Toktrapport/Havforskningsinstituttet/ISSN 1503-6294/Nr. 14 - 2003

SURVEY REPORT

FROM THE JOINT NORWEGIAN/RUSSIAN ECOSYSTEM SURVEY IN THE BARENTS SEA

AUGUST - OCTOBER

2003

The joint ecosystem survey carried out during the period 27th of July to 2nd of October 2003 encompasses various surveys that previously have been carried out jointly or at national basis in previous years. Joint investigations include the IMR/PINRO 0-group survey and acoustic survey for pelagic fish (also known as the capelin survey). Oceanographic investigations have always formed a part of both these surveys, and in recent years, studies on plankton and sea mammals have been included. In addition, a herring survey in the western parts of the Barents Sea and parts of the Norwegian Sea, a survey for bottom fishes in the western Barents Sea and a survey for young Greenland halibut north and east of Spitsbergen were also included in the ecosystem survey. The present report from the survey will cover many but not all the aspects of the survey. Main focus is on the hydrographical conditions of the Barents Sea, the results from the 0-group investigations and from the acoustic investigation on pelagic fish. Results from the investigations on plankton, bottom fishes and sea mammals will only be briefly mentioned, since the reporting of these investigations will have to await further working up of material in the laboratories. The report was made during a meeting between scientists participating in the survey, in Murmansk 3-9th October.

A list of the scientific members on all vessels is given in Appendix I. Five research vessels participated:

Vessel	Institute	Cruise leader	Date
"Johan Hjort"	IMR, Bergen	O. Nakken,	5/8 – 19/8
		P. Fossum,	19/8 – 16/9
		H. Gjøsæter	16/9 – 2/10
"G.O.Sars"	IMR, Bergen	I. Røttingen	27/7 – 15/08
		Å. Høines	21/8 – 1/9
“Jan Mayen”	IMR, Bergen	Å. Høines	1/9 – 16/9
"Tsivilsk"	PINRO, Murmansk	D. Prozorkevich	7/9 – 2/10
“Smolensk”	PINRO, Murmansk	I. Dolgolenko	25/8 – 2/10

Synopsis

The main aim of the ecosystem survey was to describe the hydrographical features of the Barents Sea, and in addition map the distribution and abundance of zooplankton and the young and adult stages of several demersal and pelagic fish species, and in addition to gather information about seabirds and sea mammals. The last part of the cruise was dedicated to the estimation of the sizes of pelagic fish stocks in the Barents Sea, the capelin, the herring, and the polar cod, in addition to studying their biology and geographical distribution.

The hydrological situation differed from that of the same period in 2002, especially in respect of water temperature. Temperatures were in general lower in the northern areas and higher in the southern areas.

The young stages (0-group) of haddock, polar cod and capelin were found to be rich year classes, cod and herring average, redfish and Greenland halibut poor.

The capelin stock was estimated at 0.5 million tonnes, 0.25 times the estimate obtained last year. About 0.3 million tonnes were assumed to be maturing.

The polar cod stock was estimated at 280 000 tonnes, which is very much lower than in recent years. A poor coverage of this stock may partly explain this reduction in estimated size.

Norwegian Spring Spawning Herring of the 2002, 2001 and 2000 year classes were found in the surveyed area, and estimated at 3.6 million tonnes, of which the 2002 year class formed a major component.

Young **blue whiting** were observed in the southwestern parts of the Barents Sea. A quantitative estimation was not attempted.

1 Methods

1.1 Hydrography

The hydrographical investigations consisted of measurements of temperature and salinity in depth profiles along sections and distributed over the total investigated area. All vessels used CTD-sondes.

1.2 0-group investigations

The geographical distribution of 0-group fish were estimated with a small mesh mid-water trawl. All vessels which participated in the survey in 2003 used the type of mid-water trawl recommended in 1980 (Anon. 1983). The standard 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 length, were made when the 0-group fish layer was recorded deeper than 60 m or 80 m on the echo-sounder. Trawling procedure was standardised in accordance with the recommendations made in 1980. A smaller sized pelagic trawl were used during the first 20 years of the 0-group investigations. After 1985 the present gear has been used regularly. In the mid nineties Nakken and Raknes (1996) recalculated the indices from the first 20 years. Their new indices are based upon an estimate of how many 0-group cod and haddock that would have been caught if the new equipment had been used during the whole period from 1965. The indices of cod and haddock recalculated by Nakken and Raknes (1996) have been incorporated in the 0-group report since 2001. Most of the stations were taken 35 nautical miles apart.

1.3 Acoustic survey for pelagic fish

The cruise leaders prior to the survey adopted a general plan for the survey. A team consisting of N.G. Ushakov (PINRO) and H. Gjøsæter (IMR) on board "Johan Hjort" conducted a joint leadership over the acoustic investigations, undertaking a day-to-day planning of survey grid. Data on cruise tracks, hydrography, integrator values etc. were exchanged by use of radio or satellite telex, and these data were used during the day-to-day planning of the survey.

The survey area was chosen based on general knowledge of the distribution of the target species, and on information about fish distribution from the first parts of the multipurpose survey.

"Johan Hjort" was granted permission to work in parts of Russian EEZ, on acceptable terms. This was an improvement compared to recent years, when the Norwegian vessels either only on unacceptable conditions or not at all were permitted to work in Russian EEZ. A good coverage of the total capelin distribution area was obtained.

The main distribution area of capelin was surveyed with course lines 10 nautical miles apart, while most other areas were surveyed with course lines 20 or more nautical miles apart. "Tsivilsk" and "Smolensk" surveyed the eastern and central parts of the Barents Sea whereas "Johan Hjort", "G.O. Sars" and “Jan Mayen” surveyed the north-western, central, and western parts. Altogether, about 17000 nautical miles of survey tracks were made, about 60% increase from last year. This increase is mostly due to the increased coverage of the southern part of the Barents Sea in connection with the 0-group trawl survey done simultaneously with the acoustic coverage.

The two Norwegian vessels worked with EK-500 (“G.O. Sars” and “Jan Mayen”) or EK60 (“Johan Hjort”) echo sounders and BEI post processing systems, "Tsivilsk" used EK60 with ER60 echo sounder application and FAMAS post-processing system and "Smolensk" used EK-500 and FAMAS post-processing system. Echo intensities were integrated continuously, and mean values per nautical mile (Norwegian vessels) or fifth nautical mile (Russian vessels) were recorded. The echograms, with their corresponding s_A-values, were scrutinised every day. Contributions from the seabed, false echoes, and noise were deleted. The two Norwegian vessels are equipped with transducers on adjustable keels that can be lowered in rough weather to avoid the damping effect of bubbles.

The corrected values for integrated echo intensity were allocated to species according to the trace pattern of the echograms and the composition of the trawl catches. Data from pelagic trawl hauls and bottom trawl hauls considered representative for the pelagic component of the stocks, which is measured acoustically, were included in the stock abundance calculations.

The echo sounders were watched continuously, and trawling was carried out whenever the recordings changed their characteristics and/or the need for biological data made it necessary. Trawling was thus carried out both for identification purposes and to obtain biological observations, i.e., length, weight, maturity stage, stomach data, and age. On "Johan Hjort", a “HCL Multisampler”, a device attached to a pelagic trawl with three cod ends that can be opened and closed by a signal from the vessel, was used when registrations at various depths were found. During the last week of the survey, an ordinary pelagic trawl was used, when the Multisampler stopped working properly. In total, the Norwegian vessels carried out 478 trawl hauls and the Russian vessels carried out 258 trawl hauls, so in total 736 hauls were made during the survey.

The vessels gave the s_A-values in absolute terms based on sphere calibrations, that is, as scattering cross section in m^2 per square nautical mile. The acoustic equipment of the vessels was calibrated by standard spheres prior to the survey (See Appendix II).

1.3.1 Area coverage

The vessel time this year allocated to the survey is difficult to compare to that last year, since the coverage of the capelin stock formed part of a multipurpose survey. The weather conditions were unfavourable during most parts of the survey, with several days of wind force above 15 m/sec, and the vessels had to wait out a couple of storms. In spite of this, a total coverage of the capelin distribution area was achieved. The survey design used in recent years, running east-west courses starting in the south, was last year abandoned in favour of starting in the north. Since the northern limit of the capelin distribution seems to be more variable than the southern limit, starting the survey in the north ensures that enough time can be allocated to the most important parts of the survey area. However, in 2003 the vessel "Jan Mayen" worked in the northern areas with main aim to map the distribution and abundance of young Greenland halibut, and during that survey the northern limit of the capelin distribution was found. Therefore, it was decided to return to the survey layout starting in the south.

1.3.2 Intercalibrations

"Tsivilsk" and "Smolensk" carried out an intercalibration at 10th September. The result shoved that the systems gave equal results: S_A (Smolensk) = 1.0026 S_A (Tsivilsk), with correlation coefficient 0.9886.

1.3.3 Computations of stock sizes

The computations of number of individuals and biomass per length-and age group of capelin and polar cod stocks were made using the stock size estimation program "BEAM" built on SAS GIS and developed at IMR. The stock size estimate of herring was made using a spreadsheet model. A strata system, dividing the Barents Sea in squares of 1° (latitude) x 2° (longitude), was used as basis for the calculation.

The mean s_A-value in each basic square was converted to fish area density ρ_A using the relation

$$\rho_A = \frac{s_A}{\overline{\sigma}}$$

and number of fish was found by multiplying with the area of the square. Numbers were converted to biomass by multiplying with observed mean fish weight in each length group.

The target strength relation for *capelin* is given by:

$$TS = 10 \cdot \log(\frac{\sigma}{4\pi}) = 19.1 \cdot \log L - 74.0$$

corresponding to a σ-value of $5.00 \cdot 10^{-7} \cdot L^{1.91}$

The target strength relation for *polar cod* is given by:

$$TS = 10 \cdot \log(\frac{\sigma}{4\pi}) = 21.8 \cdot \log L - 72.7$$

corresponding to a σ-value of $6.7 \cdot 10^{-7} \cdot L^{2.18}$

The target strength relation for *herring* is given by:

$$TS = 10 \cdot \log(\frac{\sigma}{4\pi}) = 20.0 \cdot \log L - 71.9$$

corresponding to a σ-value of $8.1 \cdot 10^{-7} \cdot L^{2.00}$

1.3.4 Sampling

	Norwegian vessels	Russian vessels	Sum
Capelin			
No of samples	196	130	326
Nos. length measured	7707	6729	14436
Nos. aged	2231	725	2956
Polar cod			
No of samples	157	91	248
Nos. length measured	6140	6094	12234
Nos. aged	1097	624	1721
Herring			
No of samples	204[1]	45	249
Nos. length measured	10748[1]	2066	12812
Nos. aged	1141	420	1561

[1]) Includes 0-group samples

1.4 Bottom trawl survey

Bottom fish were identified in the acoustic registrations along all cruise tracks, with division of s_A-values by species. Bottom trawl hauls were executed every 35-40 miles. Norwegian vessels used a Campelen trawl and Russian vessel a trawl of type 2283-02. Only two species – cod and haddock are presented in this report.

1.5 Plankton investigations

Plankton sampling was carried out by use of WP2 plankton net (diameter of the mouth area was 56 cm (0,25m^2), mesh size was 180 μm) on each oceanographic station. The sampling depth for the WP2 on the Russian vessels was from the bottom to the surface south of 74°N and from 100 m to the surface north of 74°N. On the Norwegian vessels, two hauls were made at each station: from bottom to surface and from 100 m to surface. Samples were fractioned by size categories.

The samples were dried at 70°C for 24 hours before weighing. (Weighing will be carried out in the laboratories after the survey). Large organisms were treated separately. Length of these specimens was measured before weighing. The total krill abundance from both halves of samples per cubic meter in the depth range was calculated.

1.6 Sea mammals investigations

Sea mammals were counted and specified at all vessels. On Tsivilsk and the Norwegian vessels, sea mammal specialists took care of this work.

2 Results and discussion

Survey routes with trawl stations, hydrographical stations, and plankton stations are shown in Fig. 2.1, 2.2 and 2.3 respectively.

2.1 Hydrographical conditions

Figs 2.1.1-2.1.2 show the temperature and salinity conditions along the hydrographical sections: Kola and Cape Kanin – N. The mean temperatures in the main parts of these sections are presented in Table 2.1.1. During the survey this year the standard section Bear Island – North Cape and Bear island – W was not taken. Horizontal distribution of temperature and salinity are shown for 0, 50, 100, 200 m and at the bottom in Figs 2.1.3-2.1.12.

In September the cooling of the surface waters had begun. The maximum horizontal temperature gradients (0.2°C per nautical mile) were observed in the central part of the Barents Sea at the Polar Front, at 50 m depth.

The surface water temperature was on average 2.0°C lower than the long-term mean in the northern part of the survey area, and about 0.5°C in the central areas. In the southern and southeastern areas, the temperatures were 0.5-1.5°C higher than usual. The maximum positive anomalies were observed near Kolguev Island. The distribution of the bottom temperature had the same features as the surface, but with smaller anomalies.

The water salinity in the survey area was close to the long-term mean except the superficial waters of the northern and central parts of the Barents Sea, which were fresher than usual.

In 2003 the superficial waters were much colder (on average 2.0°C) than in the same period in 2002 for the northern part of the survey area, but were warmer in the southeastern areas. The water temperature deeper than 50 m was lower than last year. The salinity differences between 2002 and 2003 were insignificant.

Oceanographic conditions in the southern Barents Sea during the survey were caused by the amplification of the heat advection by the warm currents system and the specific meteorological situation. The prevailing northern and northeastern wind in the north of the sea promoted the penetration of the colder water masses from these areas.

2.2 Distribution and abundance of 0-group fish and *Gonatus fabricii*

Trawl stations with and without catch are indicated on the distribution charts as filled and open symbols respectively. The density grading is based on catches, measured in number of fish per 1.0 nautical mile trawling. Double shading indicates dense concentrations. The criteria for discriminating between dense and scattered concentrations are the same as used in earlier reports (Anon. 1980). Abundance indices are given in Table 2.2.1. Mean values of abundance indices were calculated both for the period 1985-2003 and for the whole period 1965 – 2003. Area based abundance indices were estimated by using standard computer programs (Fotland et al. 1995). Another set of logarithmic transformed abundance indices are given for 0-group herring, cod and haddock (Table 2.2.2), calculated according to Randa (1984). These are based on the number of fish caught during a standard trawl haul of one nautical mile. Length frequency distributions of the main species are given in Table 2.2.3.

The 0-group had a more westerly distribution than in previous years. Most of the fish were concentrated in the central part of the western Barents Sea.

2.2.1 Herring (figure 2.2.1)

West of Spitsbergen only scattered distributions were observed. In the central part, the herring were found in three areas with high abundance with the same densities as in last year. This year class could be characterised as average, and of the same size as the 2002 year class.

2.2.2 Capelin (figure 2.2.2)

Dense concentrations were widespread in the NW, W and central parts of the Barents Sea. In the eastern areas there were only scattered distributions of 0-group capelin. The year class seems to be relatively strong and twice as high as that in 2002.

2.2.3 Cod (figure 2.2.3)

Dense concentrations were not as widespread as in rich years. They were found in the western parts of the sea. The total density distribution seems smaller than last year. The 2003 year class can be characterised as a little below average size.

2.2.4 Haddock (figure 2.2.4)

The total distribution area was near the same as in 2002. Nevertheless, the area of dense concentrations was 2-3 times wider then in last year. The 2003year class is strong and has the highest area index ever observed.

2.2.5 Polar cod (figure 2.2.5)

The abundance of both components was a little bit lower than last year and close to the long term average.

2.2.6 Saithe (figure 2.2.6)

Saithe were only observed in small area in the central part of the Barents Sea and the oceanic part of the 2003 year class is small.

2.2.7 Redfish (figure 2.2.7)

West off Spitsbergen redfish was observed near the same level as in 2002. In the south-west of the Barents Sea the area with scattered distribution had increased. However, the 2003 year class is another very small one.

2.2.8 Greenland halibut (figure 2.2.8)

Scattered concentrations were only found west of Spitsbergen. Total distribution area was 2-3 times lower than in 2002.

2.2.9 Long rough dab (figure 2.2.9)

There were found no areas with dense concentrations. Scattered densities were also found in smaller areas than previous years. The 2003 year class is below average.

2.2.10 Catfish (figure 2.2.10)

At least a two times wider area of scattered concentrations was found in the north-western part of the sea. One dense patch was observed south of Spitsbergen.

2.2.11 Sandeel (figure 2.2.11)

In the south-eastern part of the Barents Sea, dense registrations decreased 2-3 times while scattered distribution areas were two times larger than in 2002. To the north of the Norwegian coast, scattered concentrations were observed in a wider area than last year. No abundance index is calculated for this species.

2.2.12 Gonatus (figure 2.2.12)

In the western parts of the investigated area 0-group *Gonatus fabricii* were found in two large areas - west off Spitsbergen and in the western part of the Barents Sea. Some scattered concentrations were also found in the central areas as far as 30° E. No abundance index is calculated for this species.

2.2.13 Mackerel (figure 2.2.13)

This year, an area with scattered concentrations of 0-group mackerel was found outside the Norwegian coast from Sørøya to Nordkyn, which is a rather unusual event.

