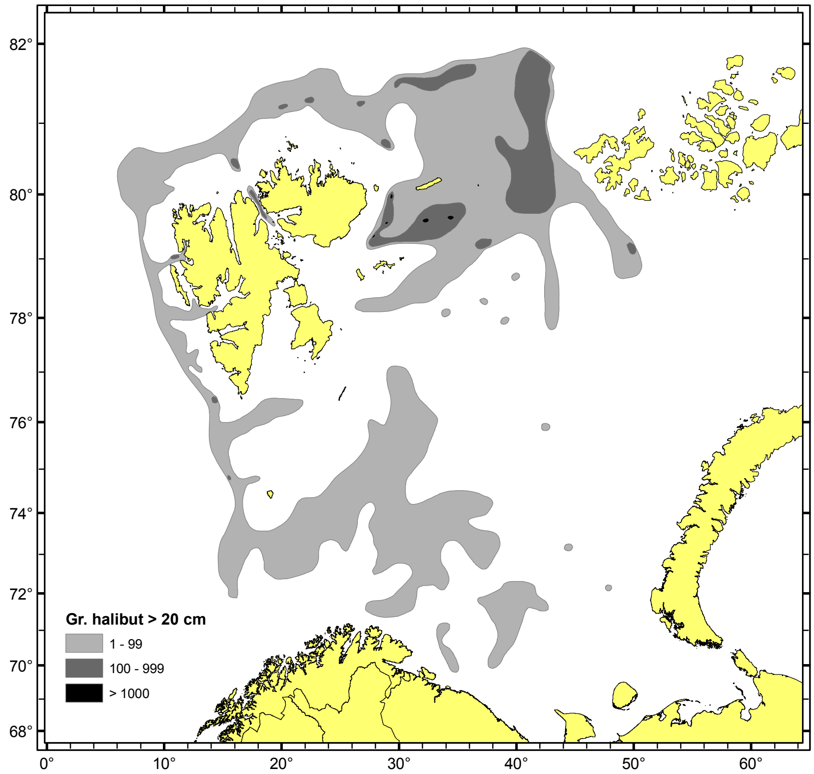


**Figure 3.4.9 Greenland halibut larger than 20 cm. Geographical distribution (catch in numbers per hour of trawling) during the ecosystem survey in autumn 2004**

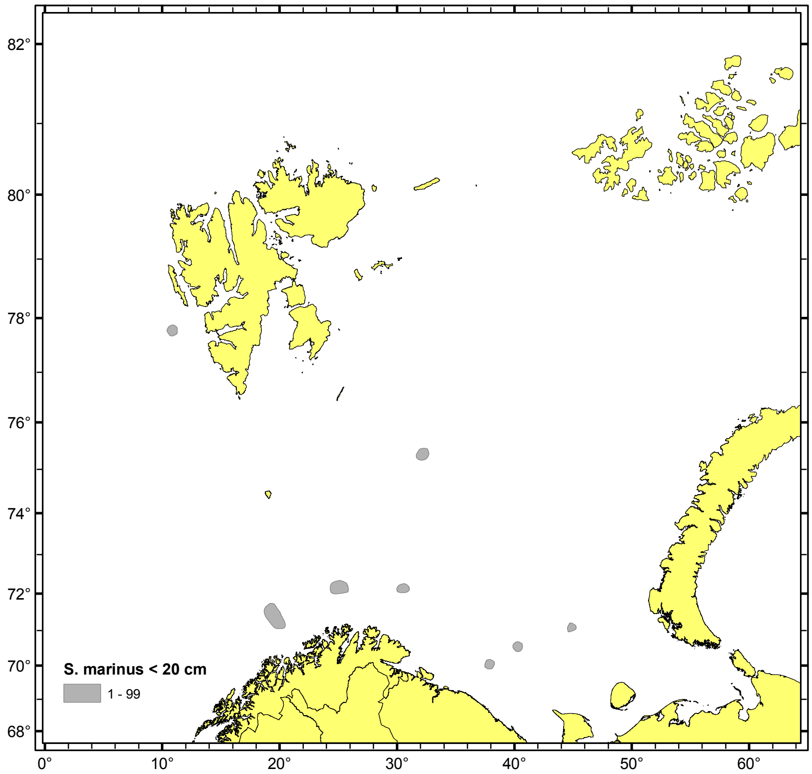


**Figure 3.4.10.** ***Sebastes marinus*** **less than 20 cm. Geographical distribution (catch in numbers per hour of trawling) during the ecosystem survey in autumn 2004**

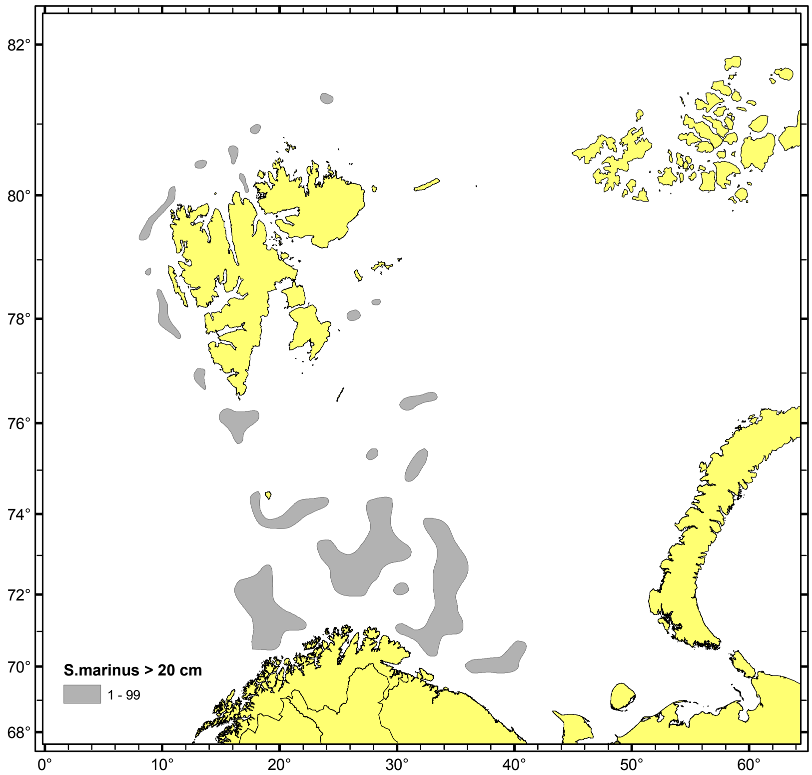


**Figure 3.4.11.** ***Sebastes marinus*** **larger than 20 cm. Geographical distribution (catch in numbers per hour of trawling) during the ecosystem survey in autumn 2004**

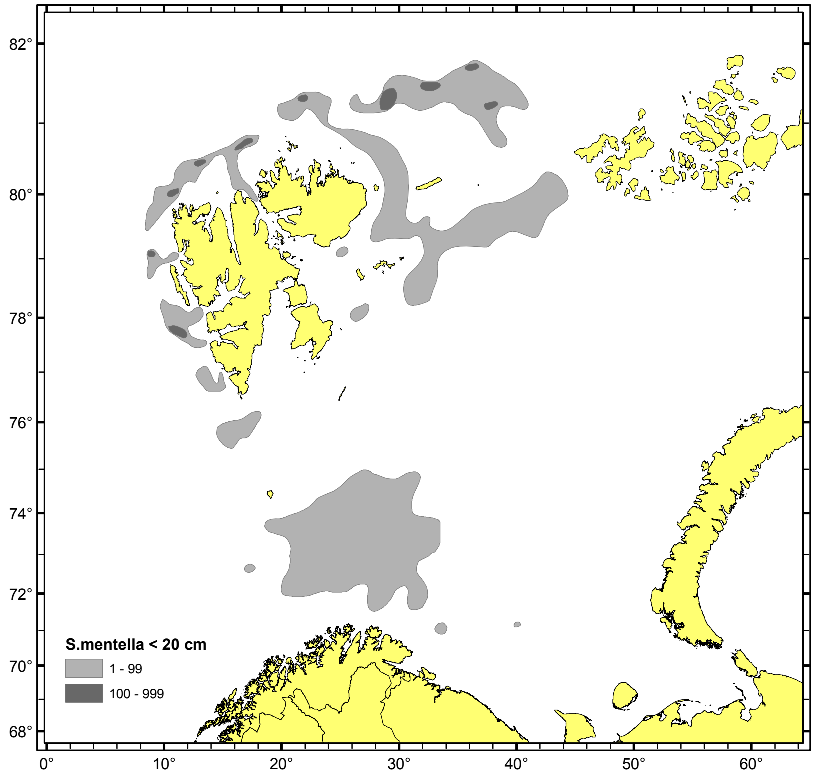


**Figure 3.4.12.** ***Sebastes mentella*** **less than 20 cm. Geographical distribution (catch in numbers per hour of trawling) during the ecosystem survey in autumn 2004**

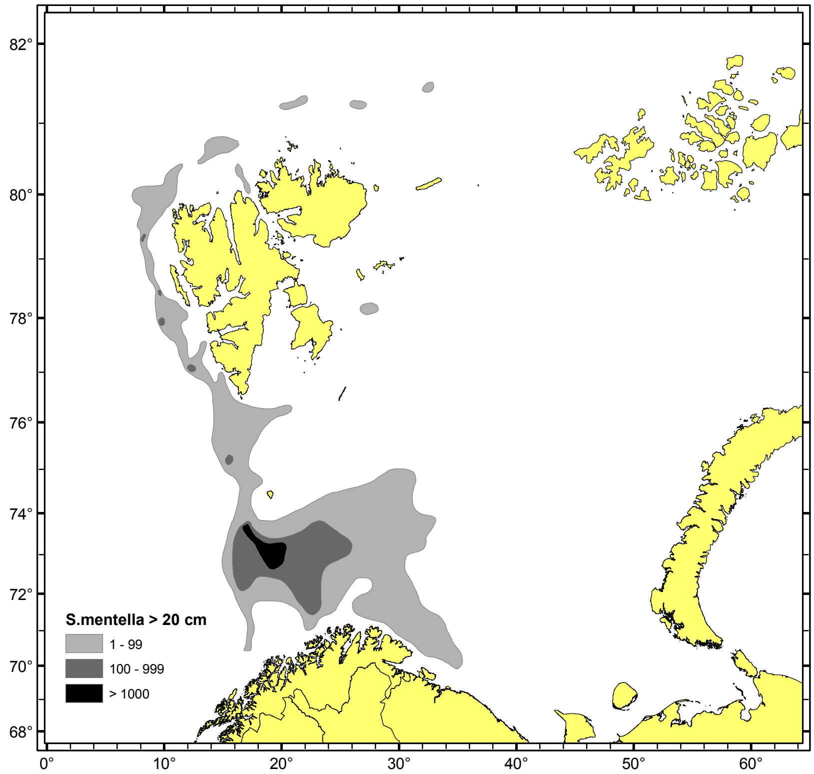


**Figure 3.4.13.** ***Sebastes mentella*** **larger than 20 cm. Geographical distribution (catch in numbers per hour of trawling) during the ecosystem survey in autumn 2004**

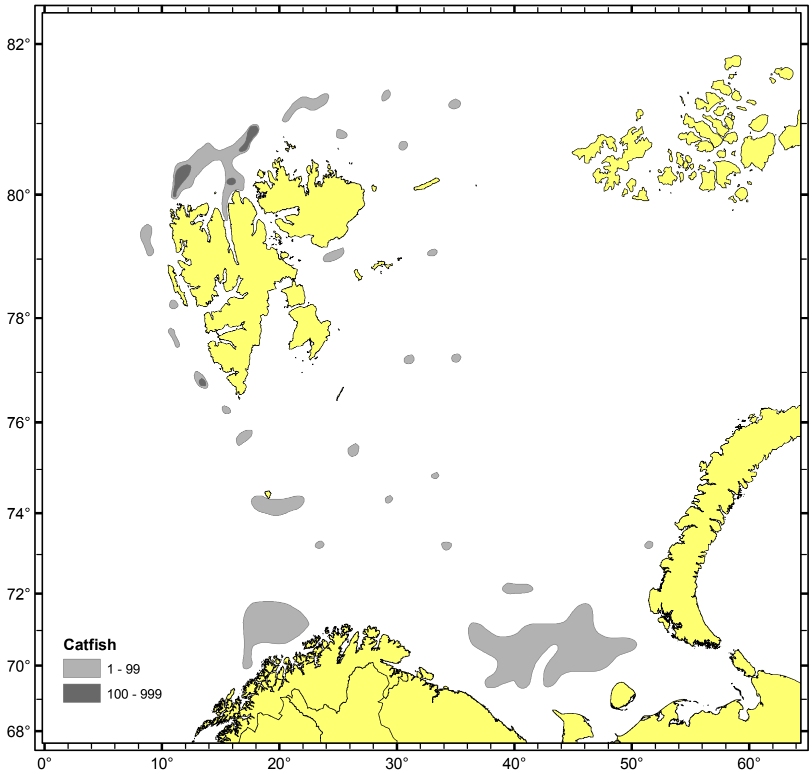


**Figure 3.4.14. Catfish. Geographical distribution (catch in numbers per hour of trawling) during the ecosystem survey in autumn 2004**