2.3 Distribution and abundance of capelin, herring and polar cod

2.3.1 Capelin

2.3.1.1 Distribution

The geographical density distribution of the total stock and each age group are shown in Figs. 2.3.1 to 2.3.5. Age- and length distribution for the polar cod stock in the subareas used for stock size estimation and for the total area are given in Figs. 2.3.6 and 2.3.7, respectively. The distribution area was moved at least 120 nautical miles southwards compared to that found last year, extending north to 78°N near Spitsbergen. The extension in the east west direction was equal to that found last year, from the Bear Island in the west to Novaya Zemlya in the east. The main concentration was found between 76° and 76°30N and from 30° to 33°E (Figure 2.3.5). In the northern part of its distribution area, capelin were found mainly in schools near the bottom. In some areas capelin were found together with polar cod. In such areas, it was difficult to discern between the two species of fish based on the recordings. A typical echogram showing small capelin schools below a scattering layer is shown in Figure 2.3.8.

2.3.1.2 Abundance estimate and size by age

The results of the estimation are given in the text table below. The 2002 estimate is shown on shaded background for comparison.

Year class		**Age**	**Number (10^9)**		**Mean weight (g)**		**Biomass (10^3 t)**	
2002	2001	1	82.4	59.7	2.4	3.9	200.8	234.3
2001	2000	2	9.6	90.8	10.2	10.1	97.4	918.6
2000	1999	3	11.0	50.2	18.4	20.7	201.6	1037.1
1999	1998	4	1.4	1.0	23.5	35.0	33.0	20.2
Total stock in:								

Year class		Age	Number (10^9)		Mean weight (g)		Biomass (10^3 t)	
2003	2002	1-4	104.4	201.3	5.1	11.0	532.8	2210.2
Based on TS value: 19.1 log L - 74.0, corresponding to $\sigma = 5.0 \cdot 10^{-7} \cdot L^{1.91}$								

Details of the 2003 estimate are shown in Table 2.3.1 and the estimates by age group of the capelin stock 1 years old and older from 1973-2003 are shown in Table 2.3.2

The total stock is estimated at about 0.5 million tonnes, about 25% of the stock estimated last year. About 52% (280 thousand tonnes) of this stock is above 14 cm and considered to be maturing. The 2002 year class (1-group) consists, according to this estimate, of about 80 billion individuals. This estimate is about 33% higher than that obtained for the 1-group last year. The mean weight is estimated at 2.4 g, which is considerably lower than that measured last year, and 1.2 g below the long-term average. The biomass of the 2002 year class is about 0.2 million tonnes. It should be kept in mind that, given the limitations of the acoustic method concerning mixed concentrations of small capelin and 0-group fish and near-surface distribution, the 1-group estimate might be more uncertain than that for older capelin.

The estimated number of fish in the 2001 year class (2-group) is about 10 billions, only about 10% of the size of the 2000 year class measured last year. Only four year classes, the 1984, the 1985, the 1992, and the 1993 year classes have been less numerous than the 2001 year class measured at the 2-year stage. The mean weight at this age is 10.2 g (10.1 g in 2002), and consequently the biomass of the two years old fish is about 0.1 million tonnes. The mean weight is lower than in recent years but is at the long-term average (Table 2.3.2).

The 2000 year class is estimated at about 11 billion individuals with mean weight 18.4 g, giving a biomass of about 0.2 million tonnes. The mean weight is lower than that for the last eight years but is at the long-term average. The 1999 year class (now 4 years old) is estimated at 1.4 billion individuals. With a mean weight of 23.5 g this age group makes up only about 30 thousand tonnes. No capelin older than four years was found.

2.3.1.3 Mortality

Table 2.3.3 shows the number of fish in the various year classes, and their "survey mortality" from age one to two.

As there has been no fishing on these age groups, the figures for total mortality constitute natural mortality only, and probably reflect quite well the predation on capelin. As can be seen from the table, the mortality was high prior to 1988, but then a substantial decrease occurred in 1988-89. This coincided with a considerable increase in the stock size caused by the rich 1989 year class. From 1990, the mortality again increased, up to 85% in 1992-93. This increase is in accordance with the observation of an increasing stock of cod, which were preying on a rapidly decreasing stock of capelin. The mortalities calculated for the period 1996-2002 varied between 20 and 52% and indicate a somewhat lower level of mortality. In 2003 a considerable increased natural mortality was observed, at the level (around 85%) observed in 1985-86 and in 1992-93. The results of the calculation for the year classes 1988, 1992, and 1994 show, however, that either the one-group are underestimated or the two-group is overestimated these years. Knowing that the measurement of the 1-group is more uncertain than the older age groups due to limitations in the acoustic method, the first mentioned possibility is the most probable.

2.3.2 Polar cod

As in previous years, the coverage of the polar cod distribution is considered incomplete. In some areas, particularly in the northern, a definite boundary of the polar cod distribution area could not be found within the time allocated to the survey. During the trawl survey for Greenland halibut during early September in the areas north and east of Spitsbergen, considerable amounts of polar cod was caught in bottom trawl in the studied areas. This situation is common during the autumn, when the polar cod stock is widely distributed in the northern part of the Barents Sea.

2.3.2.1 Distribution

The densest registrations of polar cod were found in the area between 73ºN and 74ºN, between 52ºN and 53ºE, but this species had a wide distribution, mainly to the east of 30ºE. East and south of Spitsbergen local concentrations were registered.

2.3.2.2 Abundance estimation

The stock abundance estimate by age, number, and weight was calculated using the same computer program as for capelin. The geographical density distribution of polar cod by age is shown in Figs. 2.3.9-2.3.13. Age- and length distribution for the polar cod stock in the subareas used for stock size estimation and for the total area are given in Figs. 2.3.14 and 2.3.15, respectively.

A detailed estimate based on this TS relation is given in Table 2.3.4, and the time series of abundance estimates is summarized in Table 2.3.5. The main results of the abundance estimation in 2003 are summarised in the text table below. The 2002 estimate is shown on a shaded background for comparison.

Year class		**Age**	**Number (10^9)**		**Mean weight (g)**		**Biomass (10^3 t)**	
2002	2001	1	15.4	8.4	7.4	6.7	114.1	56.8
2001	2000	2	2.1	34.8	18.4	25.2	37.9	875.9
2000	1999	3	2.0	6.4	31.3	44.4	63.9	282.2
1999	1998	4	1.5	2.3	40.6	61.7	61.3	143.2
Total stock in								
2003	2002	1-5	21.1	52.2	13.3	26.4	280.2	1377.2
Based on TS value: 21.8 log L - 72.7, corresponding to $\sigma = 6.7 \cdot 10^{-7} \cdot L^{2.18}$								

The 2002 year class (the one-year-olds) is almost twice as large as the abundance of the one-group measured last year, and their mean weight is 0.7 gram higher. The biomass is, therefore, twice as high as that of the one-year-olds measured last year. The abundance of the 2001 year class (the two-year-olds) is only about 5% of that of the two-group found last year and has in addition lower mean weight. The biomass is, therefore, below 5% of that of the 2000 year class estimated last year. The three-years-old fish (2000 year class) is about one third of the three-group estimated last year and has lower mean weight. Consequently, the biomass of this age group is only about 20% of that for the corresponding age group during the 2002 survey. The four-year-olds (1999 year class) are scarcely found. The total stock, estimated at 0.3 million tonnes, is only 20% of the biomass of that estimated last year, which was the highest but one on record.

2.3.2.3 Mortality

Table 2.3.6 shows the “survey-mortality rates” of polar cod of the year classes 1984 to 2001.

The mortality estimates are unstable during the whole period. Although unstable mortalities may indicate errors in the stock size estimation from year to year, the impression remains that there is a considerable total mortality on young polar cod. Prior to 1993, these mortality estimates represent natural mortality only, as practically no fishing took place. In the period 1993 to 1997 the Russian fleet landed between 5 000 and 50 000 tonnes of polar cod, in 1998 the catch was negligible. In 1999 the catch was about 20 000 tonnes, in 2000 35 000 tonnes, in 2001 41 200 tonnes and in 2002 37 500 tonnes. Since there has been a minimum landing size of 15 cm (from 1998, 13 cm) in that fishery, a considerable amount of this could consist of two- and even one-year-olds, and this may explain some, but only a small part of the high total mortality.

2.3.3 Herring

2.3.3.1 Distribution

The distribution of young herring is shown in Figure 2.3.16. The distribution area of juvenile herring was covered fairly well. In September juvenile herring were distributed over a vast area between 16° and 48°E and up to 74°N. Some aggregations were also found along the branch of the Novaya Zemlya current as far east as Novaya Zemlya. Aggregations with the highest density were recorded in the southern part of the sea between 26° and 40°E. Besides dense aggregations of herring were recorded by the Norwegian RV “G.O.Sars” in coastal fjords between 20° and 23°E. The distribution area of herring in 2003 was the most extensive over the past few years.

2.3.3.2 Abundance estimation

The estimated number and biomass of herring per age- and length group is given in Table 2.3.7. Total abundance was estimated at 106.6 x 10^9 fish (the majority of fish (about 94%) was from the 2002 year class) and biomass at 3.64 x 10^6 t. The biomass estimate could be somewhat inaccurate because of the shortfall of biological samples from some areas.

2.3.4 Blue whiting

In the south-western parts of the Barents Sea young blue whiting were observed. A quantitative estimation was not attempted since only a small area of the total distribution area of this species was covered.

2.4 Distribution of cod and haddock

Cod and haddock were widely distributed in the observed area. Cod was found from the coast and northwards as far as the Edge Island, and east to Novaja Zemlja. In most cases s_A-values were not higher than 10.

The distribution of haddock did not reach as far north and the main concentrations were located in central parts of sea or near the coast. The distribution of cod and haddock, as mapped using acoustics, are shown in Figures 2.4.1 and 2.4.2 respectively.

2.5 Plankton investigations

In the eastern surveyed area, most of the plankton organisms were Copepods. The basis of abundance of zooplankton was dominated by *Pseudocalanus elongatus*, and the biomass by *Calanus finmarchicus*.

The small size fraction of zooplankton (*Pseudocalanus elongatus* and others small Copepods) dominated by abundance. *Calanus finmarchicus* of the senior age groups prevailed by biomass in this area. Towards the north *Calanus finmarchicus* and *Calanus glacialis* dominated both by abundance and biomass. In the surveyed area, the average abundance of euphausids from the bottom to the surface made up 0,23 ind./m^3, from 100 m to the surface 0,18 ind./m^3.

2.6 Sea mammals investigations

The distribution of sea mammals, as mapped from sightings, is shown in Figure 2.6.1. Concentrations of sea mammals were observed mainly in central parts of the Barents Sea (between 28º-40ºN), as far as 78ºN. Since sea mammals are most often concentrated in areas with high concentrations of food objects like pelagic fish, and since pelagic fish were scarce during this survey, sea mammals were not detected in large quantities.

Table 2.1.1. The mean temperatures in the main parts of standard hydrographical sections

Year	Section² and layer (depth in meters)						
	1	2	3	4	5	6	7
	0-50	50-200	0-200	0-bot.	0-bot.	0-200	0-200
1965	6.7	3.9	4.6	4.6	3.7	5.1	-
1966	6.7	2.6	3.6	1.9	2.2	5.5	3.6
1967	7.5	4.0	4.9	6.1	3.4	5.6	4.2
1968	6.4	3.7	4.4	4.7	2.8	5.4	4.0
1969	6.7	3.1	4.0	2.6	2.0	6.0	4.2
1970	7.8	3.7	4.7	4.0	3.3	6.1	-
1971	7.1	3.2	4.2	4.0	3.2	5.7	4.2
1972	8.7	4.0	5.2	5.1	4.1	6.3	3.9
1973	7.7	4.5	5.3	5.7	4.2	5.9	5.0
1974	8.1	3.9	4.9	4.6	3.5	6.1	4.9
1975	7.0	4.6	5.2	5.6	3.6	5.7	4.9
1976	8.1	4.0	5.0	4.9	4.4	5.6	4.8
1977	6.9	3.4	4.3	4.1	2.9	4.9	4.0
1978	6.6	2.5	3.6	2.4	1.7	5.0	4.1
1979	6.5	2.9	3.8	2.0	1.4	5.3	4.4
1980	7.4	3.5	4.5	3.3	3.0	5.7	4.9
1981	6.6	2.7	3.7	2.7	2.2	5.3	4.4
1982	7.1	4.0	4.8	4.5	2.8	5.8	4.9
1983	8.1	4.8	5.6	5.1	4.2	6.3	5.1
1984	7.7	4.1	5.0	4.5	3.6	5.9	5.0
1985	7.1	3.5	4.4	3.4	3.4	5.3	4.6
1986	7.5	3.5	4.5	3.9	3.2	5.8	4.4
1987	6.2	3.3	4.0	2.7	2.5	5.2	3.9
1988	7.0	3.7	4.5	3.8	2.9	5.5	4.2
1989	8.6	4.8	5.8	6.5	4.3	6.9	4.9
1990	8.1	4.4	5.3	5.0	3.9	6.3	5.7
1991	7.7	4.5	5.3	4.8	4.2	6.0	5.4
1992	7.5	4.6	5.3	5.0	4.0	6.1	5.0
1993	7.5	4.0	4.9	4.4	3.4	5.8	5.4
1994	7.7	3.9	4.8	4.6	3.4	6.4	5.3
1995	7.6	4.9	5.6	5.9	4.3	6.1	5.2
1996	7.6	3.7	4.7	5.2	2.9	5.8	4.7
1997	7.3	3.4	4.4	4.2	2.8	5.6	4.1
1998	8.4	3.4	4.7	2.1	1.9	6.0	³)
1999	7.4	3.8	4.7	3.8	3.1	6.2	5.3
2000	7.6	4.5	5.3	5.8	4.1	5.7	5.1
2001	6.9	4.0	4.7	5.6	4.0	5.7	4.9
2002	8.6	4.8	5.8	4.0	3.7	-	5.4
2003	7.2	4.0	4.8	4.2	3.3	-	-
Average 1965-2003	7.4	3.8	4.7	4.3	3.3	5.8	4.7

¹) Earlier presented temperatures have been slightly adjusted (Tereshchenko, 1992).

²) 1-3: Murmansk Current; Kola section (70º30'N-72º30'N, 33º30'E)
4: Cape Kanin section (68º45'N-70º05'N, 43º15'E)
5: Cape Kanin section (71º00'N-72º00'N, 43º15'E)
6: North Cape Current; North Cape-Bear Island section (71º33'N, 25º02'E – 73º35'N, 20º46'E)
7: West Spitsbergen Current; Bear Island – West section (74º30'N 06º34'E – 15º55'E).

³) In 1998 only the central branch and the eastern branch of the West Spitsbergen Current were covered, and the temperatures were 5.4 and 4.5ºC respectively.

Table 2.2.1. Abundance indices of 0-group fish in the Barents Sea and adjacent waters in 1965-2003

Year	Capelin[1]	Cod[2]	Haddock[2]	Herring[3]	Polar cod		Redfish	Greenland halibut	Long rough dab
					West	East			
1965	37	11	13	-	0		159		66
1966	119	2	2	-	129		236		97
1967	89	62	76	-	165		44		73
1968	99	45	14	-	60		21		17
1969	109	211	186	-	208		295		26
1970	51	1097	208	-	197		247	1	12
1971	151	356	166	-	181		172	1	81
1972	275	225	74	-	140		177	8	65
1973	125	1101	87	-	26		385	3	67
1974	359	82	237	-	227		468	13	93
1975	320	453	224	-	75		315	21	113
1976	281	57	148	-	131		447	16	96
1977	194	279	187	-	157	70	472	9	72
1978	40	192	110	-	107	144	460	35	76
1979	660	129	95	-	23	302	980	22	69
1980	502	61	68	-	79	247	651	12	108
1981	570	65	30	-	149	93	861	38	95
1982	393	136	107	-	14	50	694	17	150
1983	589	459	219	-	48	39	851	16	80
1984	320	559	293	-	115	16	732	40	70
1985	110	742	156	-	60	334	795	36	86
1986	125	434	160	-	111	366	702	55	755
1987	55	102	72	-	17	155	631	41	174
1988	187	133	86	-	144	120	949	8	72
1989	1300	202	112	-	206	41	698	5	92
1990	324	465	227	-	144	48	670	2	35
1991	241	766	472	-	90	239	200	1	28
1992	26	1159	313	-	195	118	150	3	32
1993	43	910	240	188	171	156	162	11	55
1994	58	899	282	120	50	448	414	20	272
1995	43	1069	148	73	6	0	220	15	66
1996	291	1142	196	378	59	484	19	5	10
1997	522	1077	150	390	129	453	50	13	42
1998	428	576	593	524	144	457	78	11	28
1999	722	194	184	242	116	696	27	13	66
2000	303	870	417	213	76	387	195	28	81
2001	221	212	394	77	148	146	11	32	86
2002	327	1055	412	315	179	588	28	34	173
2003	641	698	705	277	164	368	57	9	58
1985-2003	314	669	280		116	295	319	18	116
1965-2003	288	469	202				378	17	96

[1]) Assessment for 1965-1978 in Anon. 1980 and for 1979-1993 in Ushakov and Shamray 1995

[2]) Indices for 1965-1985 for cod and haddock adjusted according to Nakken and Raknes (1996)

[3]) Calculated by Prozorkevich (2001).

Table 2.2.2. Estimated logarithmic indices with 90% confidence limits of year class abundance for 0-group herring, cod and haddock in the Barents Sea and adjacent waters 1966-2003.

Year	Herring			Cod			Haddock		
	Index	Confidence limits		Index	Confidence limits		Index	Confidence limits	
1966	0.14	0.04	0.31	0.02	0.01	0.04	0.01	0.00	0.03
1967	0.00	-	-	0.04	0.02	0.08	0.08	0.03	0.13
1968	0.00	-	-	0.02	0.01	0.04	0.00	0.00	0.02
1969	0.01	0.00	0.04	0.25	0.17	0.34	0.29	0.20	0.41
1970	0.00	-	-	2.51	2.02	3.05	0.64	0.42	0.91
1971	0.00	-	-	0.77	0.48	1.01	0.26	0.18	0.36
1972	0.00	-	-	0.52	0.35	0.72	0.16	0.09	0.27
1973	0.05	0.03	0.08	1.48	1.18	1.82	0.26	0.15	0.40
1974	0.01	0.01	0.01	0.29	0.18	0.42	0.51	0.39	0.68
1975	0.00	-	-	0.90	0.66	1.17	0.60	0.40	0.85
1976	0.00	-	-	0.13	0.06	0.22	0.38	0.24	0.51
1977	0.01	0.00	0.03	0.49	0.36	0.65	0.33	0.21	0.48
1978	0.02	0.01	0.05	0.22	0.14	0.32	0.12	0.07	0.19
1979	0.09	0.01	0.20	0.40	0.25	0.59	0.20	0.12	0.28
1980	-	-	-	0.13	0.08	0.18	0.15	0.10	0.20
1981	0.00	-	-	0.10	0.06	0.18	0.03	0.00	0.05
1982	0.00	-	-	0.59	0.61	0.77	0.38	0.30	0.52
1983	1.77	1.29	2.33	1.69	1.34	2.08	0.62	0.48	0.77
1984	0.34	0.20	0.52	1.55	1.18	1.98	0.78	0.60	0.99
1985	0.23	0.18	0.28	2.46	2.22	2.71	0.27	0.23	0.31
1986	0.00	-	-	1.37	1.06	1.70	0.39	0.28	0.52
1987	0.00	0.00	0.03	0.17	0.01	0.40	0.10	0.00	0.25
1988	0.32	0.16	0.53	0.33	0.22	0.47	0.13	0.05	0.34
1989	0.59	0.49	0.76	0.38	0.30	0.48	0.14	0.10	0.20
1990	0.31	0.16	0.50	1.23	1.04	1.34	0.61	0.48	0.75
1991	1.19	0.90	1.52	2.30	1.97	2.37	1.17	0.98	1.37
1992	1.06	0.69	1.50	2.94	2.53	3.39	0.87	0.71	1.06
1993	0.75	0.45	1.14	2.09	1.70	2.51	0.64	0.48	0.82
1994	0.28	0.17	0.42	2.27	1.83	2.76	0.64	0.49	0.81
1995	0.16	0.07	0.29	2.40	1.97	2.88	0.25	0.13	0.41
1996	0.65	0.47	0.85	2.87	2.53	3.24	0.39	0.25	0.56
1997	0.39	0.25	0.54	1.60	1.35	1.86	0.21	0.12	0.31
1998	0.59	0.40	0.82	0.68	0.48	0.91	0.59	0.44	0.76
1999	0.41	0.25	0.59	0.21	0.11	0.34	0.25	0.11	0.44
2000	0.30	0.17	0.46	1.49	1.21	1.78	0.64	0.46	0.84
2001	0.13	0.04	0.25	0.23	0.12	0.36	0.67	0.52	0.84
2002	0.53	0.36	0.73	1.22	0.97	1.50	0.99	0.75	1.25
2003	0.51	0.36	0.68	0.85	0.63	1.10	0.85	0.61	1.12
Mean 1985-2003			0.44			1.43			0.52

Table 2.2.3. Length distribution 0-group fish in the Barents Sea and adjacent waters in August-September 2003, in % (only Norwegian data).

Length, cm	Herring	Capelin	Cod	Haddock	Polar Cod	Red fish	Sandeel	Green land halibut	Long rough dab
1.0-1.4						1.13			
1.5-1.9						3.96			0.19
2.0-2.4		0.09	0.01	0.01	1.35	21.36			5.00
2.5-2.9		0.39	0.07	0.01	9.23	41.87			24.64
3.0-3.4	0.01	5.77	0.04	0.06	37.14	24.61			29.74
3.5-3.9	0.03	23.09	0.14	0.50	20.86	5.37			16.17
4.0-4.4	0.46	31.03	0.86	1.56	19.00	1.27			13.47
4.5-4.9	1.85	24.44	2.11	1.89	8.70	0.28		5.45	10.78
5.0-5.4	9.01	11.44	5.82	3.07	3.34			5.45	
5.5-5.9	8.85	2.63	9.64	4.67	0.24			1.82	
6.0-6.4	8.86	0.74	16.78	5.71	0.08			10.91	
6.5-6.9	7.99	0.13	19.13	7.77			1.49	7.27	
7.0-7.4	10.79	0.09	18.75	9.70			9.70	69.09	
7.5-7.9	8.21	0.11	13.97	9.98			7.46		
8.0-8.4	7.95	0.03	8.06	12.76			13.43		
8.5-8.9	11.28	0.01	2.95	11.52			28.36		
9.0-9.4	9.12		1.06	9.92			19.40		
9.5-9.9	9.95		0.41	6.95			10.45		
10.0-10.4	3.69		0.07	5.21			4.48		
10.5-10.9	1.74		0.07	3.30			5.22		
11.0-11.4	0.17		0.06	1.96					
11.5-11.9	0.01			1.64					
12.0-12.4	0.03			0.93					
12.5-12.9	0.00			0.54					
13.0-13.4	0.00			0.20					
13.5-13.9	0.01			0.12					
14.0-14.4	0.01			0.04					
Tot catch	162039	668517	90355	39903	6927	707	67	55	509
Mean L (mm)	76.0	43.2	68.2	81.0	36.4	27.8	92.6	67.8	34.0

Table 2.3.1. Acoustic estimate of Barents Sea capelin, August-September 2003

Length (cm)	Age/Year class 1 2002	2 2001	3 2000	4 1999	Sum (10^6)	Biomass (10^3 t)	Mean weight (g)
6.5 - 7.0	4482				4482	4.5	1.0
7.0 - 7.5	8670				8670	9.3	1.1
7.5 - 8.0	4980				4980	7.5	1.5
8.0 - 8.5	14626				14626	28.9	2.0
8.5 - 9.0	15621				15621	35.4	2.3
9.0 - 9.5	13086				13086	37.1	2.8
9.5 - 10.0	9251	5			9256	29.5	3.2
10.0 - 10.5	6994	2			6996	26.5	3.8
10.5 - 11.0	3238	29			3267	14.9	4.6
11.0 - 11.5	1317	262			1579	7.4	4.7
11.5 - 12.0	163	952			1115	6.7	6.0
12.0 - 12.5	16	1137			1153	7.9	6.9
12.5 - 13.0		902			902	7.3	8.1
13.0 - 13.5		1407	98		1505	13.4	8.9
13.5 - 14.0		1450	161		1611	16.7	10.4
14.0 - 14.5		1430	741		2171	26.2	12.1
14.5 - 15.0		1211	1443	19	2673	37.7	14.1
15.0 - 15.5		570	1785	47	2402	39.3	16.4
15.5 - 16.0		181	2113	190	2484	45.2	18.2
16.0 - 16.5		58	2171	199	2428	47.9	19.7
16.5 - 17.0			1351	260	1611	36.2	22.4
17.0 - 17.5			765	346	1111	27.6	24.9
17.5 - 18.0			330	199	529	14.4	27.2
18.0 - 18.5			21	97	118	3.6	30.6
18.5 - 19.0			3	42	45	1.5	33.6
19.0 - 19.5				3	3	0.1	37.1
TSN (10^6)	82444	9596	10982	1402	104424		
TSB (10^3 t)	200.8	97.4	201.6	33.0		532.8	
Mean length (cm)	8.8	13.5	15.8	16.9	10.1		
Mean weight (g)	2.4	10.2	18.4	23.5			5.1
SSN (10^6)		3450	10723	1402	15572		
SSB (10^3 t)		48.2	198.7	32.6		279.6	

Based on TS value: 19.1 log L - 74.0, corresponding to $\sigma = 5.0 \cdot 10^{-7} \cdot L^{1.9}$

Table 2.3.2. Acoustic estimates of the Barents Sea capelin stock by age in autumn 1973-2003. Biomass (B) in 10^6 tonnes, average weight (AW) in grams. All estimates based on TS = 19.1 Log L -74.0 dB.

Year	Age 1		2		3		4		5		Sum 2+
	B	AW	B	AW	B	AW	B	AW	B	AW	B
1973	1.69	3.2	2.32	6.2	0.73	18.3	0.41	23.8	0.01	30.1	3.47
1974	1.06	3.5	3.06	5.6	1.53	8.9	0.07	20.8	+	25.0	4.66
1975	0.65	3.4	2.39	6.9	3.27	11.1	1.48	17.1	0.01	31.0	7.15
1976	0.78	3.7	1.92	8.3	2.09	12.8	1.35	17.6	0.27	21.7	5.63
1977	0.72	2.0	1.41	8.1	1.66	16.8	0.84	20.9	0.17	22.9	4.08
1978	0.24	2.8	2.62	6.7	1.20	15.8	0.17	19.7	0.02	25.0	4.01
1979	0.05	4.5	2.47	7.4	1.53	13.5	0.10	21.0	+	27.0	4.10
1980	1.21	4.5	1.85	9.4	2.83	18.2	0.82	24.8	0.01	19.7	5.51
1981	0.92	2.3	1.83	9.3	0.82	17.0	0.32	23.3	0.01	28.7	2.98
1982[1]	1.22	2.3	1.33	9.0	1.18	20.9	0.05	24.9			2.56
1983	1.61	3.1	1.90	9.5	0.72	18.9	0.01	19.4			2.63
1984	0.57	3.7	1.43	7.7	0.88	18.2	0.08	26.8			2.39
1985	0.17	4.5	0.40	8.4	0.27	13.0	0.01	15.7			0.68
1986	0.02	3.9	0.05	10.1	0.05	13.5	+	16.4			0.10
1987[2]	0.08	2.1	0.02	12.2	+	14.6	+	34.0			0.02
1988	0.07	3.4	0.35	12.2	+	17.1					0.35
1989	0.61	3.2	0.20	11.5	0.05	18.1	+	21.0			0.25
1990	2.66	3.8	2.72	15.3	0.44	27.2	+	20.0			3.16
1991	1.52	3.8	5.10	8.8	0.64	19.4	0.04	30.2			5.78
1992	1.25	3.6	1.69	8.6	2.17	16.9	0.04	29.5			3.90
1993	0.01	3.4	0.48	9.0	0.26	15.1	0.05	18.8			0.79
1994	0.09	4.4	0.04	11.2	0.07	16.5	+	18.4			0.11
1995	0.05	6.7	0.11	13.8	0.03	16.8	0.01	22.6			0.15
1996	0.24	2.9	0.22	18.6	0.05	23.9	+	25.5			0.27
1997	0.42	4.2	0.45	11.5	0.04	22.9	+	26.2			0.49
1998	0.81	4.5	0.98	13.4	0.25	24.2	0.02	27.1	+	29.4	1.25
1999	0.16	4.2	1.01	13.6	0.27	26.9	0.09	29.3			2.12
2000	1.70	3.8	1.59	14.4	0.95	27.9	0.08	37.7			2.57
2001	0.37	3.3	2.40	11.0	0.81	26.7	0.04	35.5	+	41.4	3.25
2002	0.23	3.9	0.92	10.1	1.04	20.7	0.02	35.0			1.98
2003	0.20	2.4	0.10	10.2	0.20	18.4	0.03	23.5			0.33
Average	0.69	3.6	1.40	10.3	0.90	18.4	0.27	24.2			2.47

[1] Computed values based on the estimates in 1981 and 1983

[2] Combined estimates from multispecies survey and succeeding survey with "Eldjarn"

Table 2.3.3. Survey mortalities for capelin from age 1 to age 2

Year	Year class	Age 1 (10^9)	Age 2 (10^9)	Total mort. %	Total mort. Z
1984-1985	1983	154.8	48.3	69	1.16
1985-1986	1984	38.7	4.7	88	2.11
1986-1987	1985	6.0	1.7	72	1.26
1987-1988	1986	37.6	28.7	24	0.27
1988-1989	1987	21.0	17.7	16	0.17
1989-1990	1988	189.2	177.6	6	0.06
1990-1991	1989	700.4	580.2	17	0.19
1991-1992	1990	402.1	196.3	51	0.72
1992-1993	1991	351.3	53.4	85	1.88
1993-1994	1992	2.2	3.4	-	-
1994-1995	1993	19.8	8.1	59	0.89
1995-1996	1994	7.1	11.5	-	-
1996-1997	1995	81.9	39.1	52	0.74
1997-1998	1996	98.9	72.6	27	0.31
1998-1999	1997	179.0	101.5	43	0.57
1999-2000	1998	155.9	110.6	29	0.34
2000-2001	1999	449.2	218.7	51	0.72
2001-2002	2000	113.6	90.8	20	0.22
2002-2003	2001	59.7	9.6	84	1.83

Table 2.3.4. Acoustic estimate of polar cod in August-September 2003

Length (cm)	Age/Year class 1 2002	2 2001	3 2000	4 1999	5+ 1998-	Sum (10^6)	Biomass (10^3)	Mean weight (g)
6.5 - 7.0	408					408	0.9	2.2
7.0 - 7.5	262					262	0.7	2.8
7.5 - 8.0	388					388	1.2	3.0
8.0 - 8.5	849	49				897	3.6	4.0
8.5 - 9.0	923	0				923	4.2	4.5
9.0 - 9.5	923	26				950	5.1	5.4
9.5 - 10.0	1176	0				1176	6.7	5.7
10.0 - 10.5	1360	3				1363	8.9	6.5
10.5 - 11.0	1931	20				1951	14.9	7.6
11.0 - 11.5	3671	137				3808	32.7	8.6
11.5 - 12.0	2054	122				2176	21.6	9.9
12.0 - 12.5	1223	162				1386	14.7	10.6
12.5 - 13.0	150	297				447	6.6	14.7
13.0 - 13.5	92	275	9			376	5.7	15.2
13.5 - 14.0	21	143	188			352	6.4	18.1
14.0 - 14.5	0	260	190			450	8.8	19.4
14.5 - 15.0	1	85	164	147		397	9.1	23.0
15.0 - 15.5		171	243	0		414	10.0	24.0
15.5 - 16.0		43	171	65		279	7.5	27.0
16.0 - 16.5		73	76	124		274	7.8	28.6
16.5 - 17.0		29	132	101		261	8.2	31.2
17.0 - 17.5		13	201	83		297	10.0	33.6
17.5 - 18.0		7	185	103		295	10.7	36.3
18.0 - 18.5		2	132	239		372	15.1	40.6
18.5 - 19.0		58	136	116		309	13.2	42.5
19.0 - 19.5		18	120	86		225	10.2	45.4
19.5 - 20.0		0	5	197		202	9.9	49.1
20.0 - 20.5		64	5	85	2	156	8.0	51.6
20.5 - 21.0			41	44	0	85	4.7	54.8
21.0 - 21.5			0	53	1	55	3.3	60.8
21.5 - 22.0			0	50	0	50	3.1	62.4
22.0 - 22.5			34	0	0	34	2.5	72.1
22.5 - 23.0			2	10	0	11	0.8	71.5
23.0 - 23.5			0	3	8	11	0.7	62.2
23.5 - 24.0			5		0	5	0.4	80.0
24.0 - 24.5					13	13	1.0	81.8
24.5 - 25.0					0	0	0.0	
25.0 - 25.5					5	5	0.5	108.0
25.5 - 26.0					10	10	0.9	94.0
TSN (10^6)	15434	2057	2038	1507	38	21074		
TSB (10^3 tonnes)	114.1	37.9	63.9	61.3	3.1		280.2	
Mean length (cm)	10.5	13.7	16.5	18.2	24.3	11.9		
Mean weight (g)	7.4	18.4	31.3	40.6	81.9			13.3

Based on TS value: 21.8 log L - 72.7, corresponding to $\sigma = 6.7 \cdot 10^{-7} \cdot L^{2.18}$

Table 2.3.5. Acoustic estimates of polar cod by age in August-September 1986-2003. TSN and TSB is total stock numbers (10^6) and total stock biomass (10^3 tonnes) respectively. Numbers based on TS = 21.8 Log L - 72.7 dB.