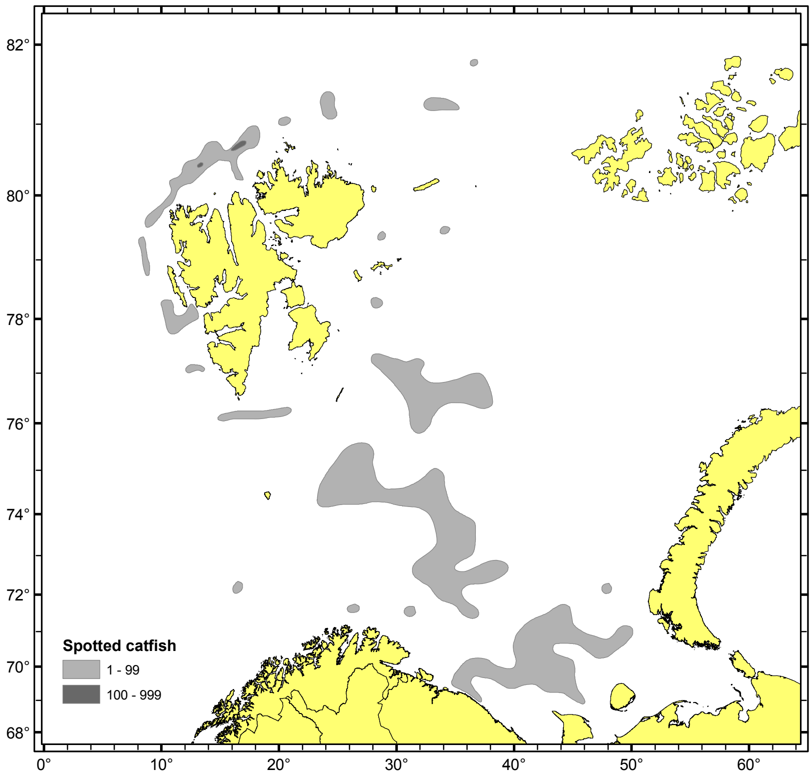


**Figure 3.4.15. Spotted catfish. Geographical distribution (catch in numbers per hour of trawling) during the ecosystem survey in autumn 2004**

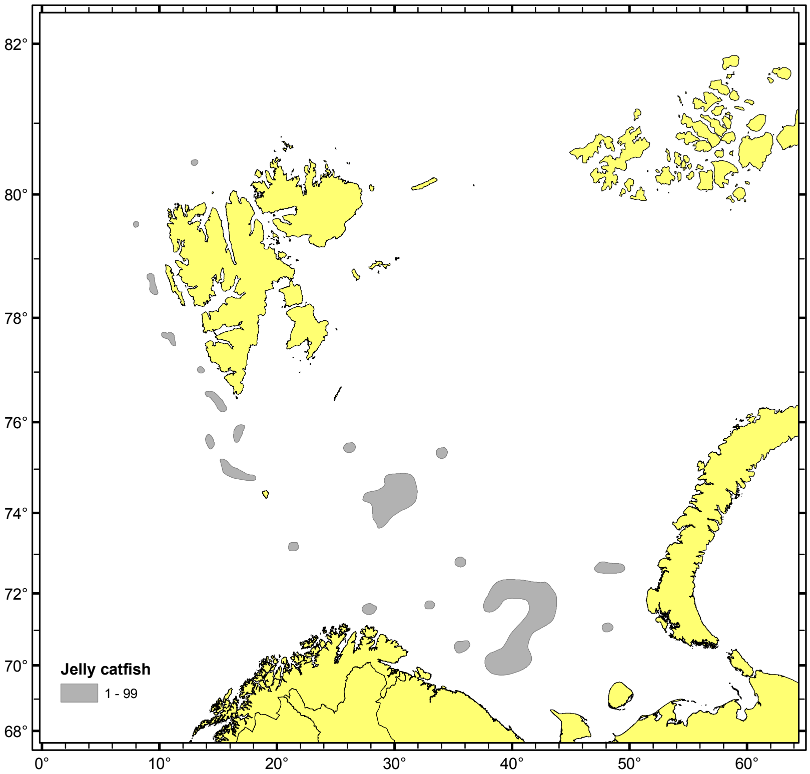


**Figure 3.4.16. Jelly catfish. Geographical distribution (catch in numbers per hour of trawling) during the ecosystem survey in autumn 2004**

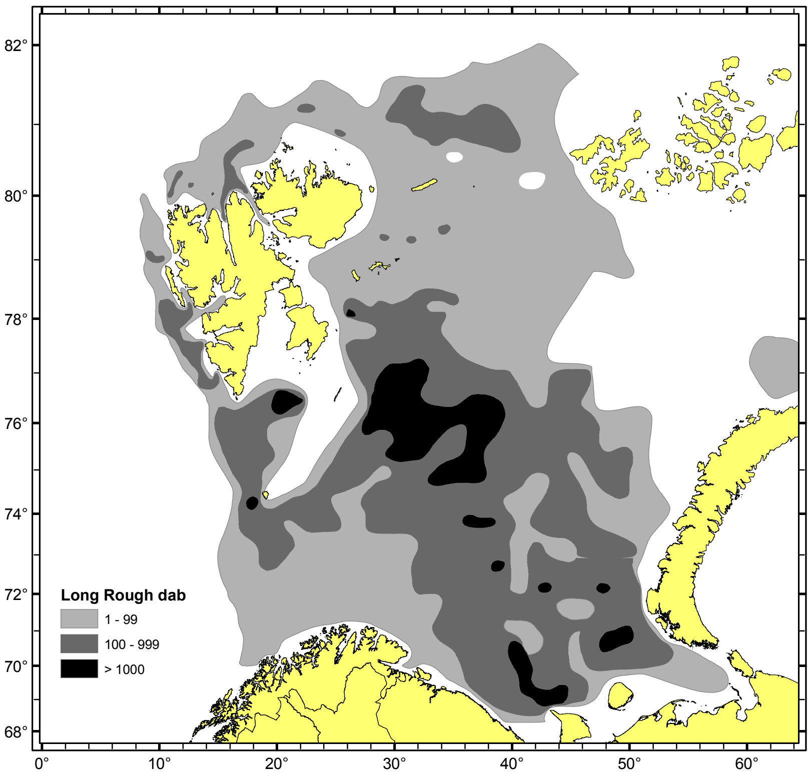


**Figure 3.4.17. Long rough dab. Geographical distribution (catch in numbers per hour of trawling) during the ecosystem survey in autumn 2004**

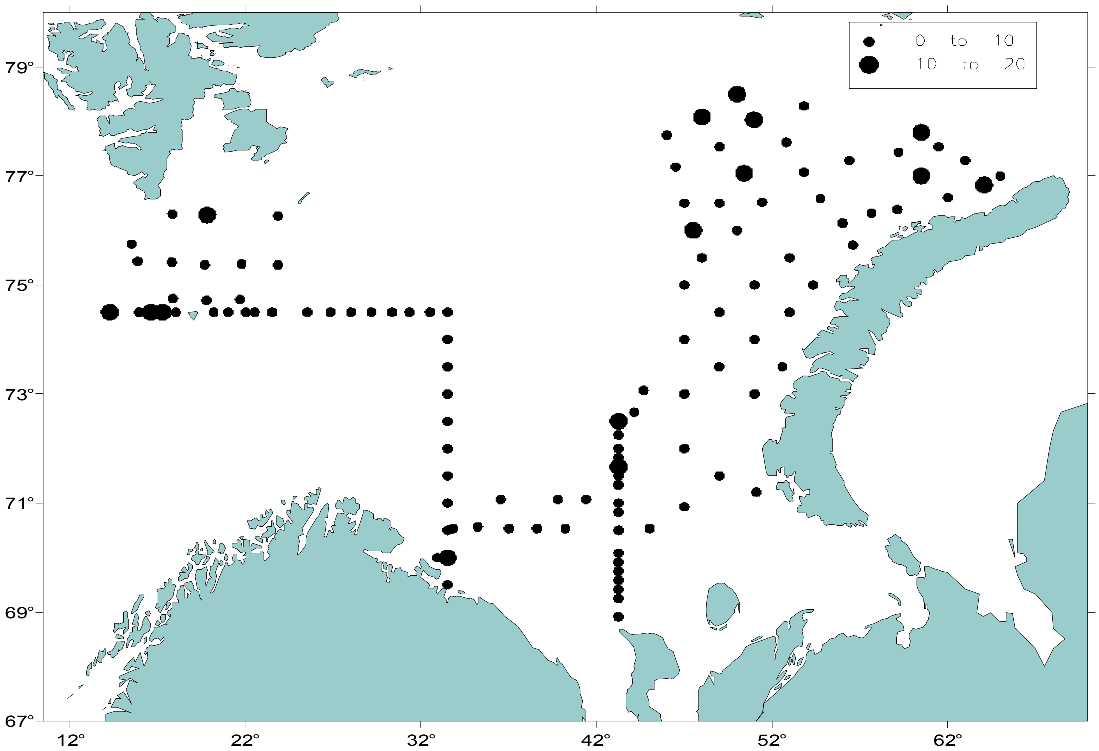


**Figure 4.2.1. Plankton biomass (dry weight, g/m$^2$) in the Barents Sea in bottom-0 m layer by Juday net catches in August-September 2004 (r/v "F. Nansen")**

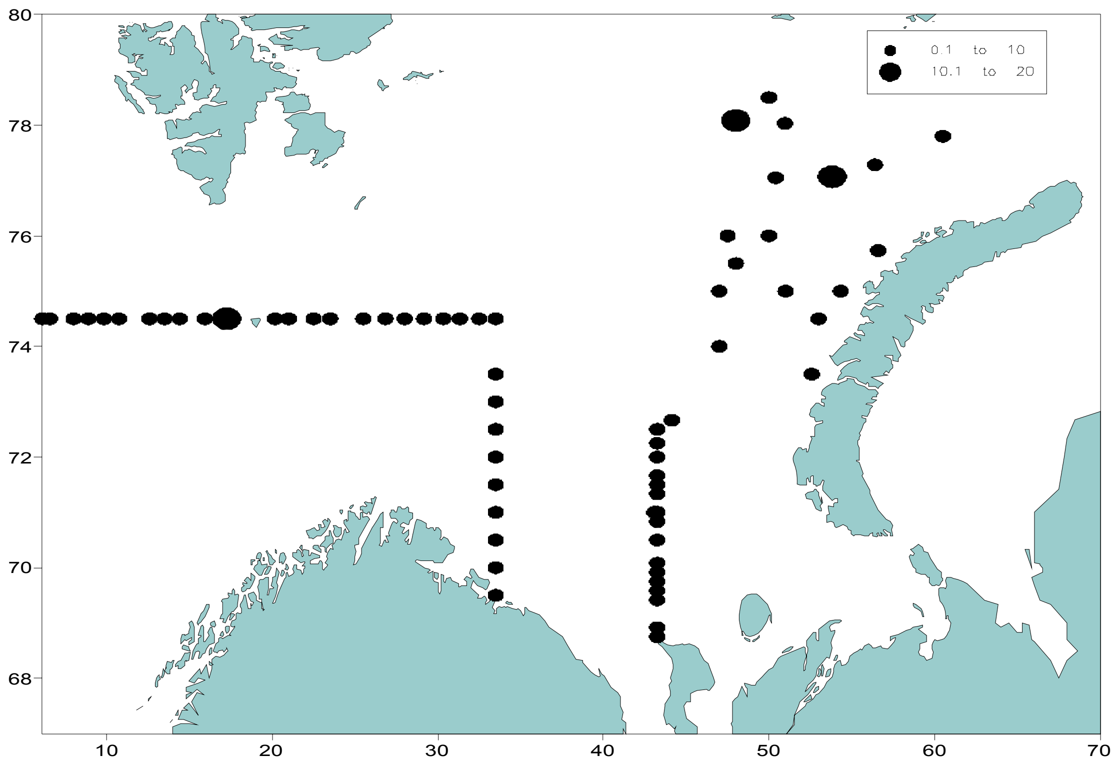


**Figure 4.2.2. Plankton biomass (dry weight, g/m$^2$) in the Barents Sea in 0-50 m layer by WP-2 net catches in August-September 2004 (r/v "F. Nansen")**