	Age 1		Age 2		Age 3		Age 4+		Total	
Year	TSN	TSB	TSN	TSB	TSN	TSB	TSN	TSB	TSN	TSB
1986	24038	169.6	6263	104.3	1058	31.5	82	3.4	31441	308.8
1987	15041	125.1	10142	184.2	3111	72.2	39	1.2	28333	382.8
1988	4314	37.1	1469	27.1	727	20.1	52	1.7	6562	86.0
1989	13540	154.9	1777	41.7	236	8.6	60	2.6	15613	207.8
1990	3834	39.3	2221	56.8	650	25.3	94	6.9	6799	127.3
1991	23670	214.2	4159	93.8	1922	67.0	152	6.4	29903	381.5
1992	22902	194.4	13992	376.5	832	20.9	64	2.9	37790	594.9
1993	16269	131.6	18919	367.1	2965	103.3	147	7.7	38300	609.7
1994	27466	189.7	9297	161.0	5044	154.0	790	35.8	42597	540.5
1995	30697	249.6	6493	127.8	1610	41.0	175	7.9	38975	426.2
1996	19438	144.9	10056	230.6	3287	103.1	212	8.0	33012	487.4
1997	15848	136.7	7755	124.5	3139	86.4	992	39.3	28012	400.7
1998	89947	505.5	7634	174.5	3965	119.3	598	23.0	102435	839.5
1999	59434	399.6	22760	426.0	8803	286.8	435	25.9	91463	1141.9
2000	33825	269.4	19999	432.4	14598	597.6	840	48.4	69262	1347.8
2001	77144	709.0	15694	434.5	12499	589.3	2271	132.1	107713	1869.6
2002	8431	56.8	34824	875.9	6350	282.2	2322	143.2	52218	1377.2
2003	15434	114.1	2057	37.9	2038	63.9	1545	64.4	21074	280.2
Average	27848	213.4	10862	237.6	4046	148.5	604	31.2	43417	633.9

Table 2.3.6. Survey mortalities for polar cod from age 1 to age 2, and from age 2 to age 3.

Year	Year class	Age 1 (10^9)	Age 2 (10^9)	Total mort. %	Total mort Z
1986-1987	1985	24.0	10.1	58	0.86
1987-1988	1986	15.0	1.5	90	2.30
1988-1989	1987	4.3	1.8	58	0.87
1989-1990	1988	13.5	2.2	84	1.81
1990-1991	1989	3.8	4.2	-	-
1991-1992	1990	23.7	14.0	41	0.53
1992-1993	1991	22.9	18.9	17	0.19
1993-1994	1992	16.3	9.3	43	0.56
1994-1995	1993	27.5	6.5	76	1.44
1995-1996	1994	30.7	10.1	67	1.11
1996-1997	1995	19.4	7.8	59	0.91
1997-1998	1996	15.8	7.6	52	0.73
1998-1999	1997	89.9	22.8	75	1.37
1999-2000	1998	59.4	20.0	66	1.09
2000-2001	1999	33.8	15.7	54	0.77
2001-2002	2000	77.1	34.8	55	0.80
2002-2003	2001	8.4	2.1	75	1.38

Year	Year class	Age 2 (10^9)	Age 3 (10^9)	Total mort. %	Total mort Z
1986-1987	1984	6.3	3.1	51	0.71
1987-1988	1985	10.1	0.7	93	2.67
1988-1989	1986	1.5	0.2	87	2.01
1989-1990	1987	1.8	0.7	61	2.57
1990-1991	1988	2.2	1.9	14	0.15
1991-1992	1989	4.2	0.8	81	1.66
1992-1993	1990	14.0	3.0	78	1.54
1993-1994	1991	18.9	5.0	74	1.33
1994-1995	1992	9.3	1.6	83	1.76
1995-1996	1993	6.5	3.3	51	0.68
1996-1997	1994	10.1	3.1	69	1.18
1997-1998	1995	7.8	4.0	49	0.67
1998-1999	1996	7.6	8.8	-	-
1999-2000	1997	22.8	14.6	36	0.44
2000-2001	1998	20.0	12.5	38	0.47
2001-2002	1999	15.7	6.4	59	0.90
2002-2003	2000	34.8	2.0	94	2.86

Table 2.3.7. Acoustic estimate of young herring in the Barents Sea August-September 2003.

Length (cm)	Age			Sum (10^6)	Biomass (10^3t)	Mean weight (g)
	2002	2001	2000			
	1	2	3			
10.5-10.9	48.6			48.6	0.40	8.3
11.0-11.4	64.8			64.8	0.64	9.9
11.5-11.9	156.0			156.0	1.66	10.6
12.0-12.4	752.0			752.0	8.77	11.7
12.5-12.9	1277.3			1277.3	17.55	13.7
13.0-13.4	1862.1			1862.1	27.15	14.6
13.5-13.9	2109.3			2109.3	33.84	16.0
14.0-14.9	3977.3			3977.3	71.04	17.9
14.5-14.9	4944.6			4944.6	100.82	20.4
15.0-15.4	7424.8			7424.8	166.88	22.5
15.5-15.9	10442.5			10442.5	268.26	25.7
16.0-16.4	11619.7			11619.7	324.48	27.9
16.5-16.9	16819.8			16819.8	534.01	31.7
17.0-17.4	12681.3	528.4		13209.7	452.70	34.3
17.5-17.9	11693.4			11693.4	461.68	39.5
18.0-18.4	6439.1	1287.8		7726.9	321.89	41.7
18.5-18.9	2638.8	1319.4		3958.2	181.31	45.8
19.0-19.4	2502.0			2502.0	118.55	47.4
19.5-19.9	995.2	497.6		1492.8	77.29	51.8
20.0-20.4	789.1			789.1	45.34	57.5
20.5-20.9	439.3			439.3	27.21	61.9
21.0-21.4	108.8	108.8		217.5	14.68	67.5
21.5-21.9		111.7		111.7	8.31	74.4
22.0-22.4		52.9		52.9	4.24	80.2
22.5-22.9		52.9		52.9	4.61	87.1
23.0-23.4		122.0		122.0	11.61	95.2
23.5-23.9		254.2		254.2	26.00	102.3
24.0-24.4			439.3	439.3	48.77	111.0
24.5-24.9			528.9	528.9	64.07	121.1
25.0-25.4			740.5	740.5	97.41	131.5
25.5-25.9			449.6	449.6	64.23	142.9
26.0-26.4			211.6	211.6	32.82	155.1
26.5-26.9			79.3	79.3	13.37	168.5
27.0-27.4			26.4	26.4	4.84	183.0
TSN (10^6)	99785.7	4335.7	2475.6	106596.9		
TSB (10^3 t)	3090.9	220.1	325.5		3636.4	
Mean length (cm)	16.3	18.9	25.0	16.7		
Mean weight (g)	31.0	50.8	131.5			34.0
TS=20.0* lg(L) - 71.9						

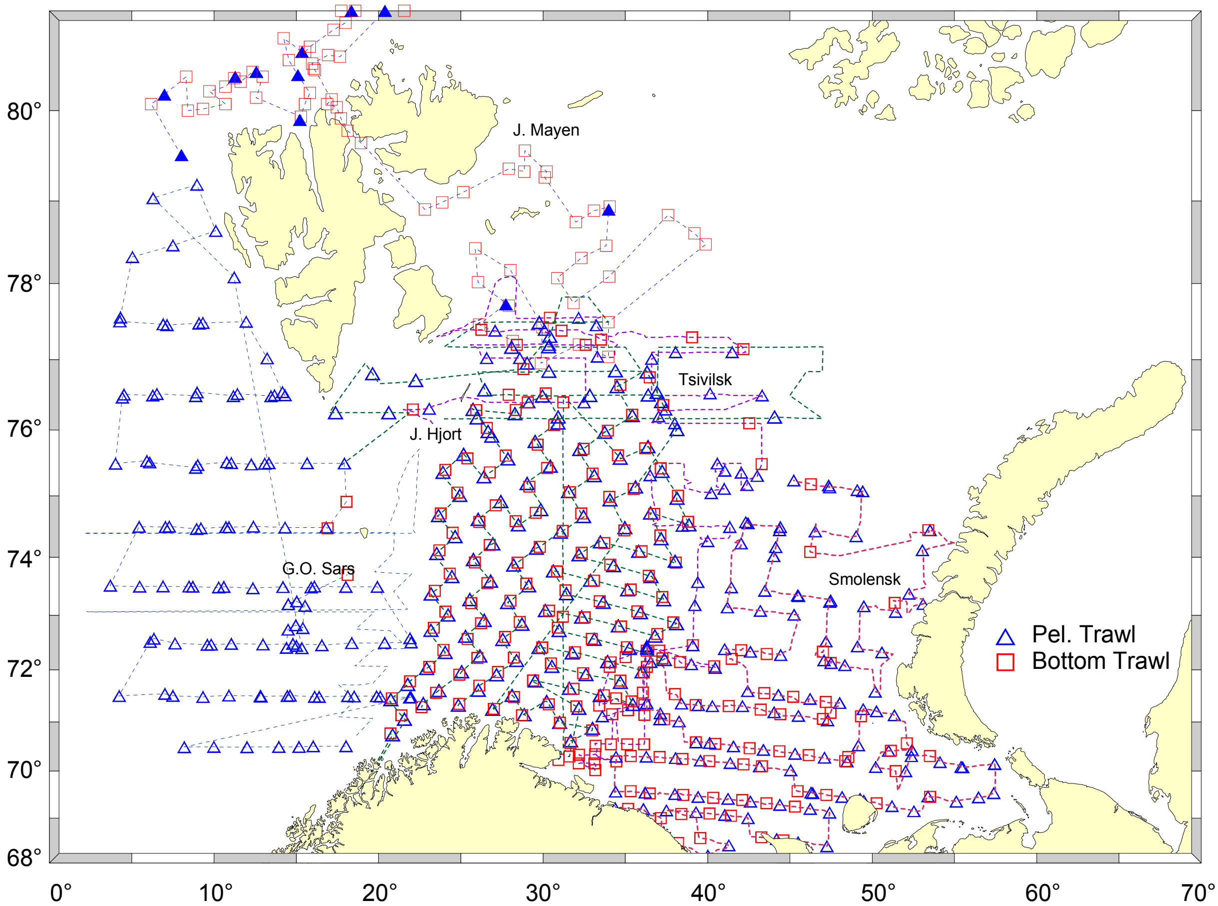

Figure 2.1 Survey routes and trawl stations for "G.O. Sars", "Johan Hjort", "Jan Mayen", "Tsivilsk" and "Smolensk" August-September 2003

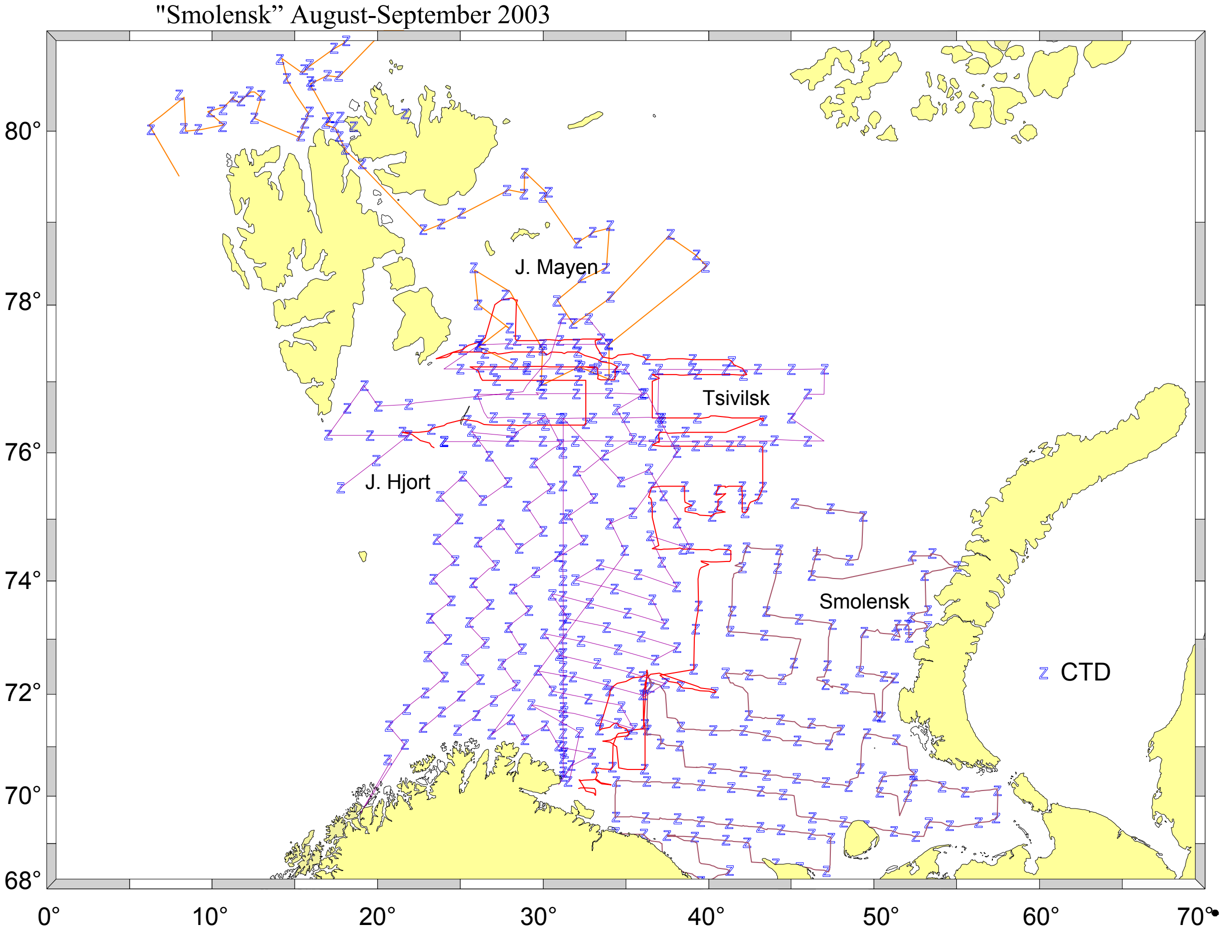

Figure 2.2 Survey routes and hydrographic stations for "Johan Hjort", "Jan Mayen", "Tsivilsk", and "Smolensk" August-September 2003

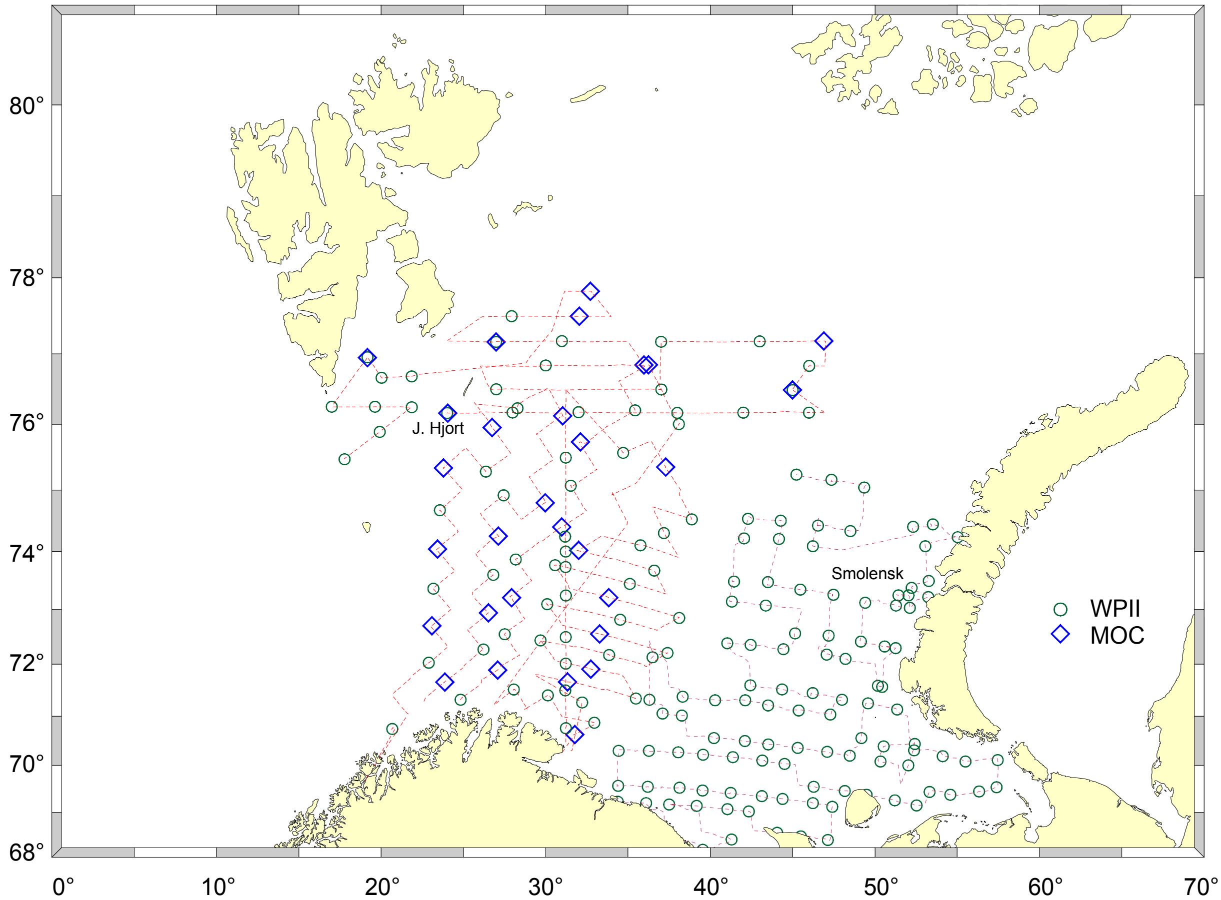

Figure 2.3 Survey routes and plankton stations for " Johan Hjort ", "Tsivilsk", and "Smolensk" August-September 2003