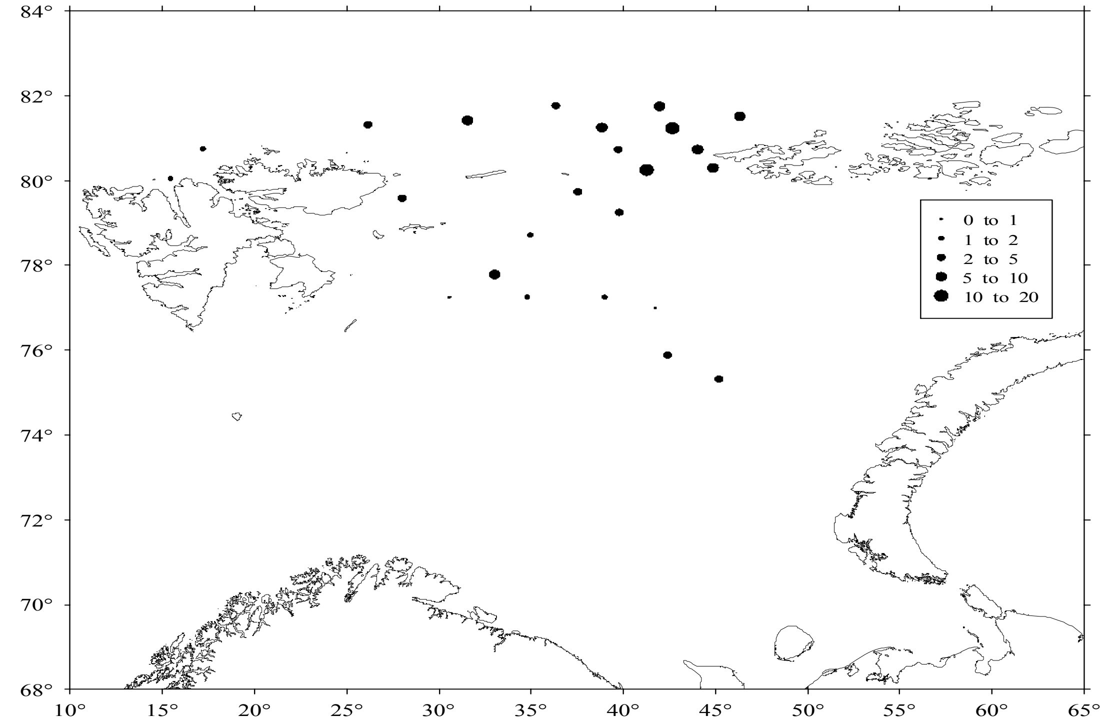


**Figure 4.2.3. Plankton biomass (dry weight, g m$^2$) in the Barents Sea in 50-0 m layer by Juday net catches in August-September 2004 (r/v "Smolensk")**

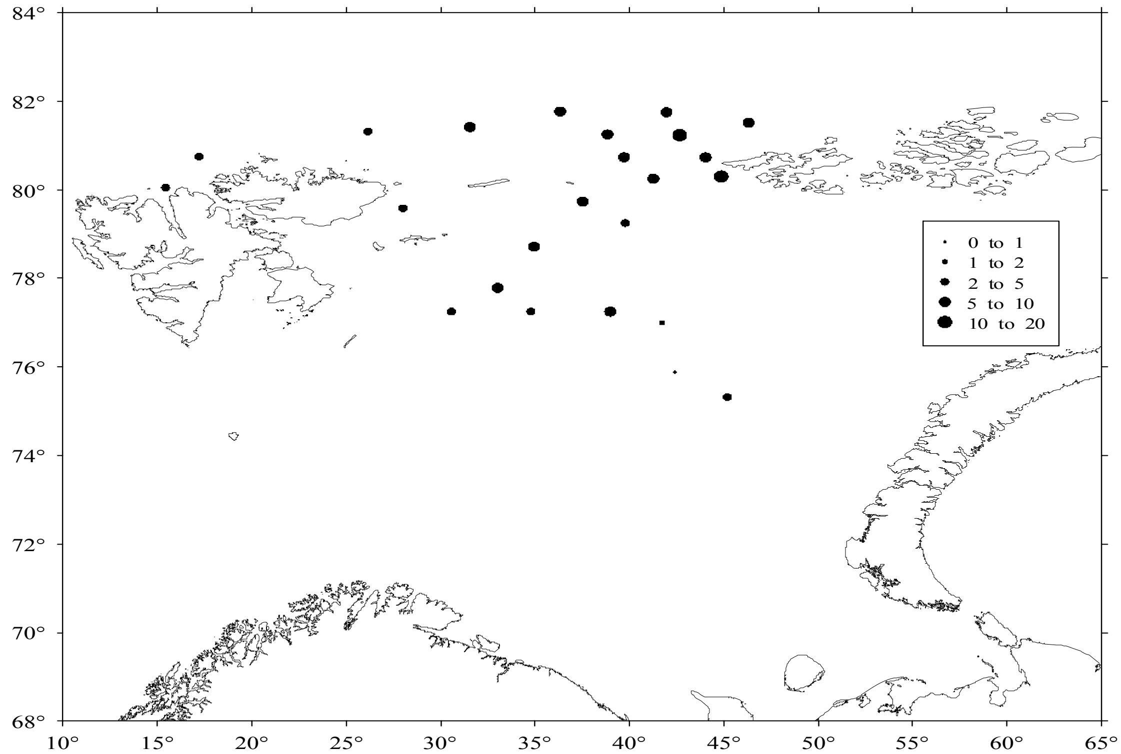


**Figure 4.2.4. Plankton biomass (dry weight, g m$^2$) in the Barents Sea in 100-0 m layer by Juday net catches in August-September 2004 (r/v "Smolensk")**

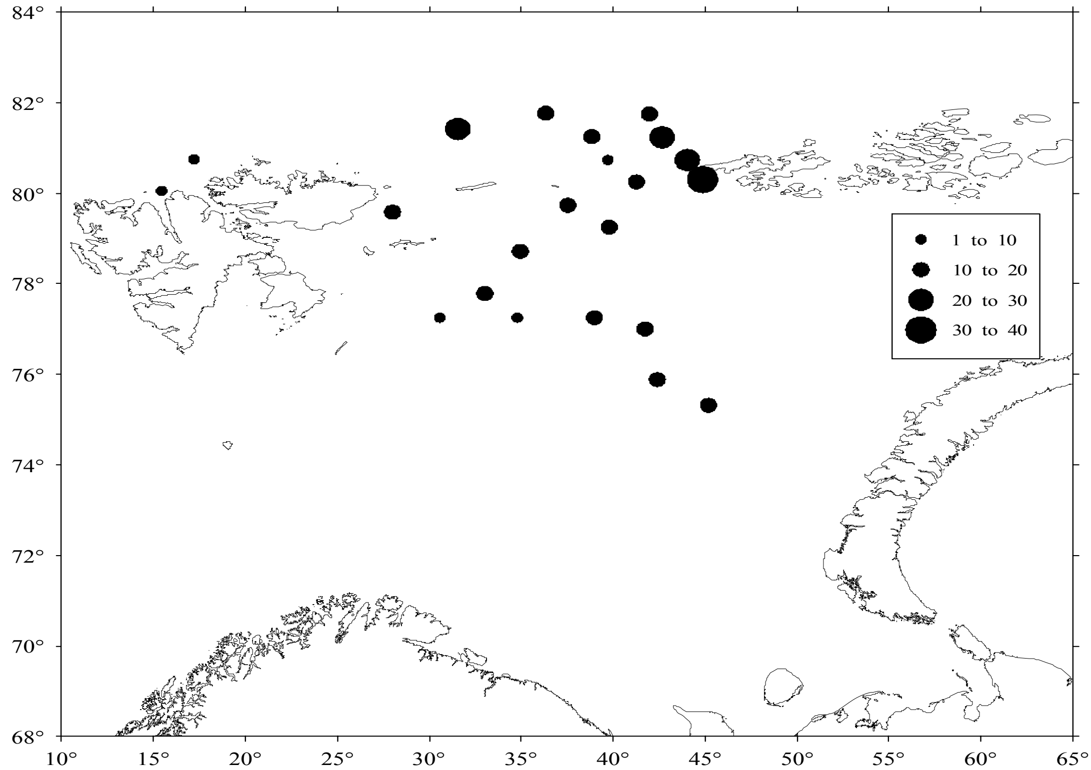


**Figure 4.2.5. Plankton biomass (dry weight, g m$^2$) in the Barents Sea in bottom-0 m layer by Juday net catches in August-September 2004 (r/v "Smolensk")**

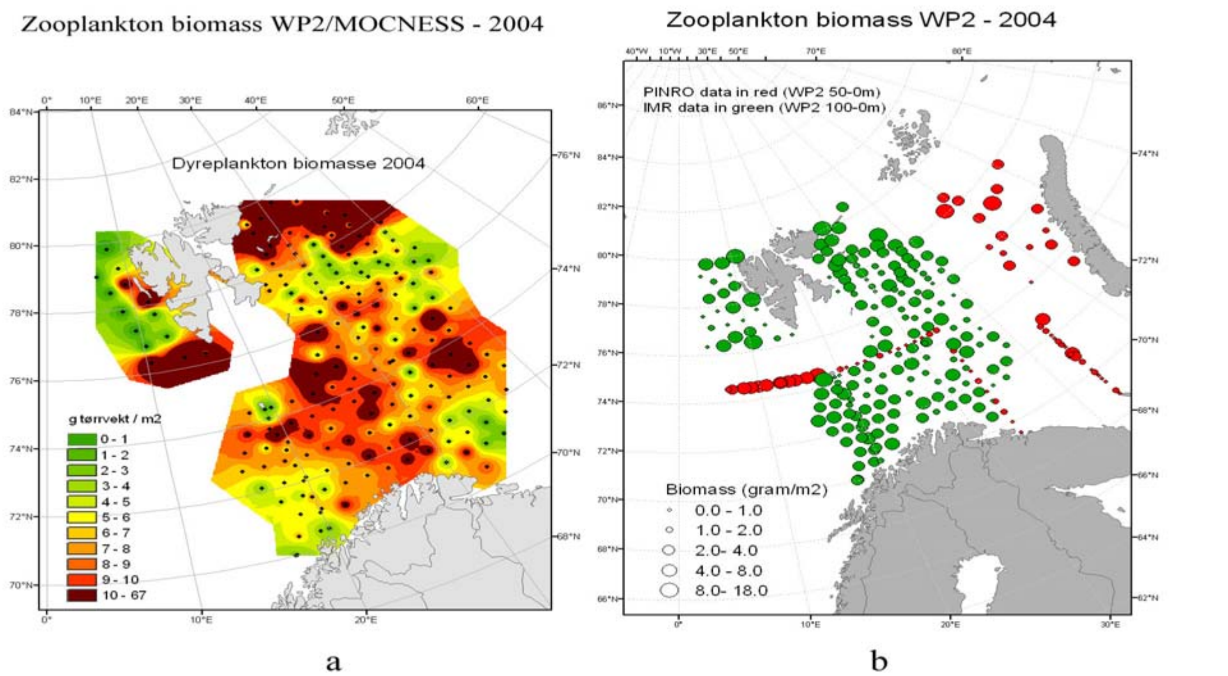


**Figure 4.2.6. Horizontal distribution of zooplankton in 2004 (g dry weight m$^2$ from bottom - 0 m) based on WP2 and MOCNESS (a) and horizontal distribution of zooplankton (g dry weight m$^2$ from 100 - 0 m and 50-0m) based on WP2 (b)**