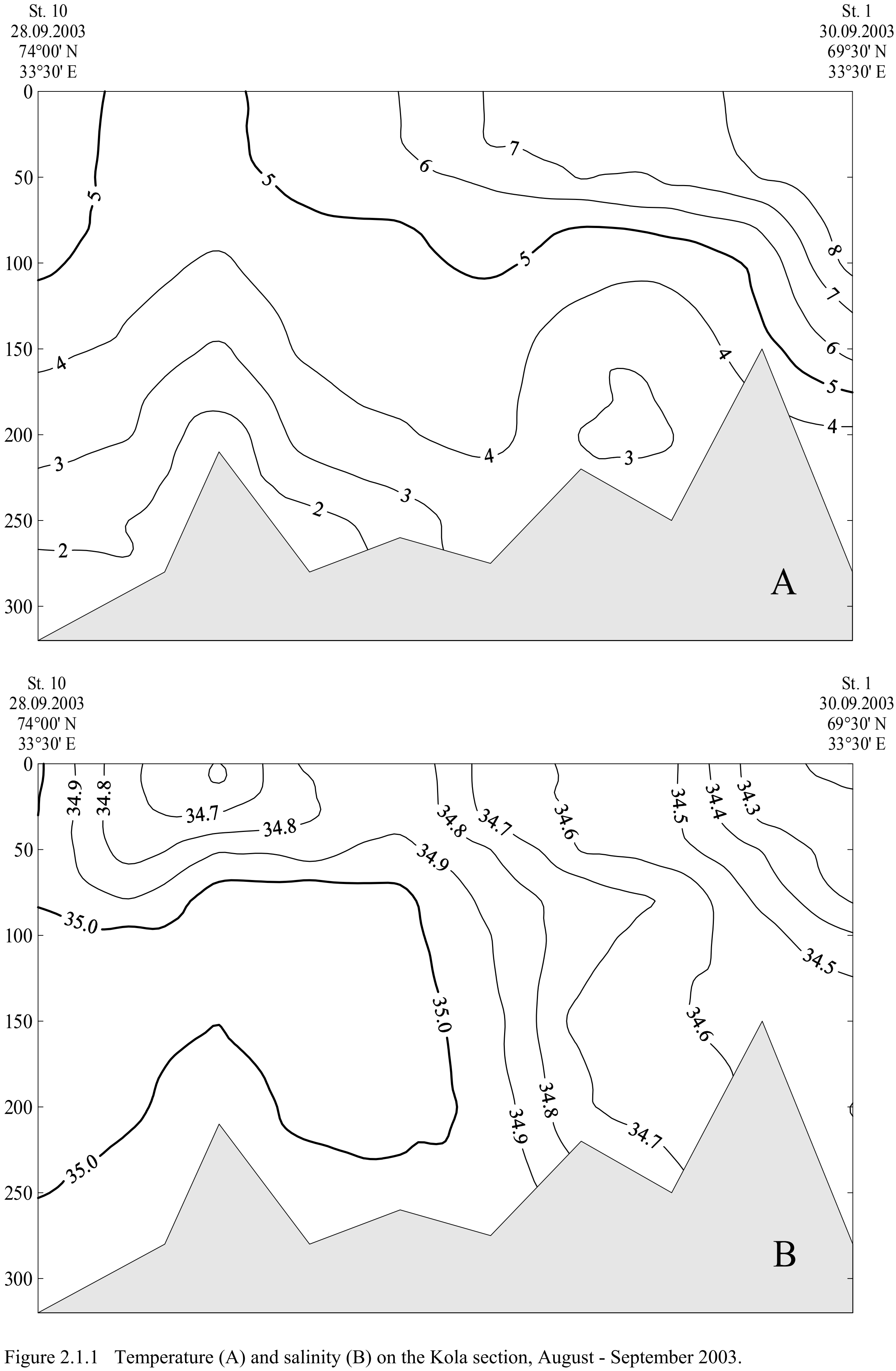

Figure 2.1.1 Temperature (A) and salinity (B) on the Kola section, August - September 2003.

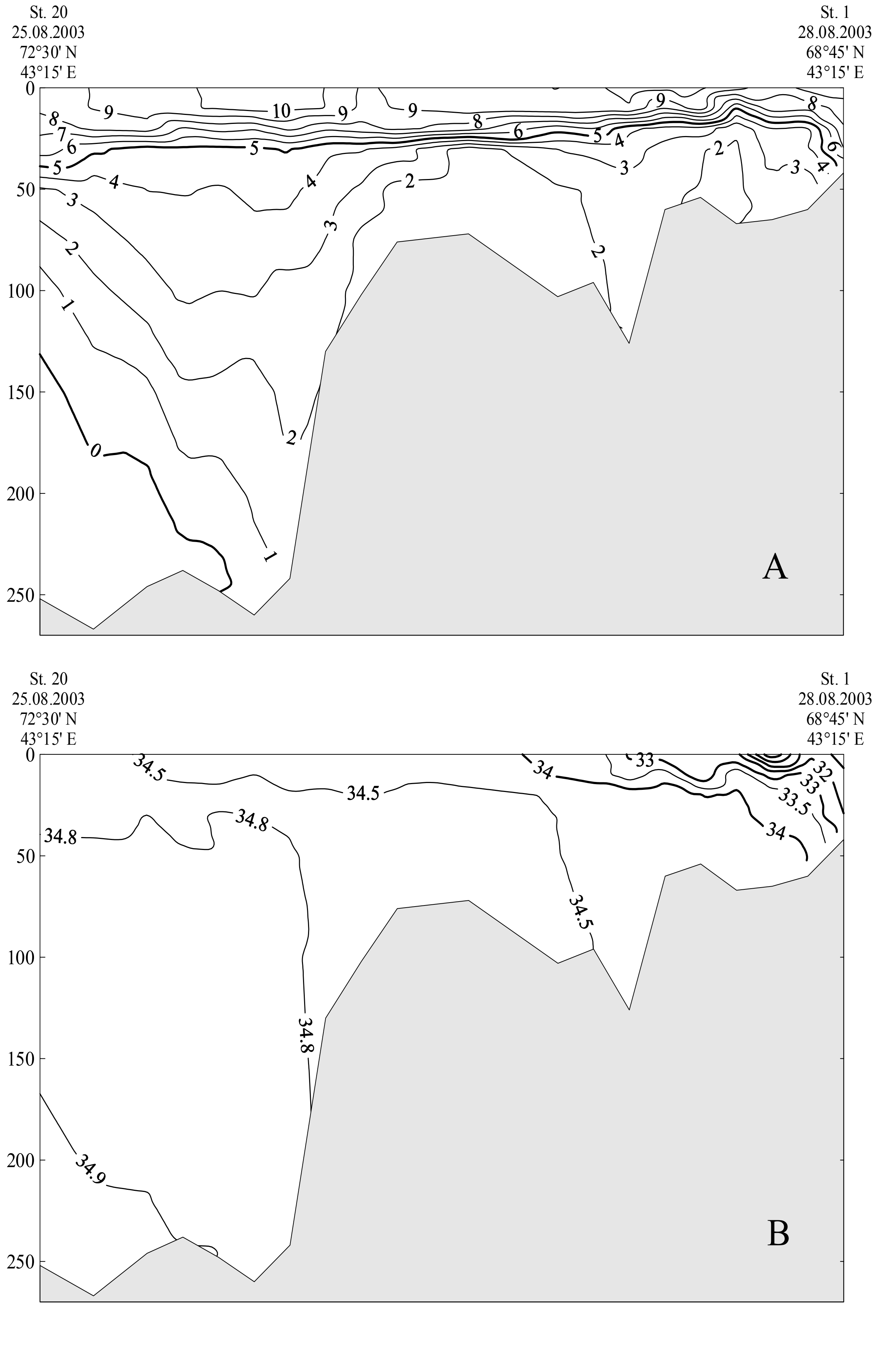

Figure 2.1.2 Temperature (A) and salinity (B) on the Kanin section, August - September 2003.

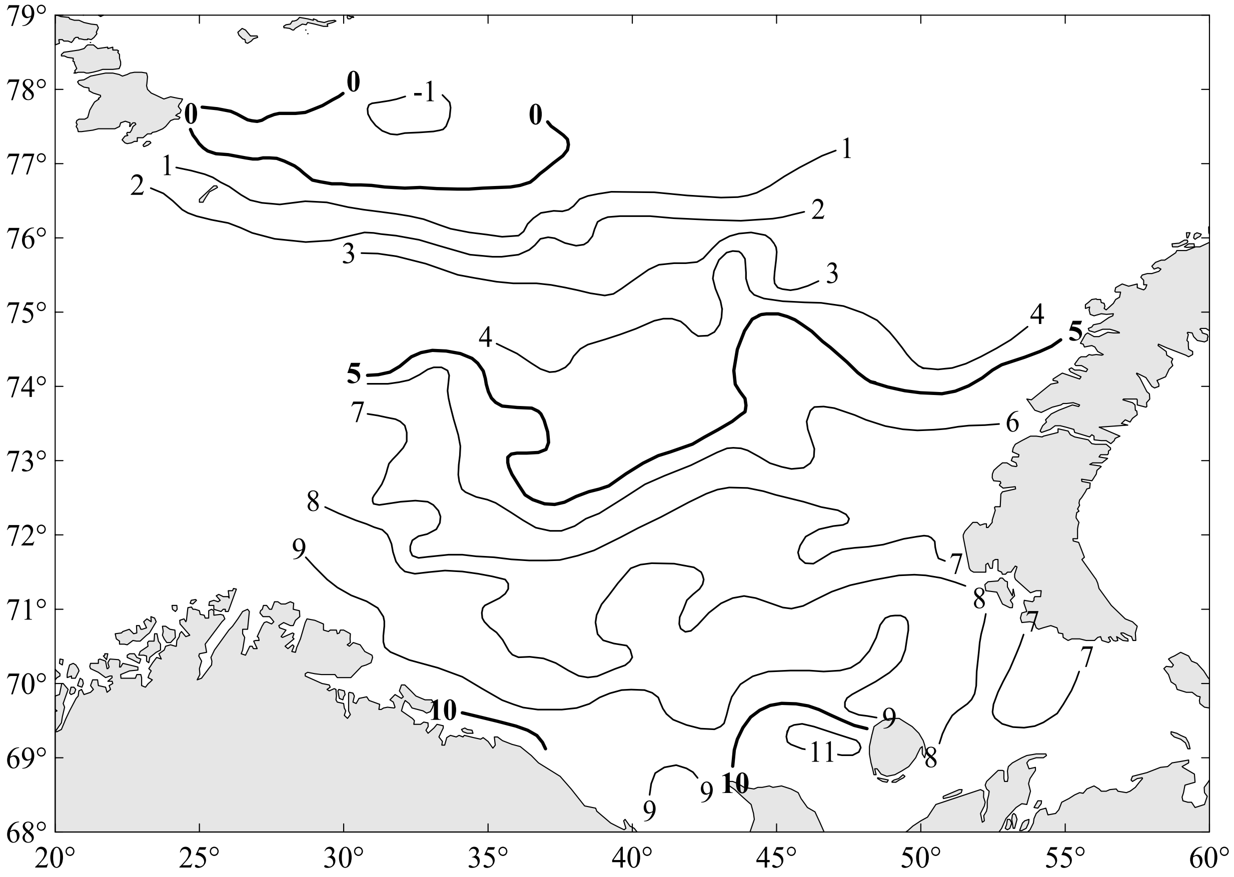

Figure 2.1.3 Distribution of temperatures (ºC) at surface, September 2003.

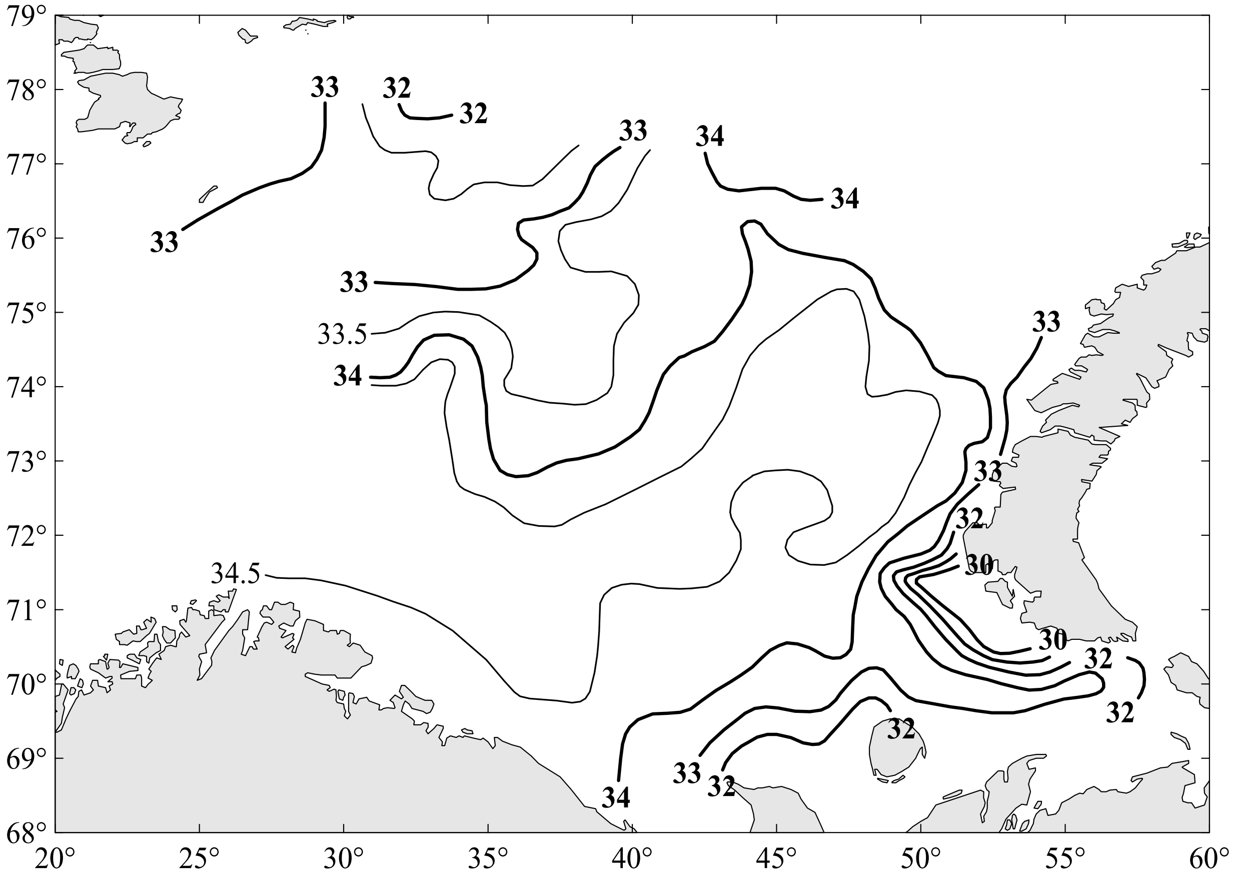

Figure 2.1.4 Distribution of salinities at surface, September 2003.