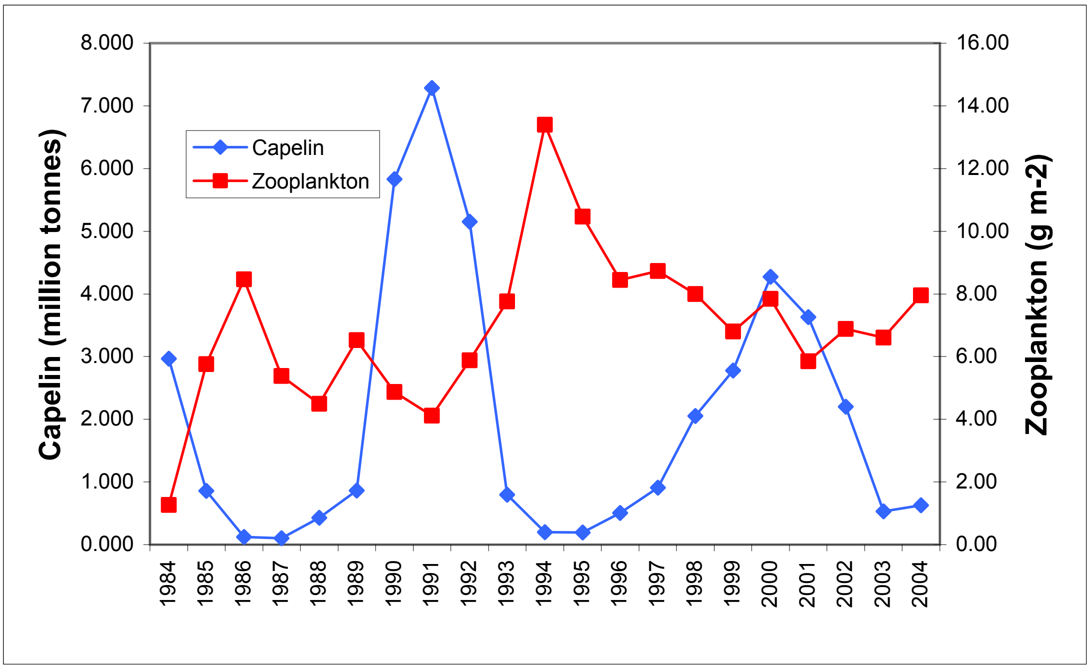


**Figure 4.2.7. Annual fluctuations in zooplankton biomass and size of capelin stock in the Barents Sea**

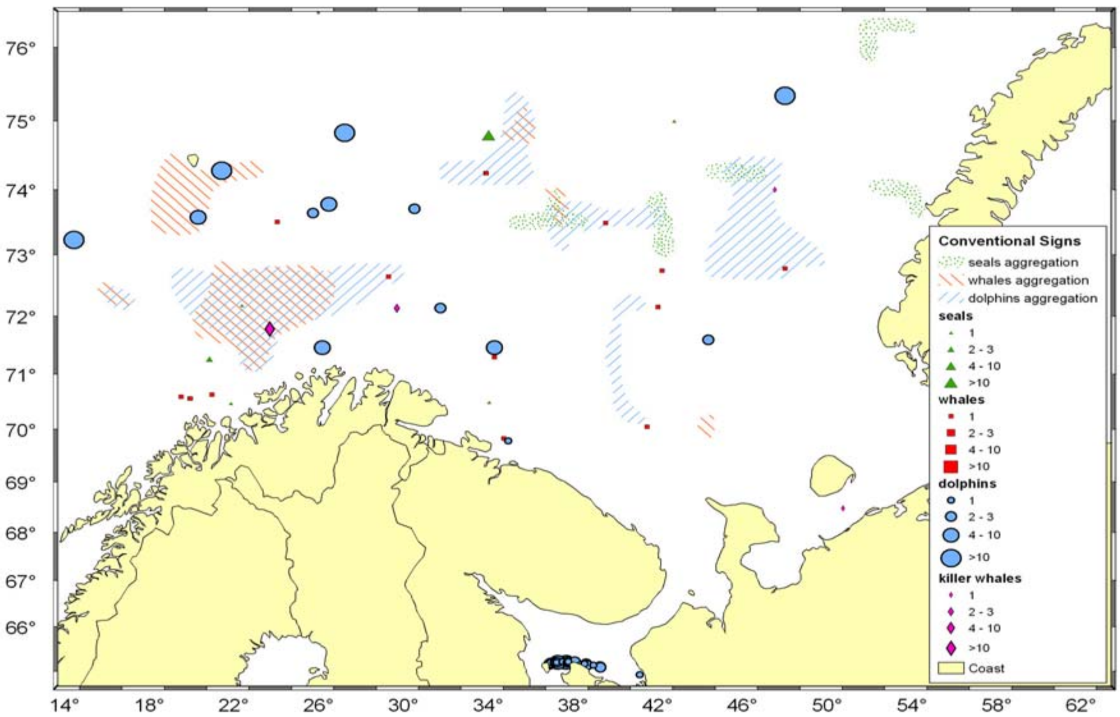


**Figure 5.2.1 Distribution of marine mammals in the Barents Sea in August 2004 according to ship- and airborne observations**

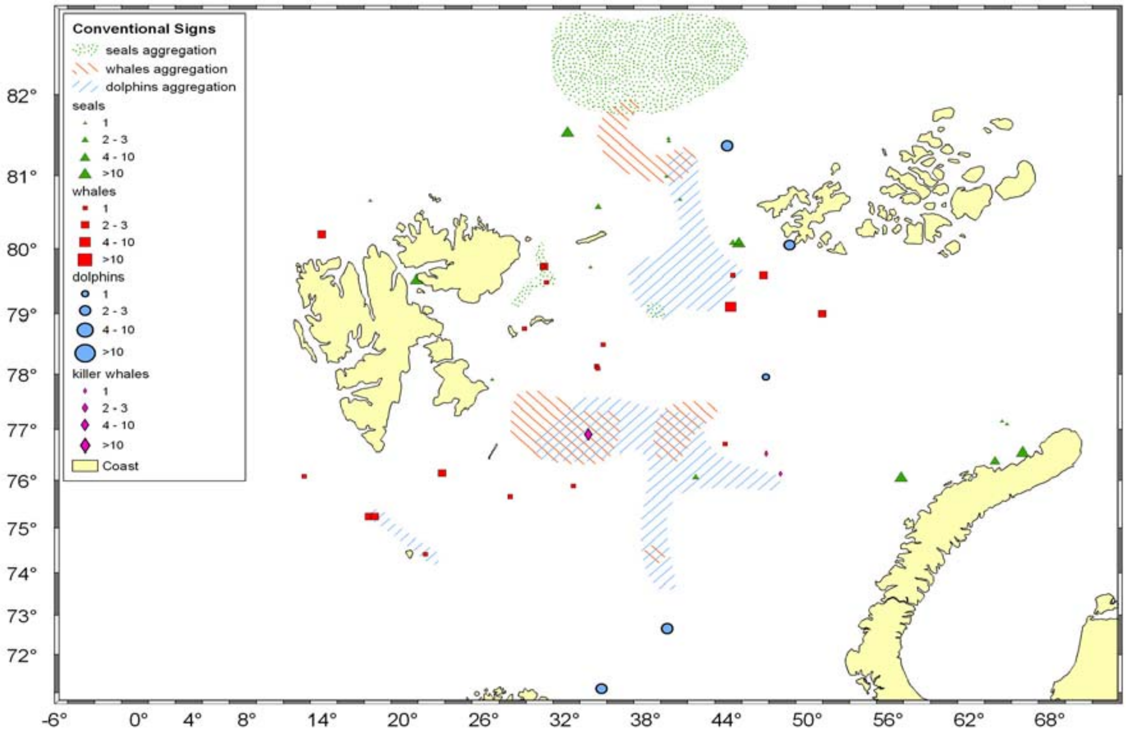


**Figure 5.2.2. Distribution of marine mammals in the Barents Sea according to aerial surveys by research aircraft An-26 "Arctica" from 17 till 30 September 2004 and ship-borne observations in September 2004**

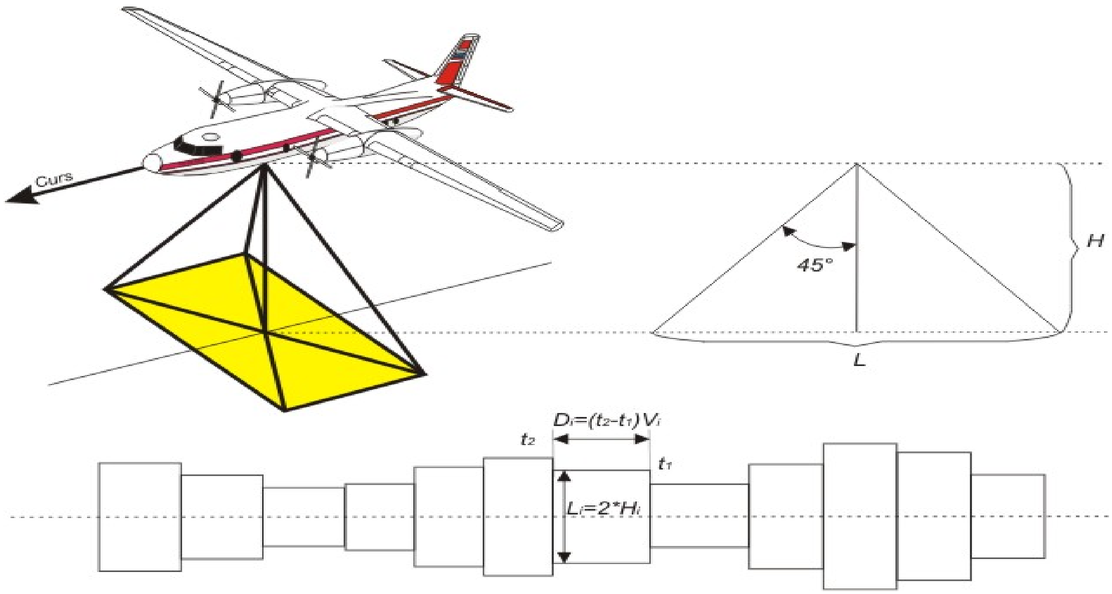


**Figure 6.1.1. An outline of primary bird abundance data collection procedure along survey transects (where: $t_1$ and $t_2$ - times of count; V – aircraft speed; H – flight altitude; L – width of visual strip)**

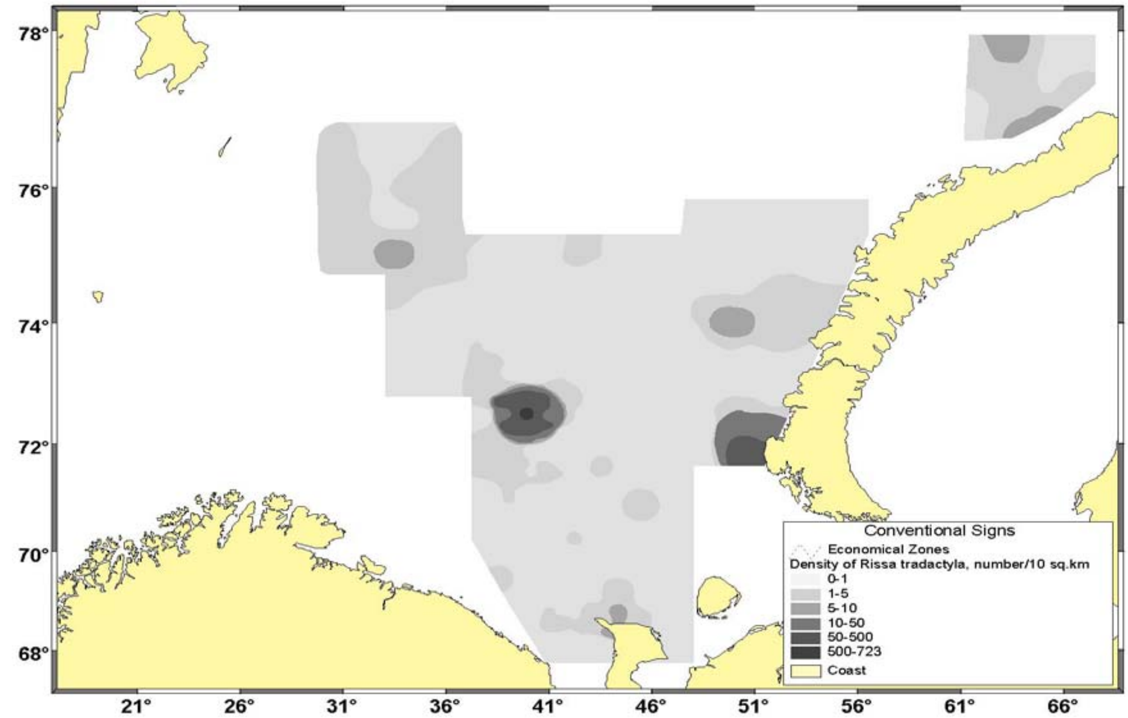


**Figure 6.2.2. Distribution of black-legged kittiwake in the Barents Sea in the period from 20 August till 5 September 2003**