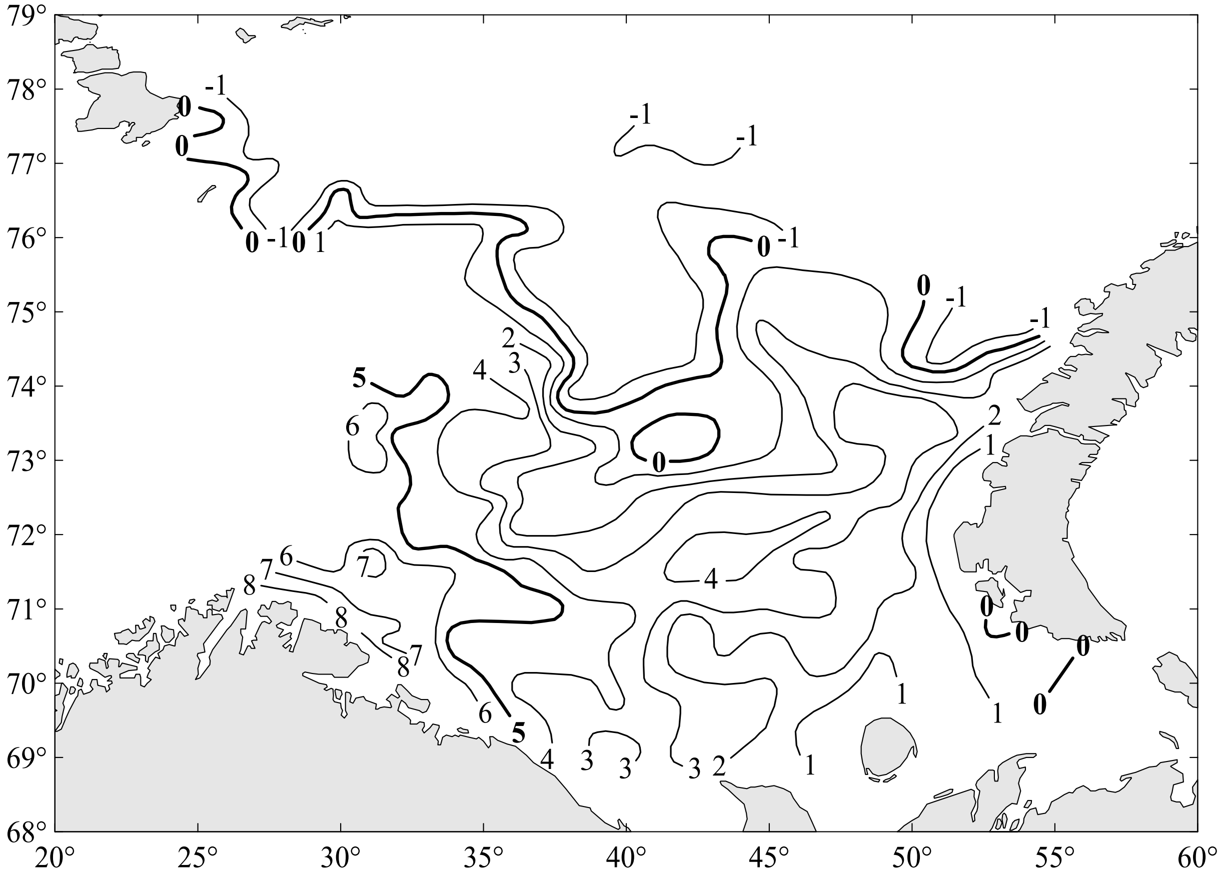

Figure 2.1.5 Distribution of temperatures (ºC) at 50 meters depth, September 2003.

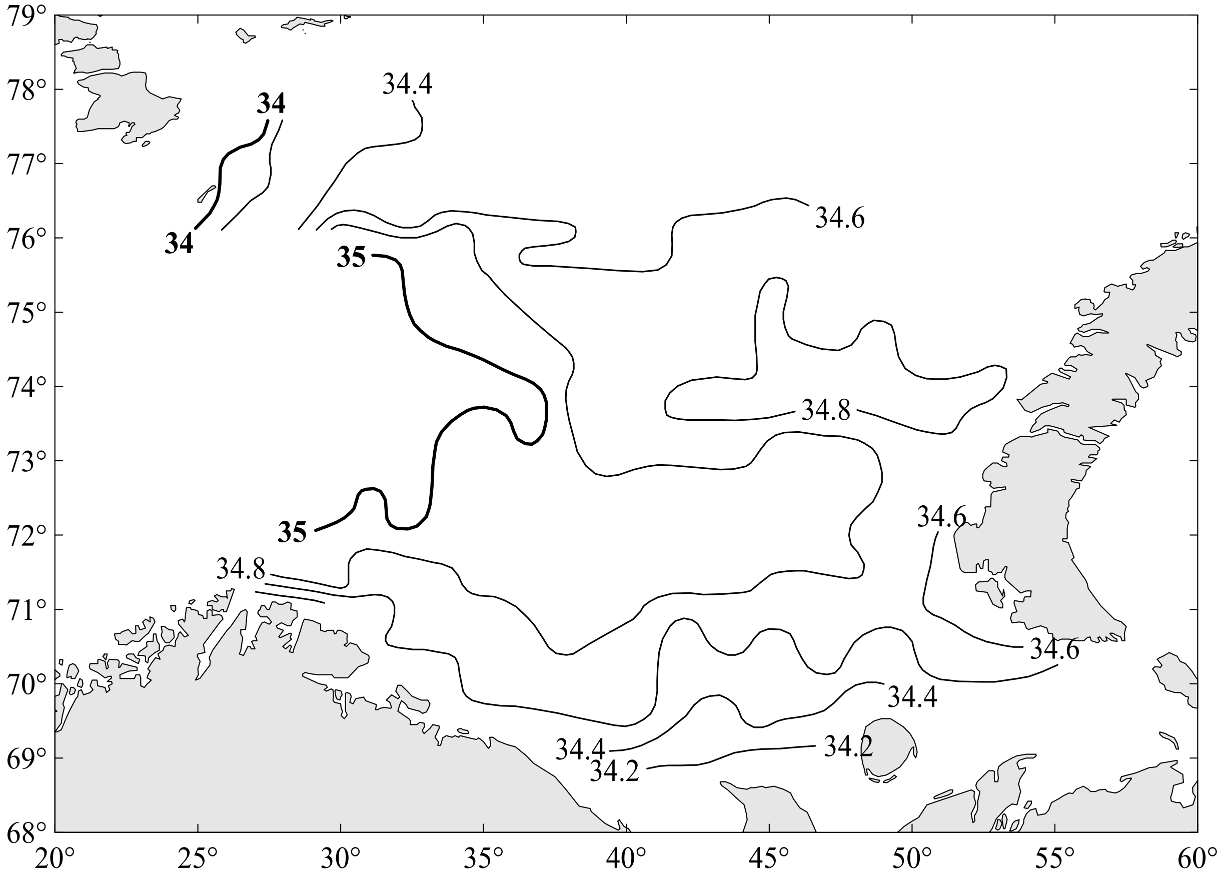

Figure 2.1.6 Distribution of salinities at 50 meters depth, September 2003.

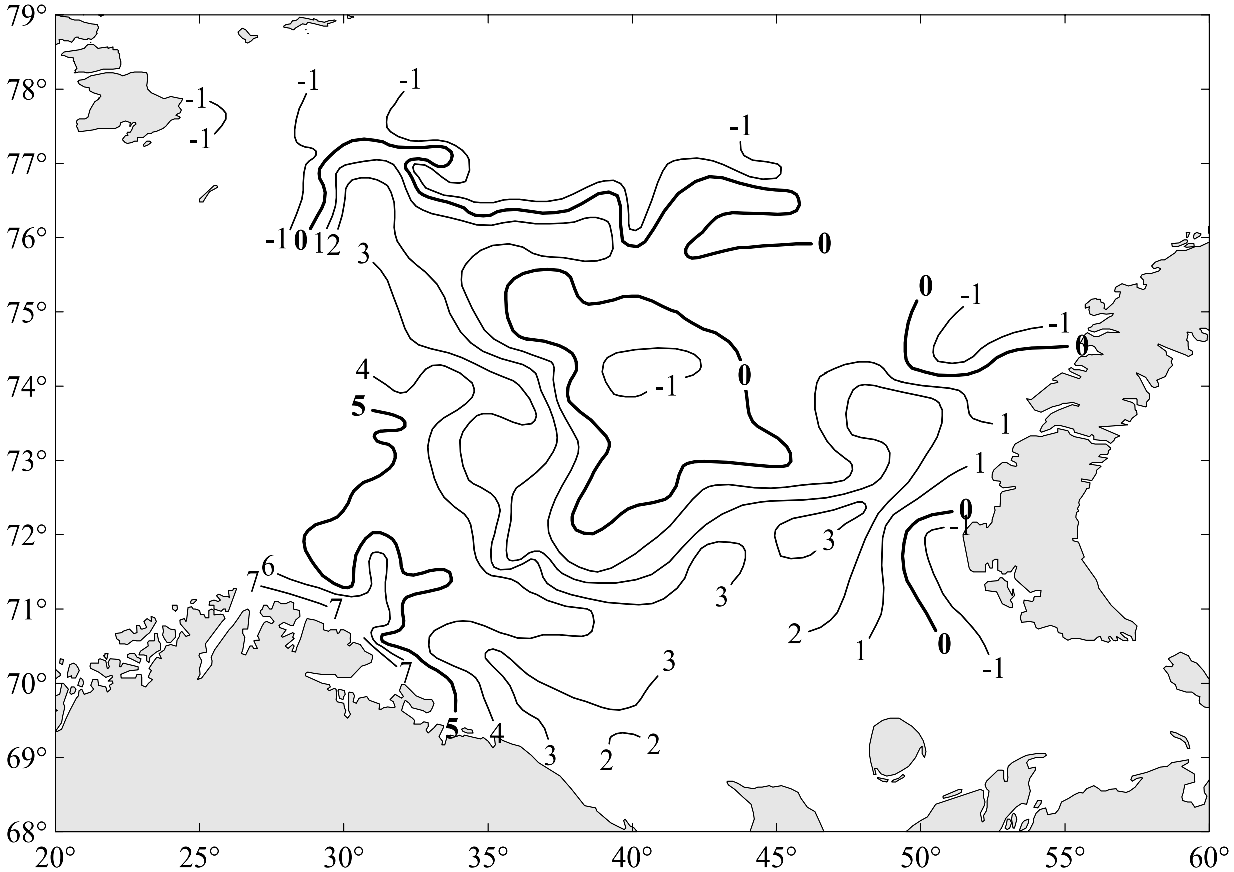

Figure 2.1.7 Distribution of temperatures (ºC) at 100 meters depth, September 2003.

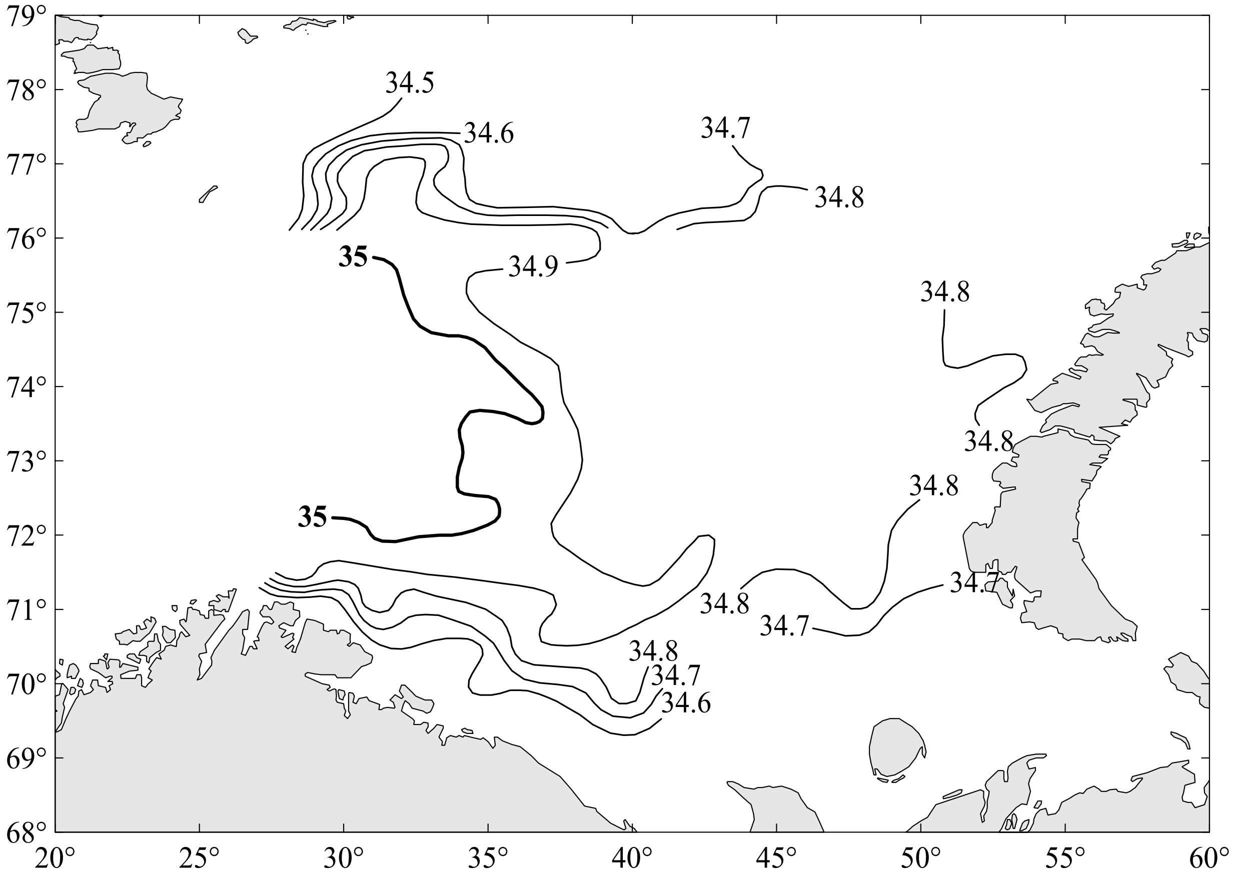

Figure 2.1.8 Distribution of salinities at 100 meters depth, September 2003.

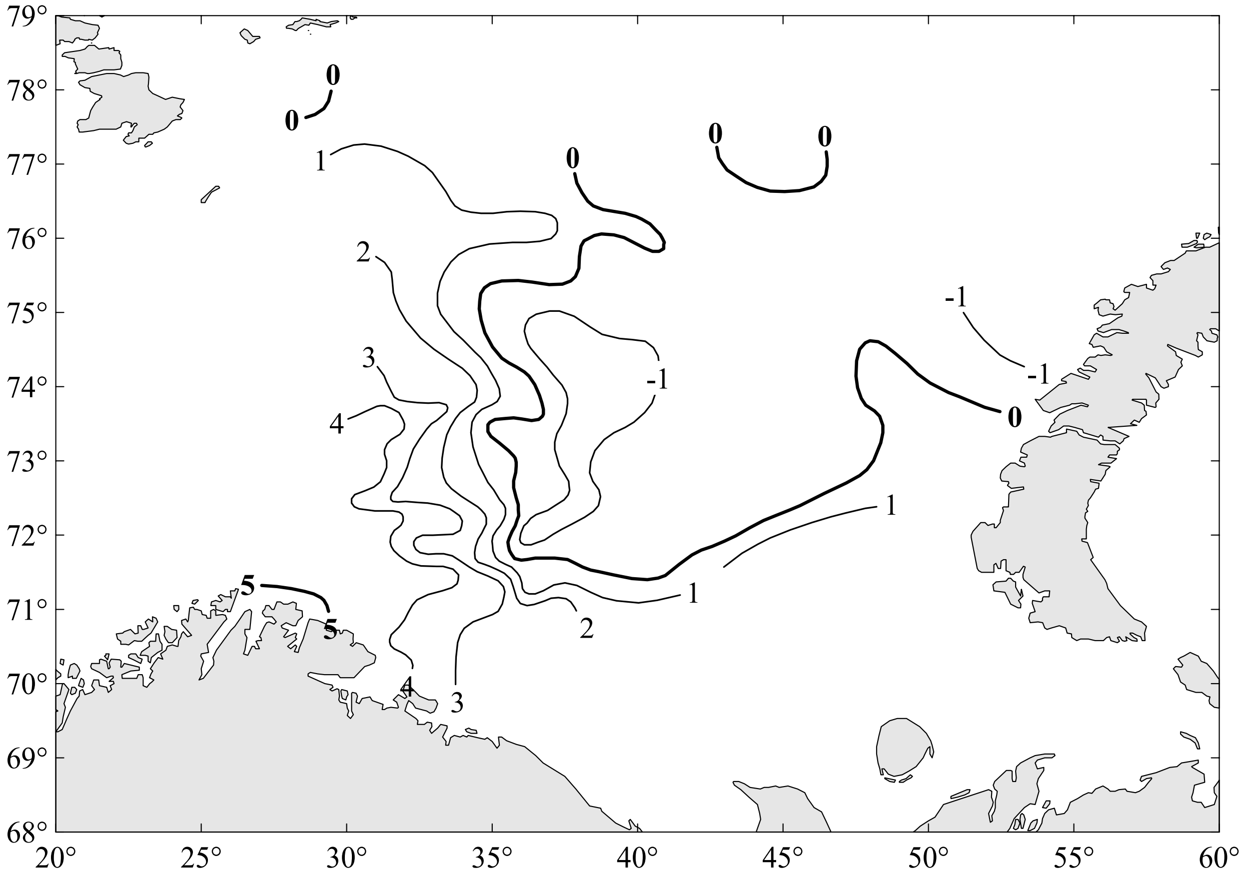

Figure 2.1.9 Distribution of temperatures (ºC) at 200 meters depth, September 2003.