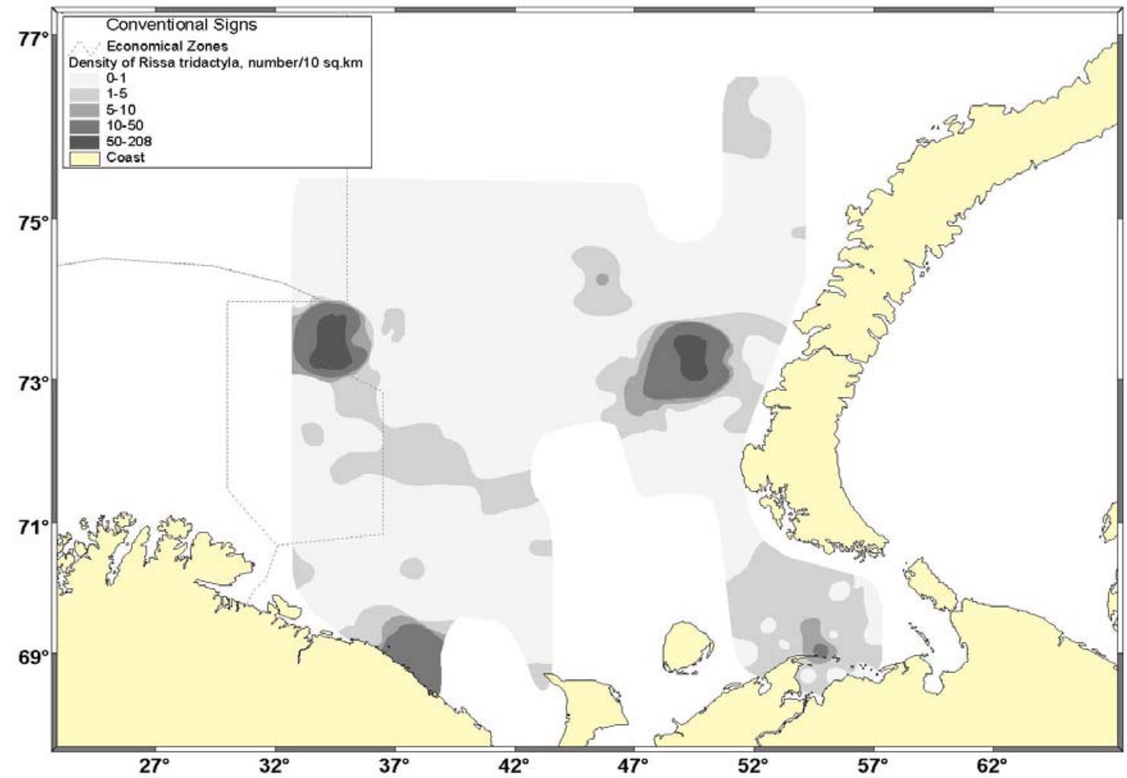


**Figure 6.2.3. Distribution of black-legged kittiwake in the Barents Sea in the period from 22 August till 3 September 2004**

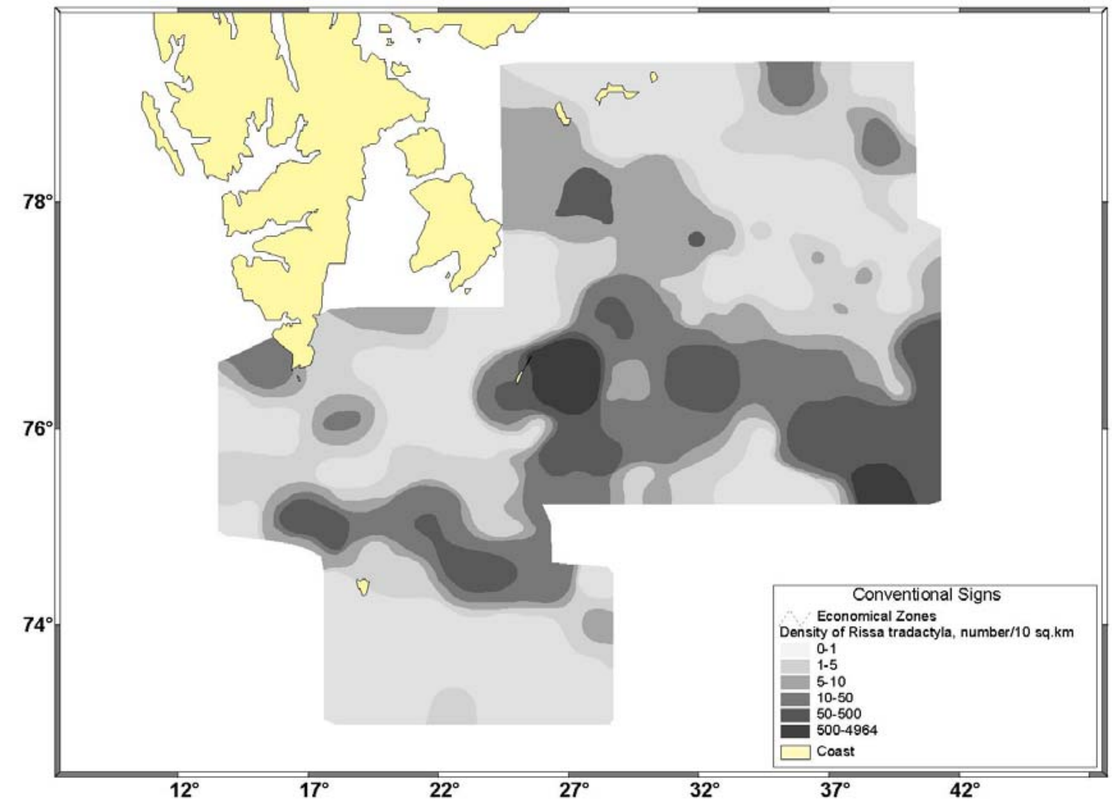


**Figure 6.2.4. Distribution of black-legged kittiwake in the Barents Sea in the period from 16 September till 1 October 2003**

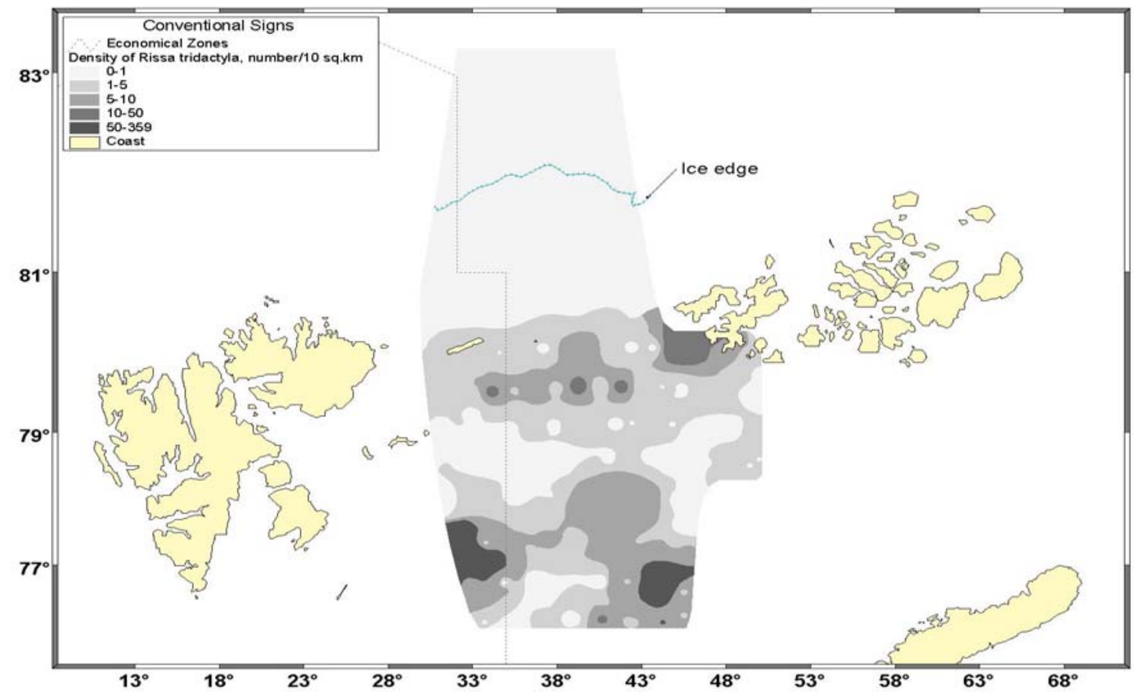


**Figure 6.2.5. Distribution of black-legged kittiwake in the Barents Sea in the period from 17 till 30 September 2004**

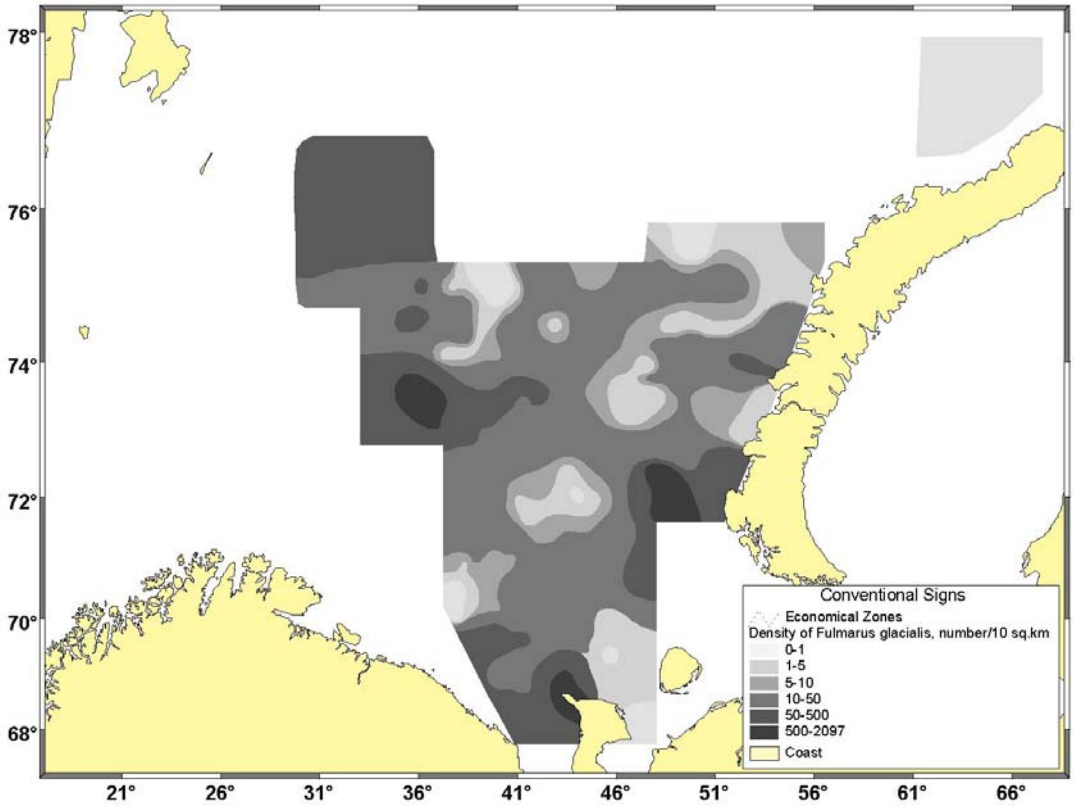


**Figure 6.2.6. Distribution of northern fulmar in the Barents Sea in the period from 20 August till 5 September 2003**

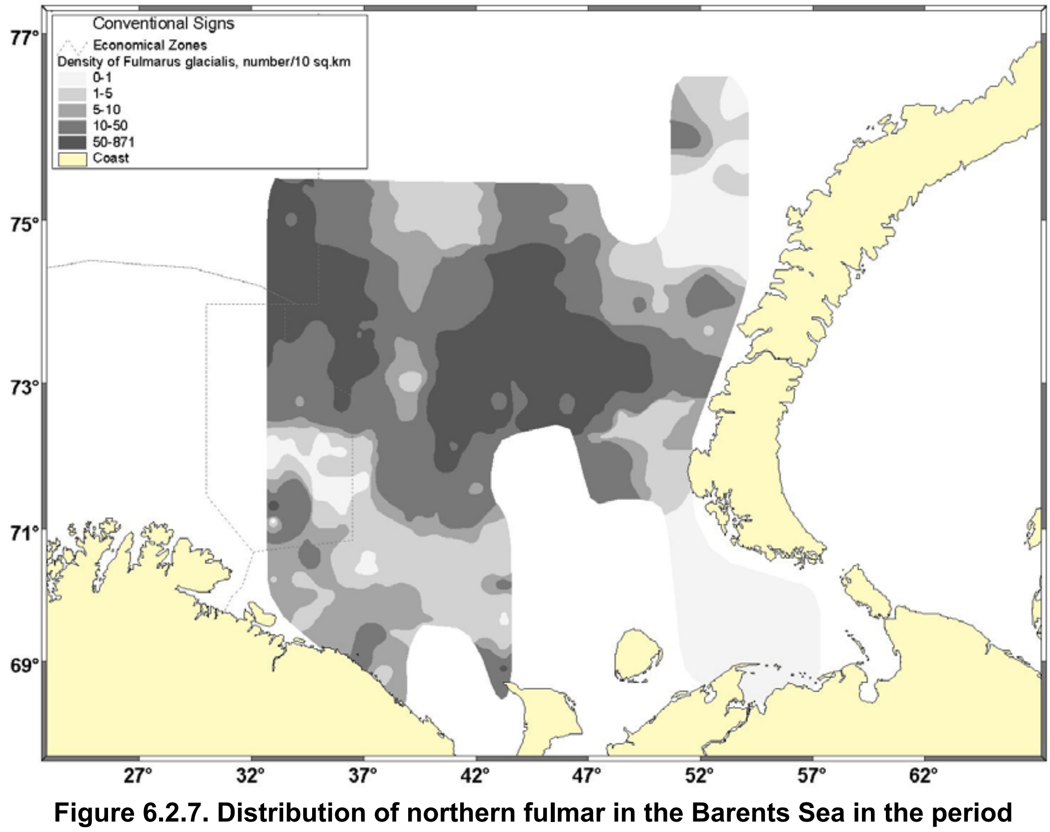


**Figure 6.2.7. Distribution of northern fulmar in the Barents Sea in the period from 22 August till 3 September 2004**

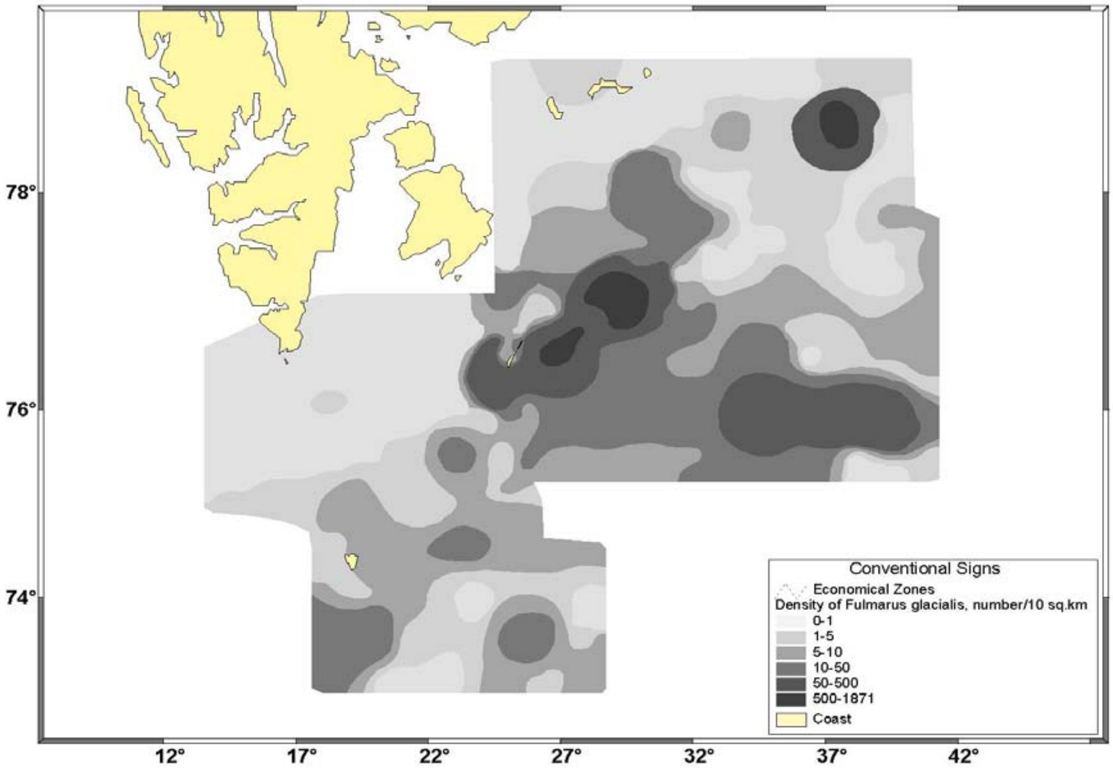


**Figure 6.2.8 Distribution of northern fulmar in the Barents Sea in the period from 16 September till 1 October 2003**

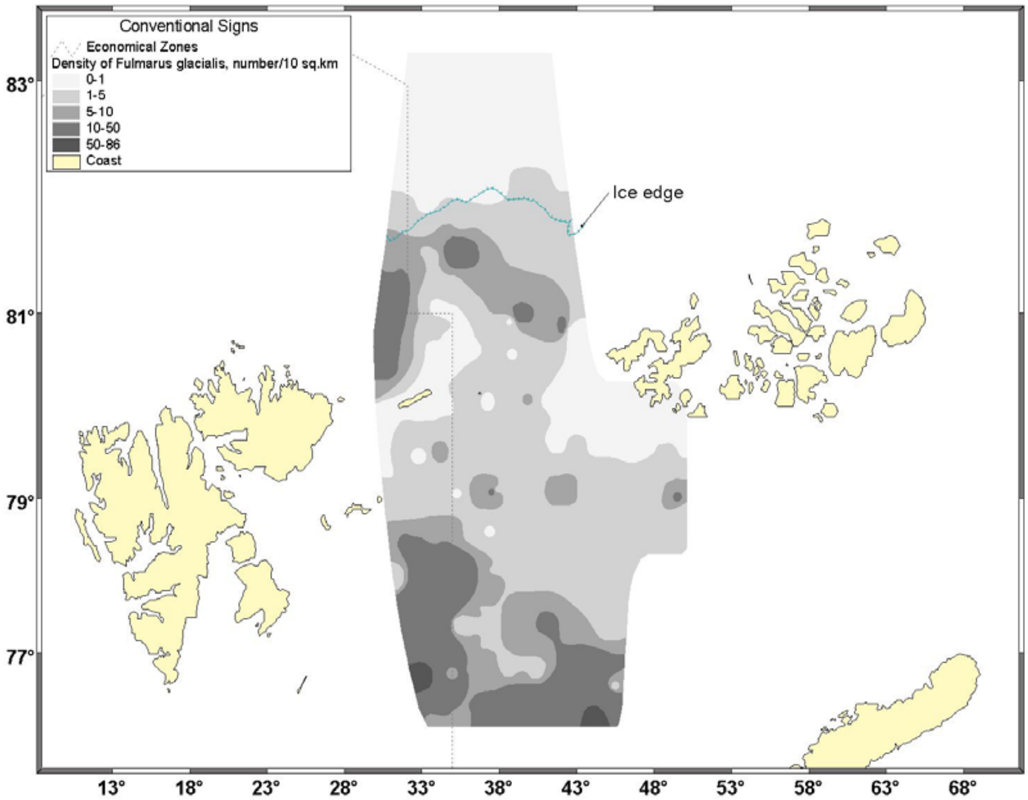


**Figure 6.2.9. Distribution of northern fulmar in the Barents Sea in the period from 17 till 30 September 2004**

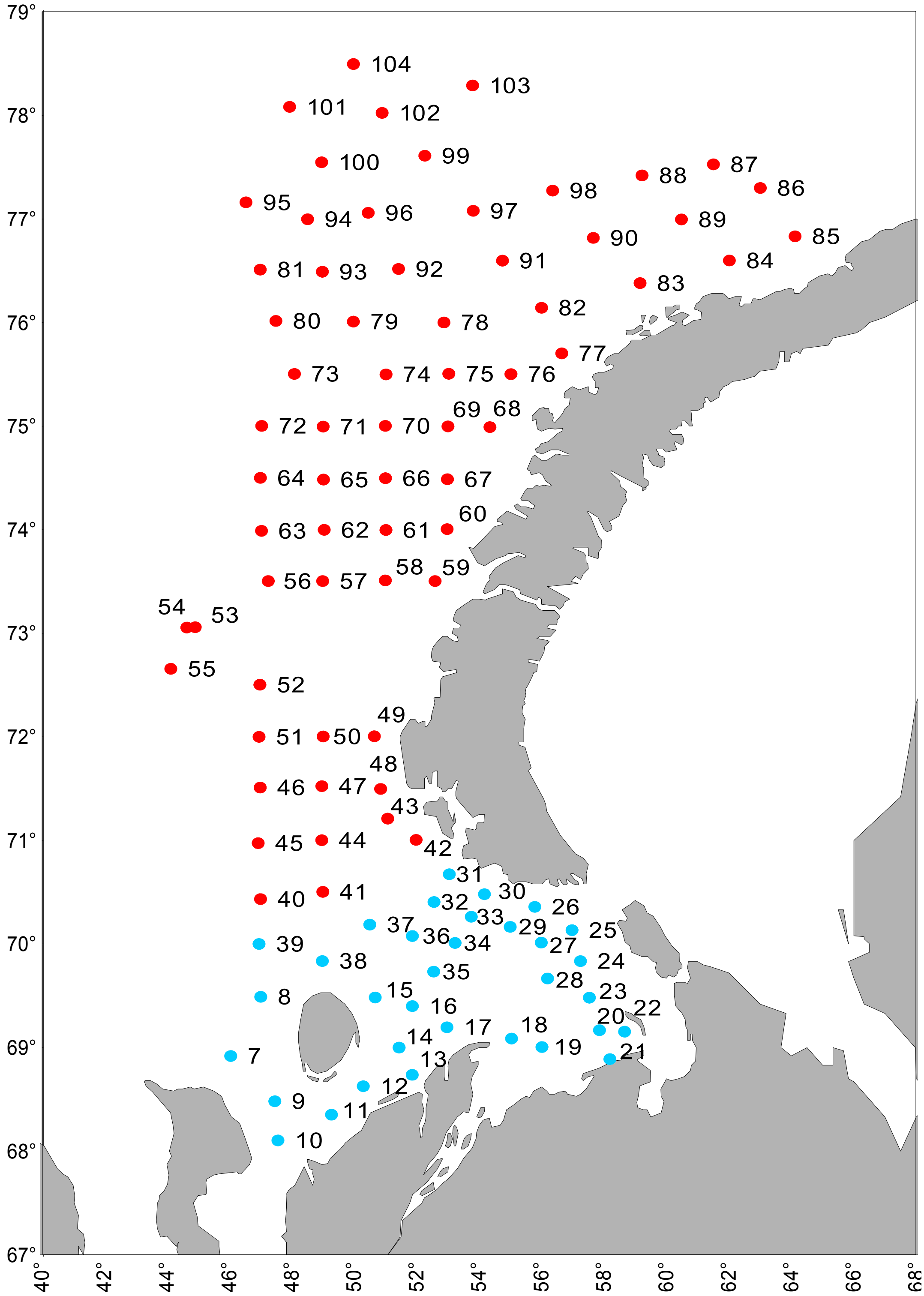


**Figure 7.2.1. Chart of benthos stations made by the R/V "Smolensk", from 05.08.04 to 20.08.04 (symbols are painted in blue) and by the R/V "Fridtjof Nansen", from 20.08.04 to 19.09.04 (symbols are painted in red)**