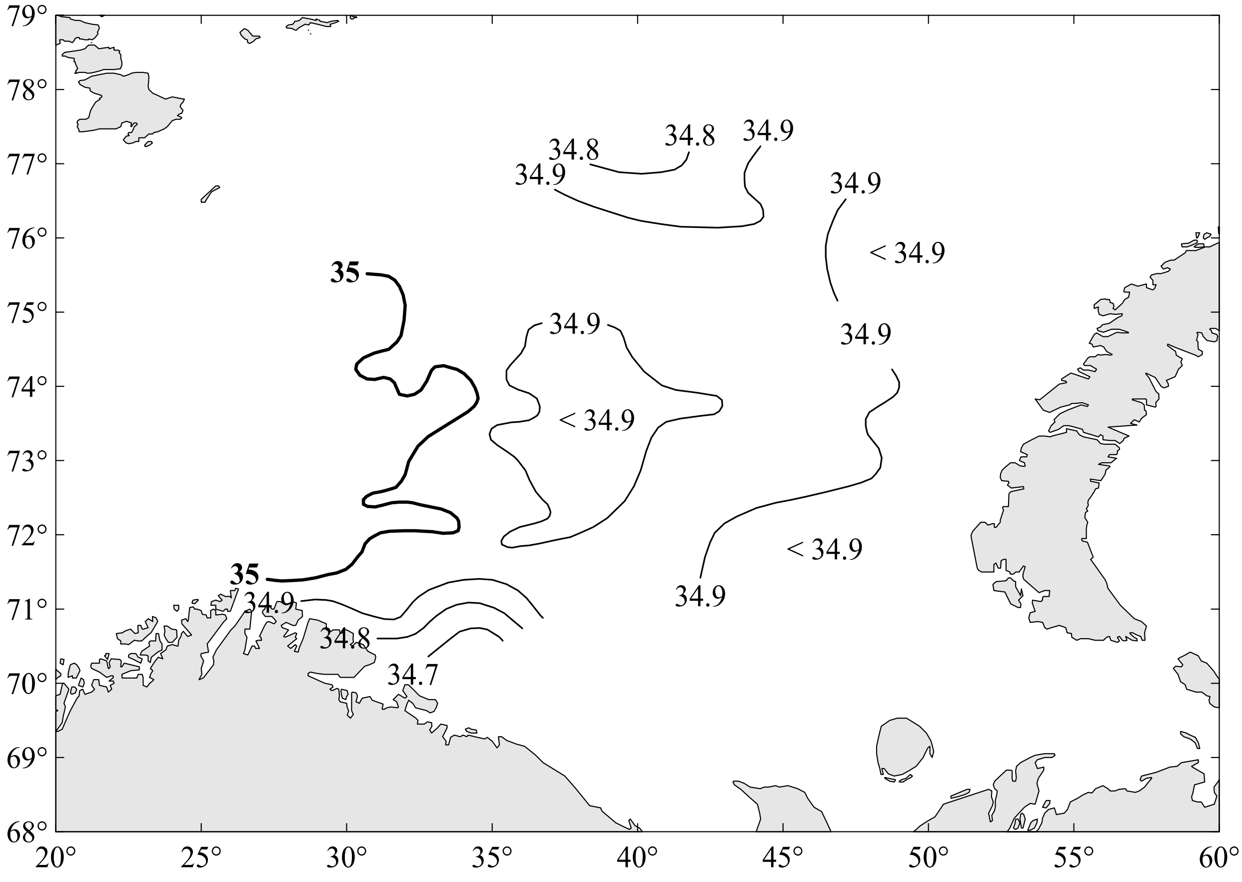

Figure 2.1.10 Distribution of salinities at 200 meters depth, September 2003.

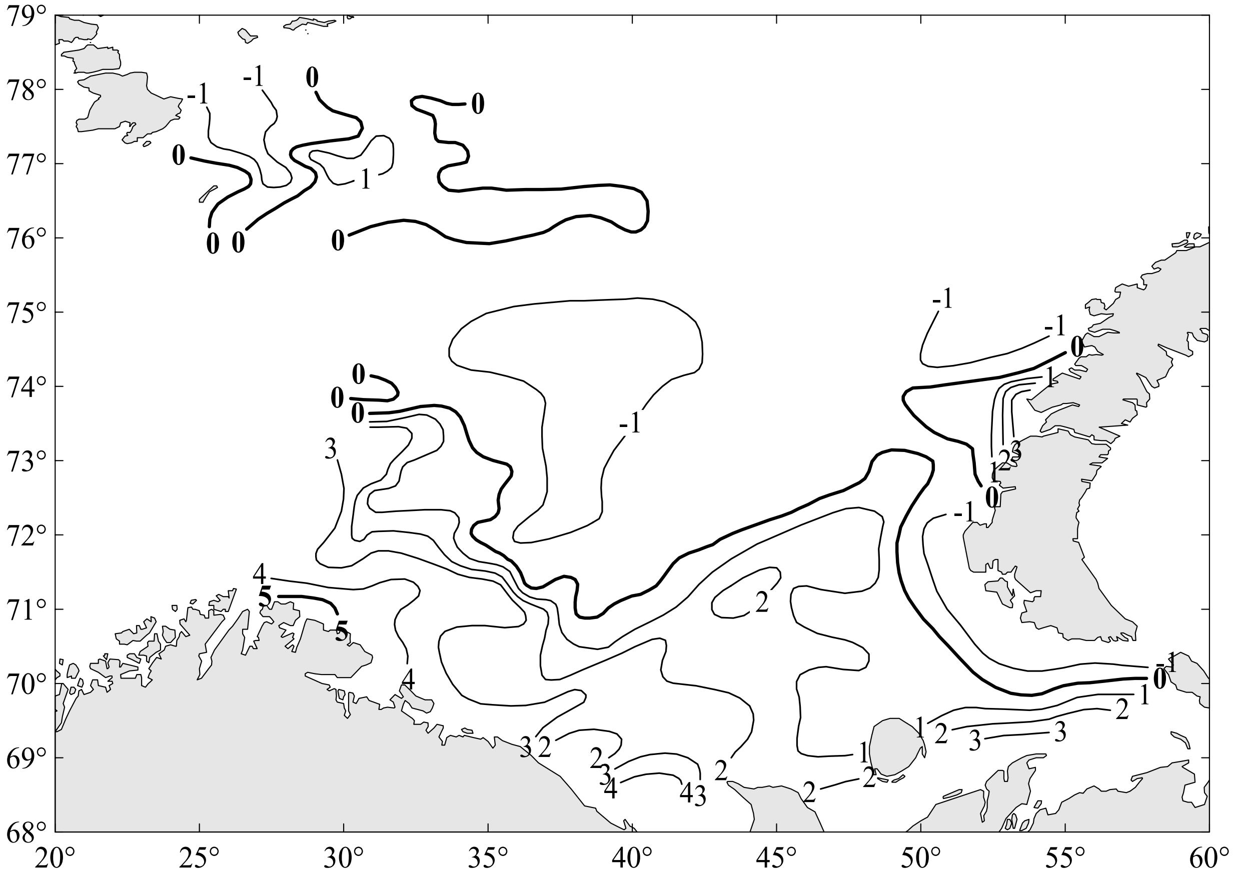

Figure 2.1.11 Distribution of temperatures (ºC) at bottom depth, September 2003.

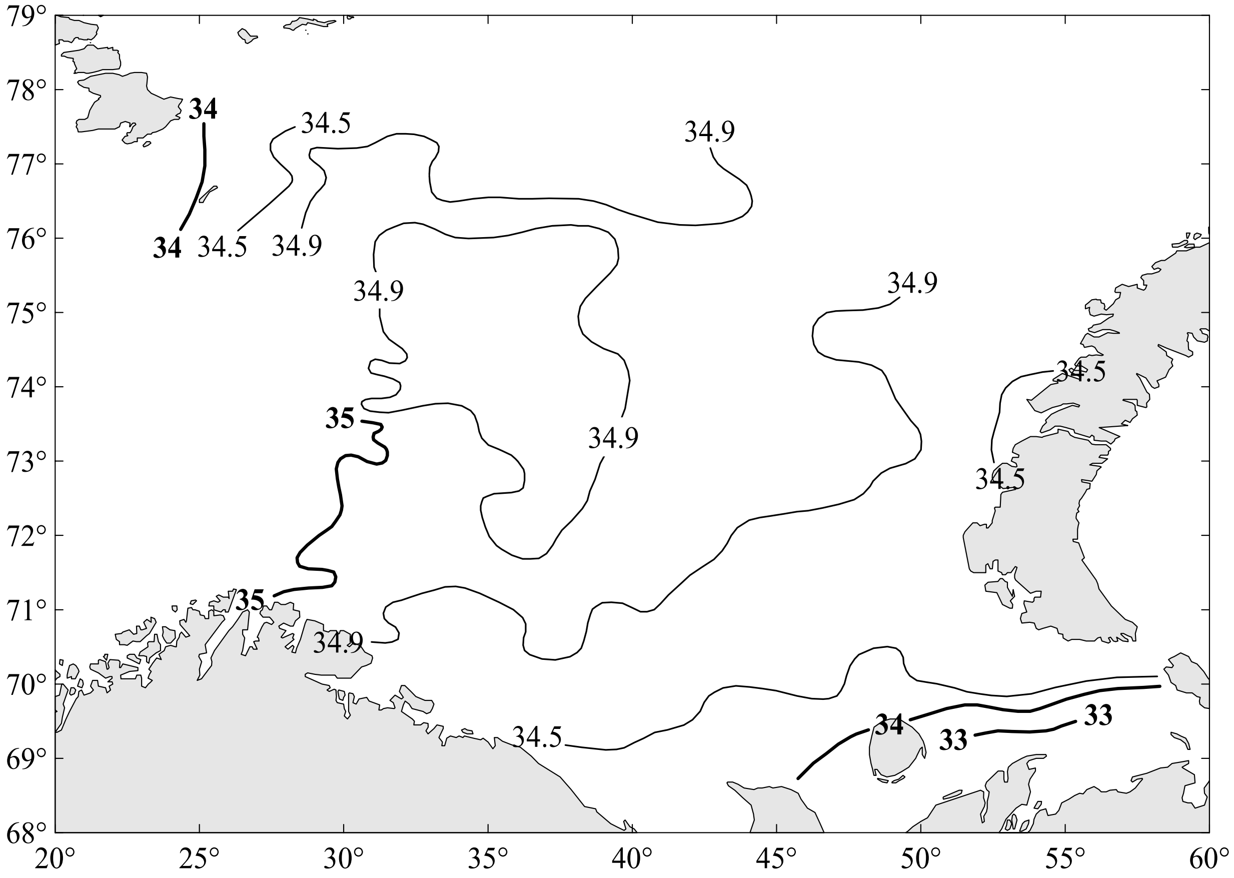

Figure 2.1.12 Distribution of salinities at bottom depth, September 2003.

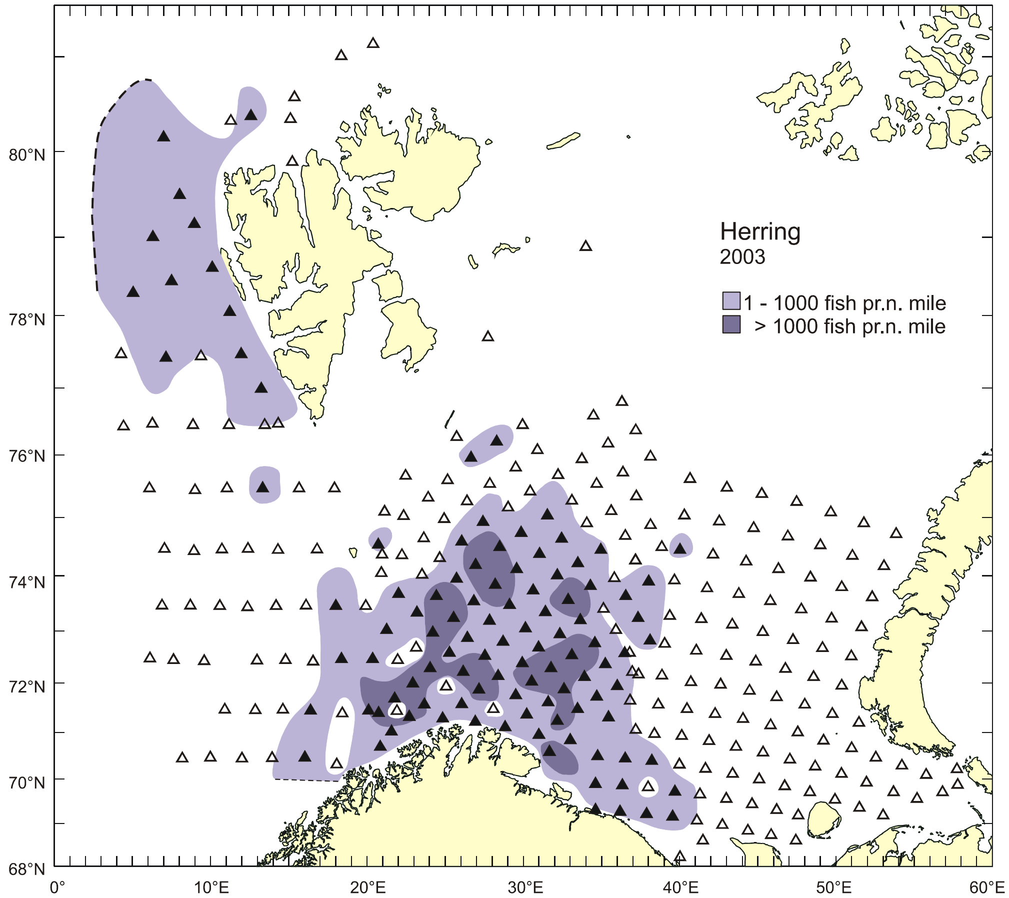

Figure 2.2.1. Distribution of 0-group Herring August - September 2003.

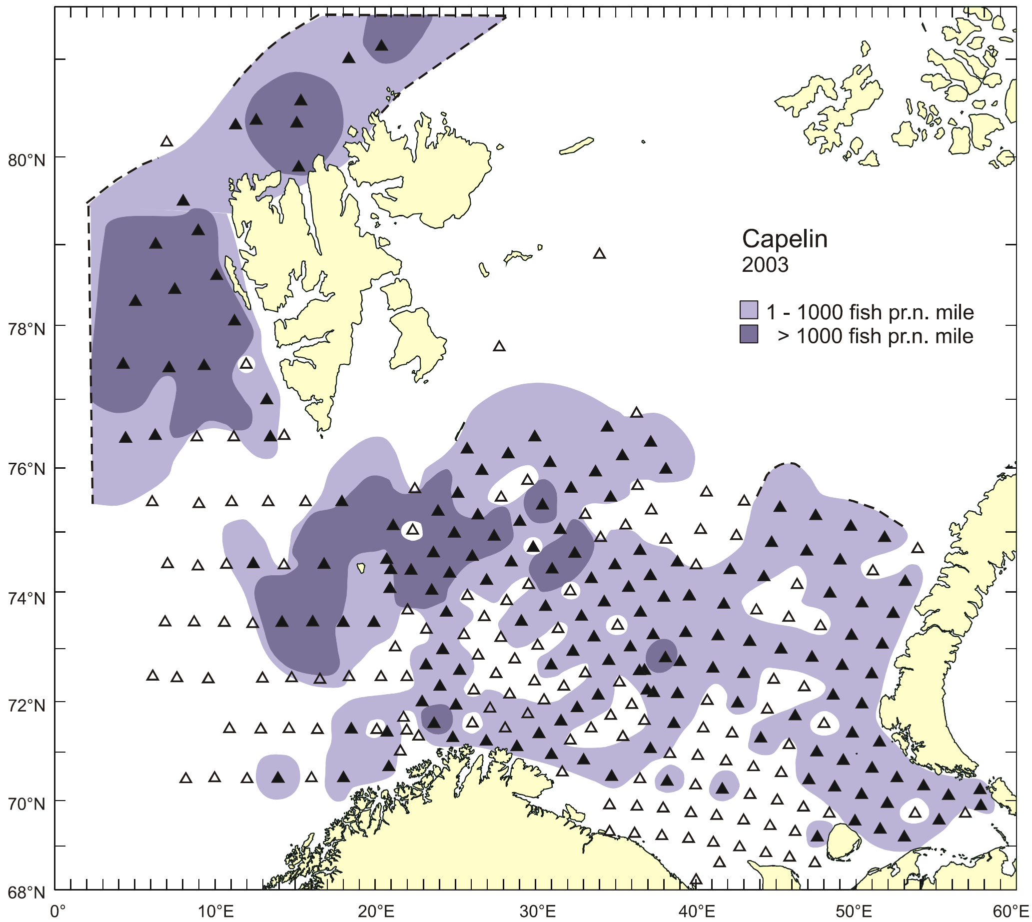

Figure 2.2.2. Distribution of 0-group Capelin August - September 2003.