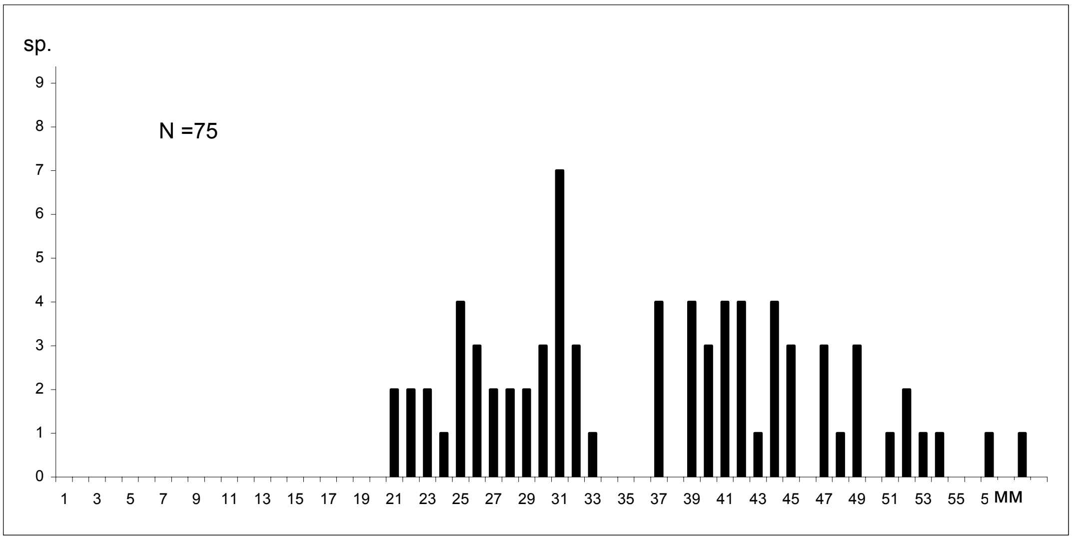


**Figure 7.2.2. Size structure of Strongylocentrotus spp. community at station 48 on the data of mass measurements of trawl catch**

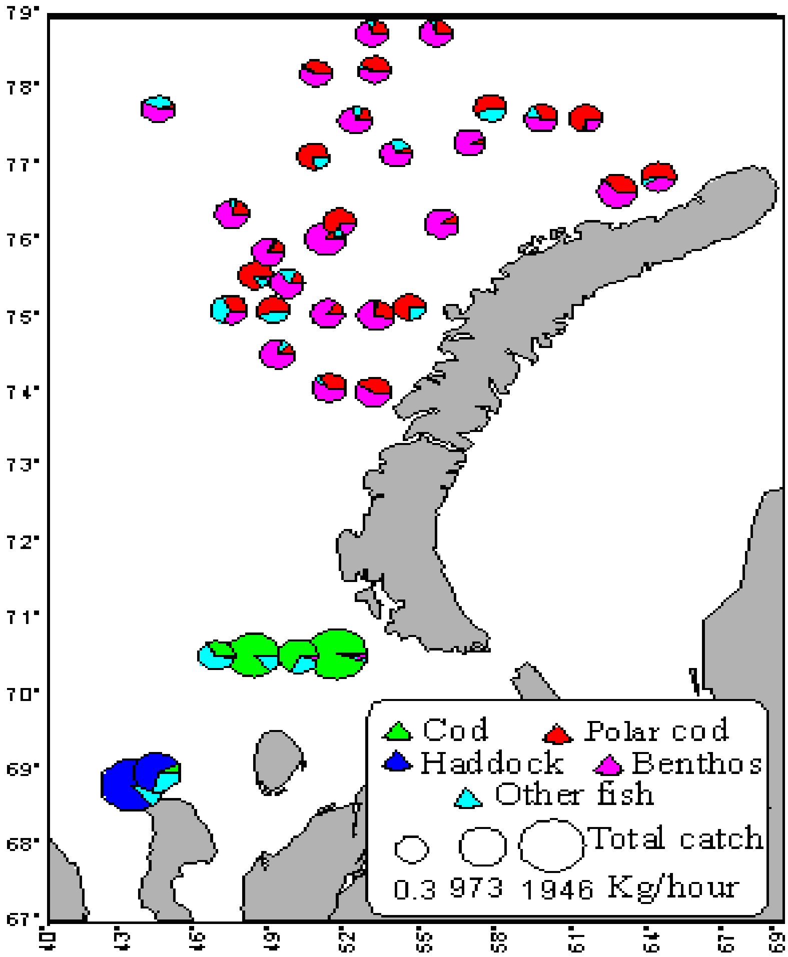


**Figure 7.2.3. Examples of catches bottom trawling in the Eastern Barents Sea and ratio of zoo benthos by catch to fish catches**

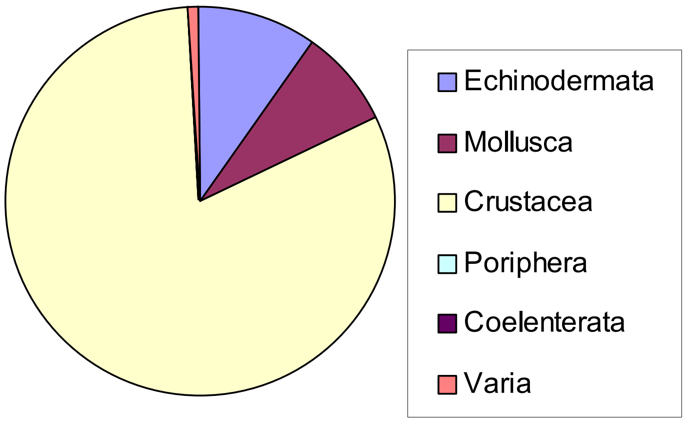


**Figure 7.2.4. Ratio between the taxonomical groups of bottom invertebrates in ichthyological trawl catches in the South-Eastern Barents Sea**

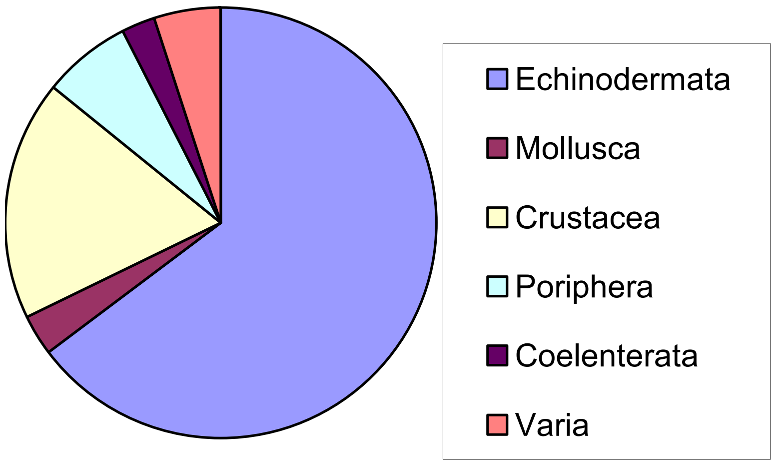


**Figure 7.2.5. Ratio between the taxonomical groups of bottom invertebrates in ichthyological trawl catches in the North-Eastern Barents Sea**

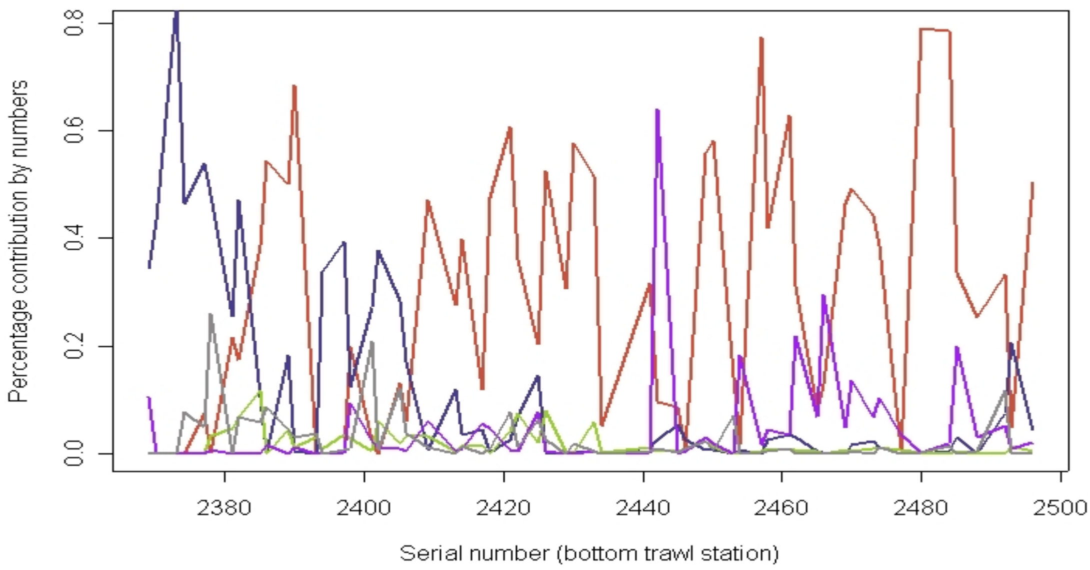


**Figure 7.4.1. Percentage contribution by numbers for the five most common species in terms of presence at stations. Red: *Ctenodiscus crispata,* Blue: *Pontaster tenuispinus,* Green: *Astarte crenata,* Purple: *Ophiura sarsi,* Grey: *Actiniarida sp.***

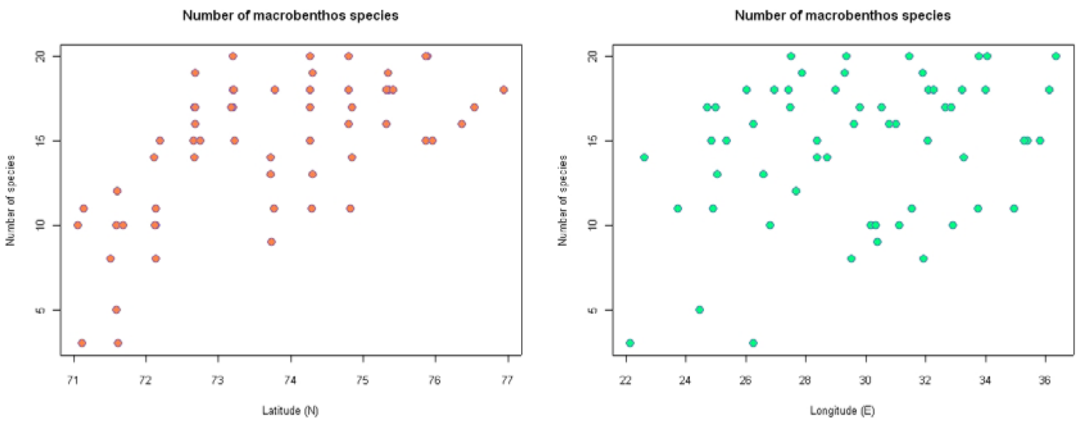


**Figure 7.4.2. Number of species in bottom-trawl hauls by latitude and longitude**

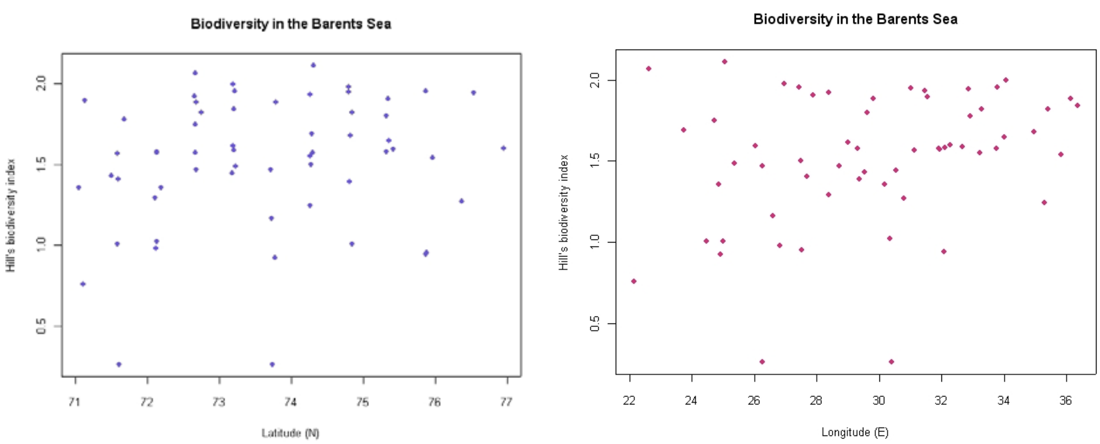


**Figure 7.4.3. Biodiversity (Hill's index) in bottom trawl samples (non-fish only) in the Barents Sea by latitude and longitude**

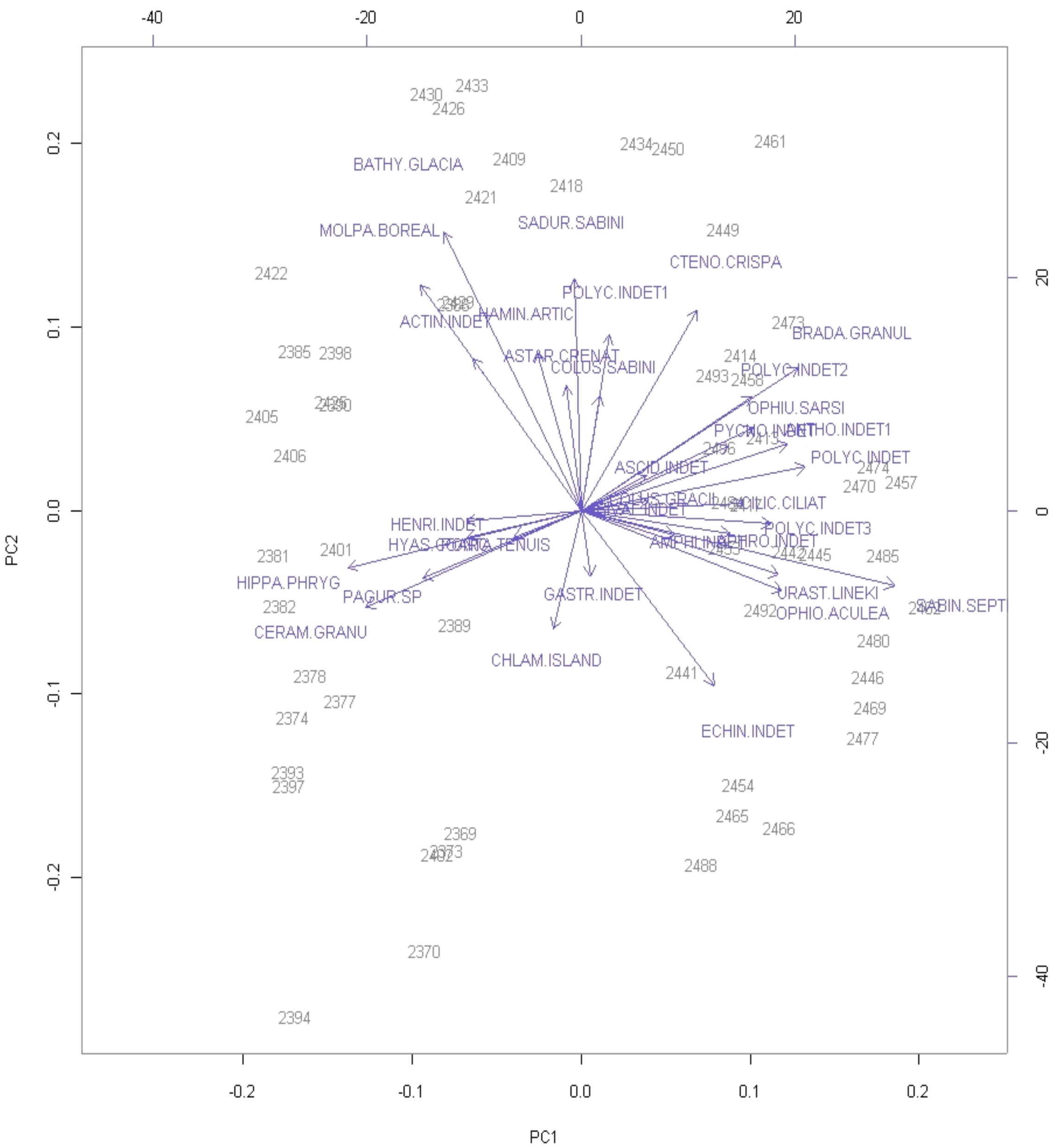


**Figure 7.4.4. Biplot of principal component analysis of proportion of biomass by each species at each station. Scores of stations (grey) and loadings of the different species (blue). The data has been log-transformed to clarify the relationships between the species**

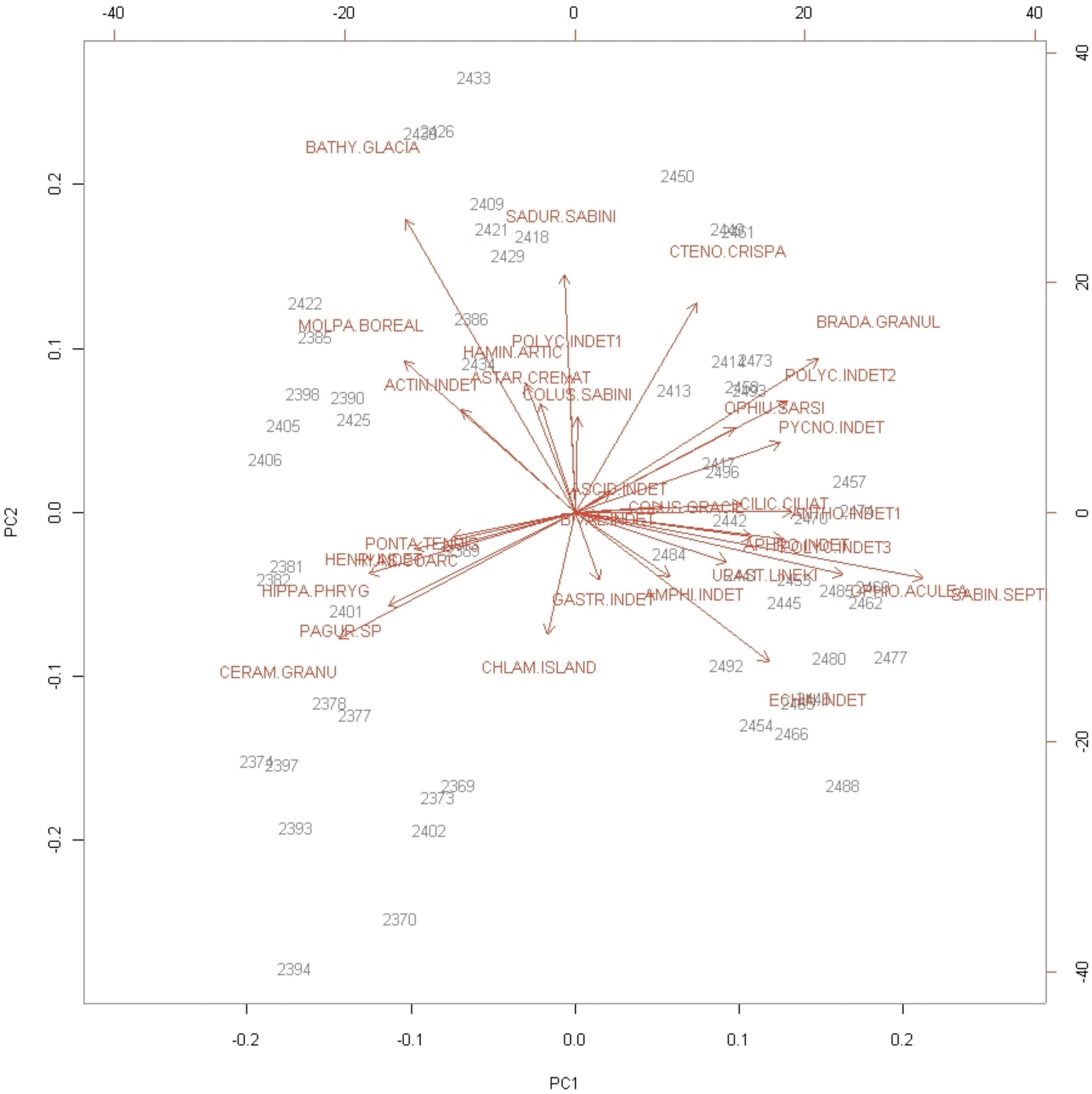


**Figure 7.4.5. Biplot of principal component analysis of proportion of numbers by each species at each station. Scores of stations (grey) and loadings of the different species (red). The data has been log-transformed to clarify the relationships between the species**

# APPENDIX 1

Ecosystem survey 2004

| Research vessel | Participants |
|---|---|
| **“Smolensk”** (06/08-03/10) | G. Zuikov, V. Kapralov, S. Klinushkin (06-20/8), P. Lyubin (06-20/8), N. Mukhina, A. Nikifirov, D. Prozorkevich (cruise leader), T. Prokhorova, S. Ratushnyy, O. Sazhenkov, I. Trofimov, S. Kharlin, T. Yusupov |
| **“F. Nansen”** (07/08-03/10) | A. Amelkin, T. Gavrilik, I. Dolgolenko (cruise leader), S. Ivanov, R. Klepikovsky, S. Klinushkin (21/8-03/10), A. Klyuykov, P. Lyubin (21/8-03/10), P. Murashko, V. Popov, T. Semochkina, V. Sergeev, T. Sergeeva, V. Tataurov, N. Torgunova, L. Shibaev, N. Zozulya, V. Zubarevich, V. Zubov |
| **”J. Hjort”** (01/08-04/10) | **Part 1 (01/08-12/08):** S. Aanes (cruise leader), O.O. Arnøy, K.B. Eriksen, K. Hansen, J. Johannessen, H. Larsen, S. Lemvik, L. Rey, T. Sivertsen, A. Storaker, Ø. Torgersen, J. Welcker.<br>**Part 2(13/08-19/08):** J. Andersen, O.O. Arnøy, A. Dommasnes (cruise leader), K.B. Eriksen, K. Hansen, H. Larsen, S. Lemvik, M. Mjanger, L. Rey, T. Sivertsen, A. Storaker, Ø. Torgersen, N. Ushakov, J. Welcker.<br>**Part 3 (20/08-08/09):** J. Andersen, B. Bogstad, G. Dingsør, B. Endresen, M. Fonn, P. Fossum (cruise leader), H. Græsdal, H. Larsen, E. Meland, F. Midtøy, M. Mjanger, J.E. Nygaard, E. Olsen, B. Skjold, T. Sivertsen, N. Ushakov, J. Welcker.<br>**Part 4 (11/09-04/10):** J. Alvarez, L. Drivenes, K.A. Fagerheim, H. Gjøsæter (cruise leader), M. Johannessen, G. McCallum, A. Kristiansen, R. Pettersen, B. Røttingen, B.V. Svendsen, Ø. Torgersen, N. Ushakov, J. Welcker. |
| **“Jan Mayen”** (04/08-22.08 and 10.09-01/10 ) | **Part 1 (04-22/08):** I. Ahlquist, M. Aschan (cruise leader, 04-12/08), P.J. Helgesen, A. Harbitz, T. Haugland, E. Johannesen, H. Miran, W. Richardsen, J. Størkersen (12-22/08), K. Sunnanå (cruse leader, 12-22/08), G. Søvik (04-12/08).<br>**Part 2 (10/09-01/10):** O.T. Albert, E.D. Eliassen, E. Hermansen, J. Johannesen, S. Kleven, W. Richardsen, L. Solbakken, A. Sæverud, T. Wenneck (cruise leader) |

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