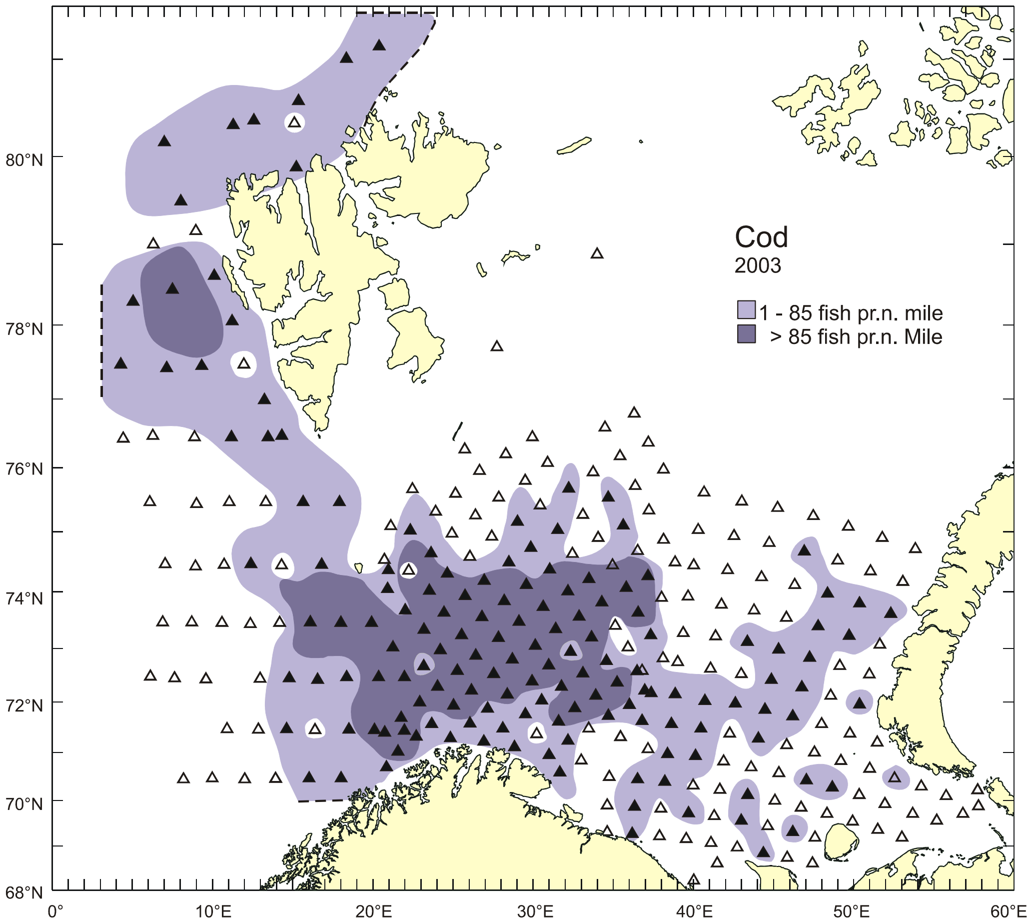

Figure 2.2.3. Distribution of 0-group Cod August - September 2003.

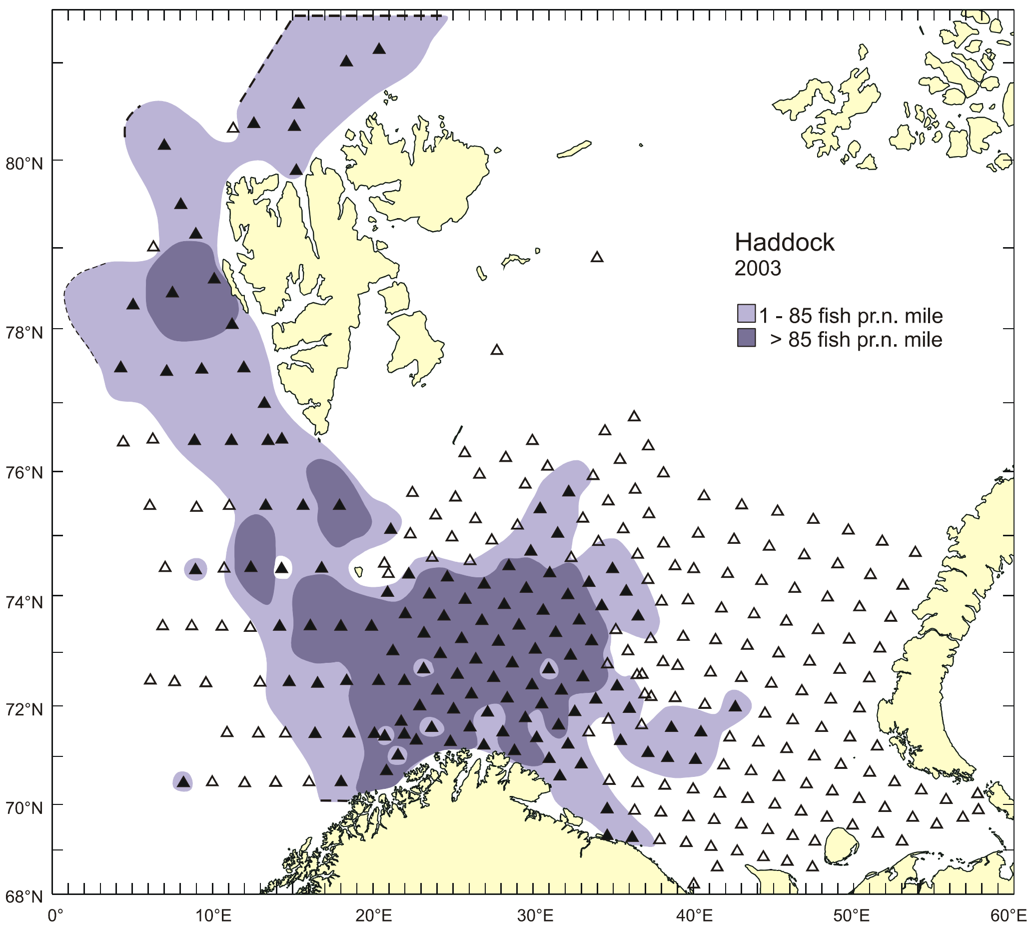

Figure 2.2.4. Distribution of 0-group Haddock August - September 2003.

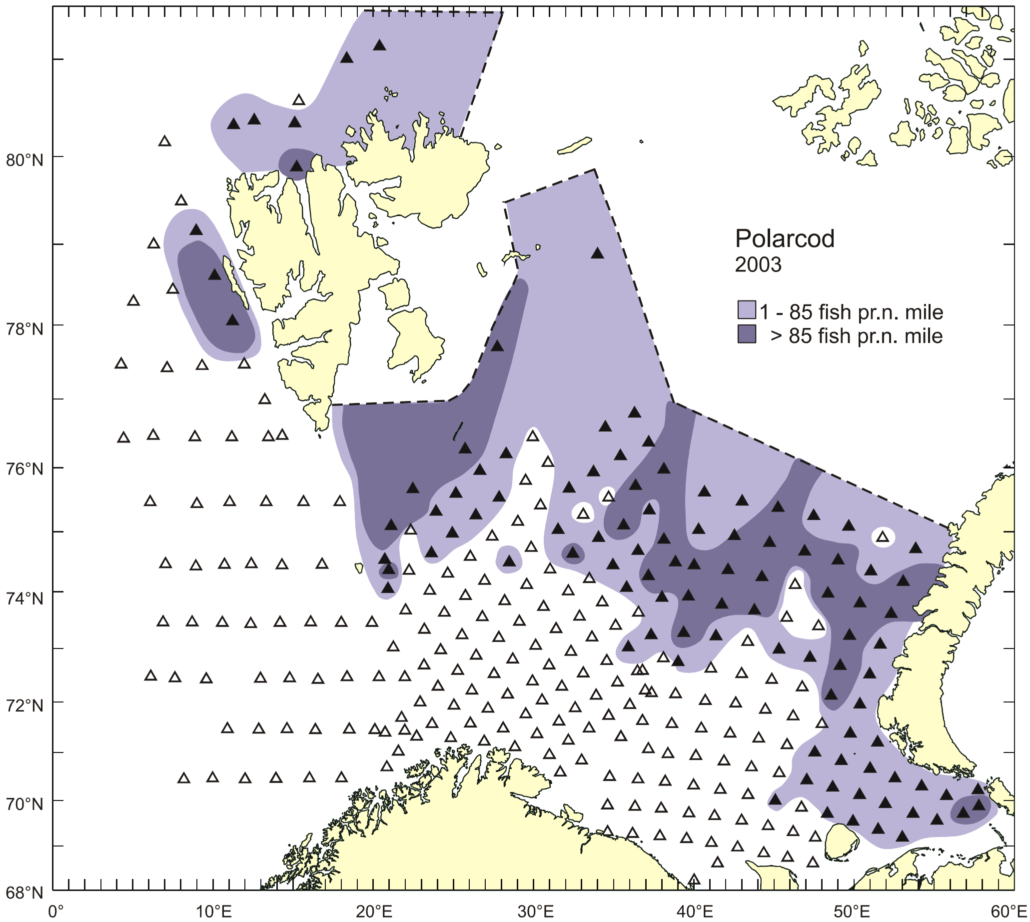

Figure 2.2.5. Distribution of 0-group Polar cod August - September 2003.

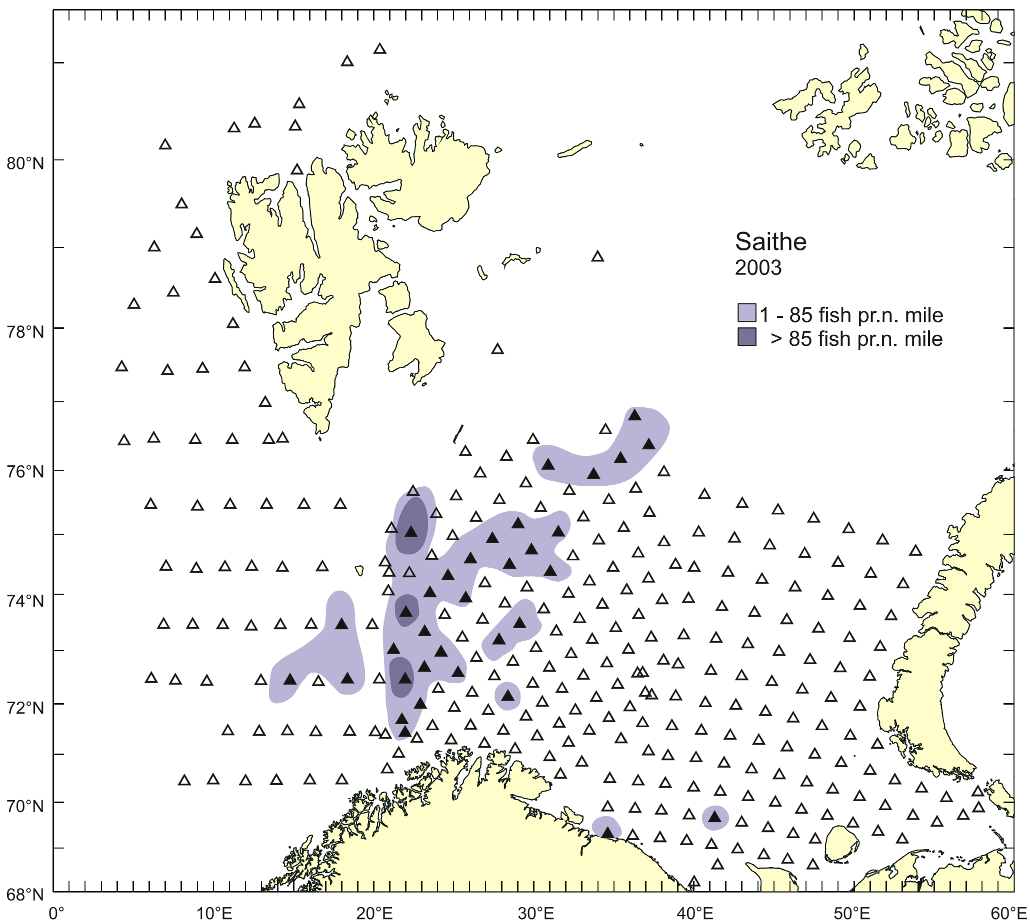

Figure 2.2.6. Distribution of 0-group Saithe August - September 2003.

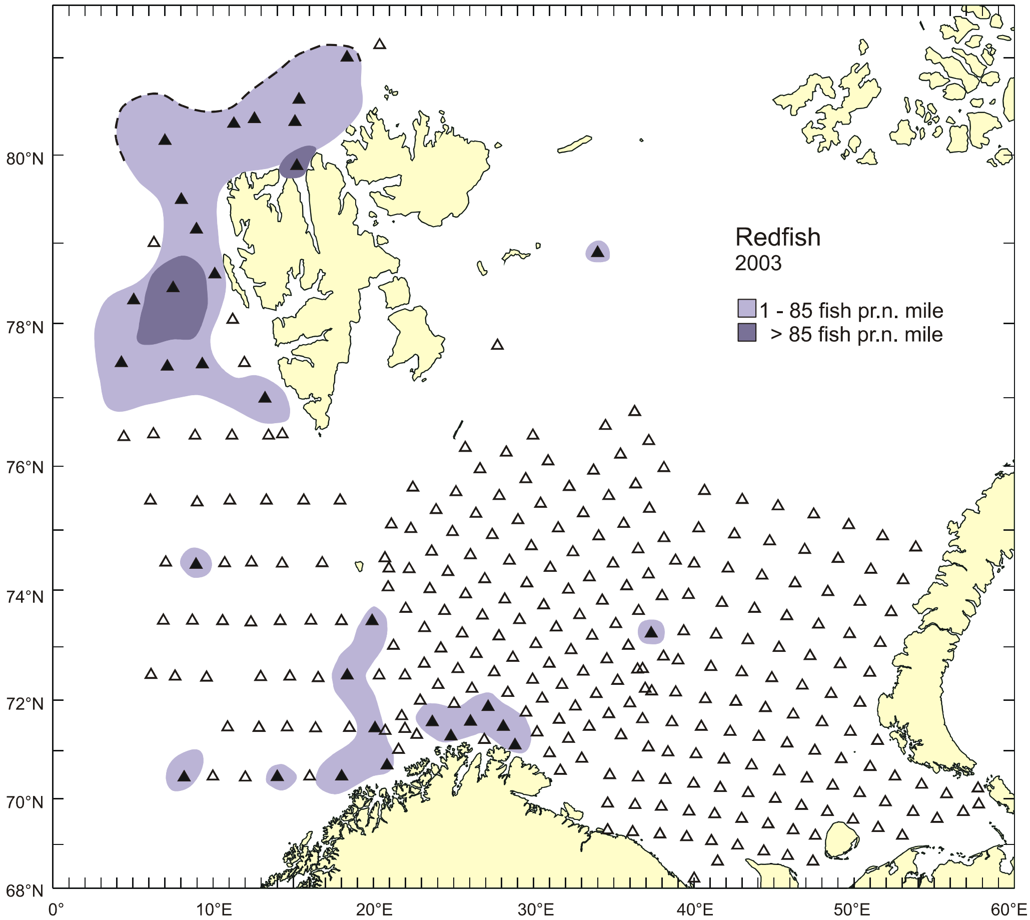

Figure 2.2.7. Distribution of 0-group Redfish August - September 2003.

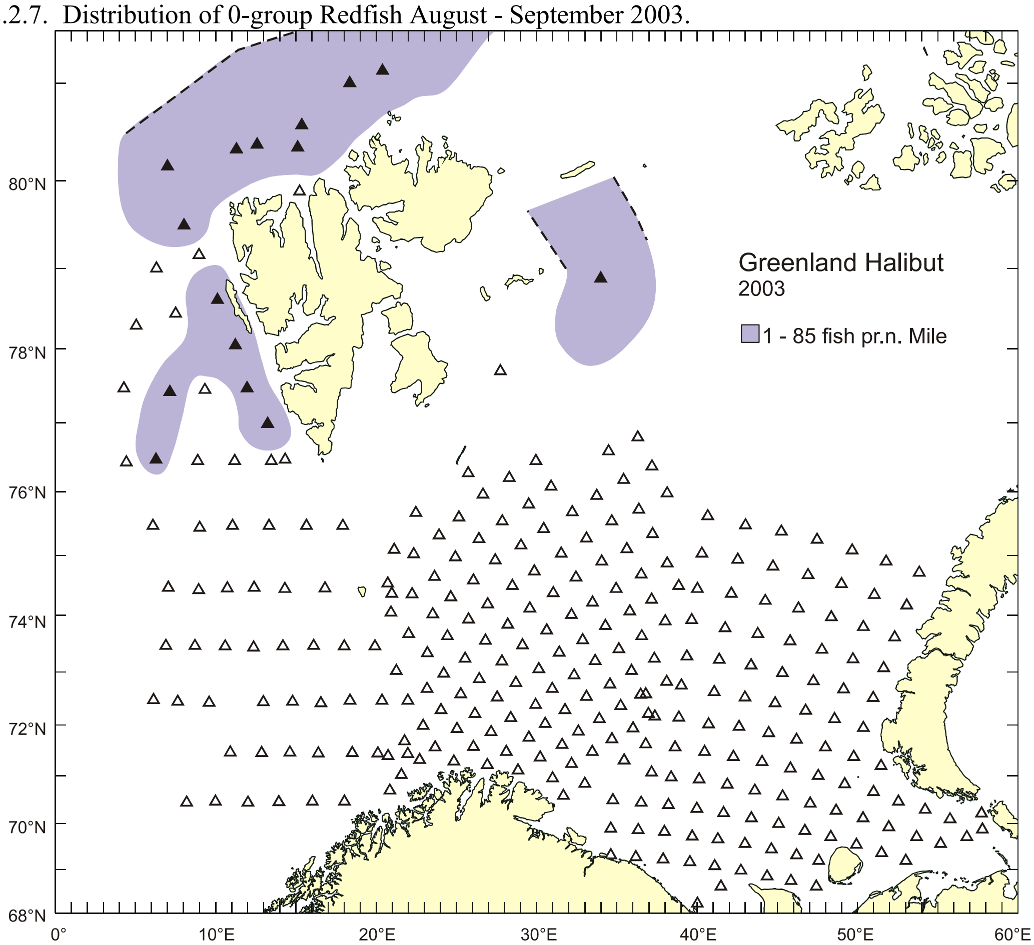

Figure 2.2.8. Distribution of 0-group Greenland halibut August - September 2003.

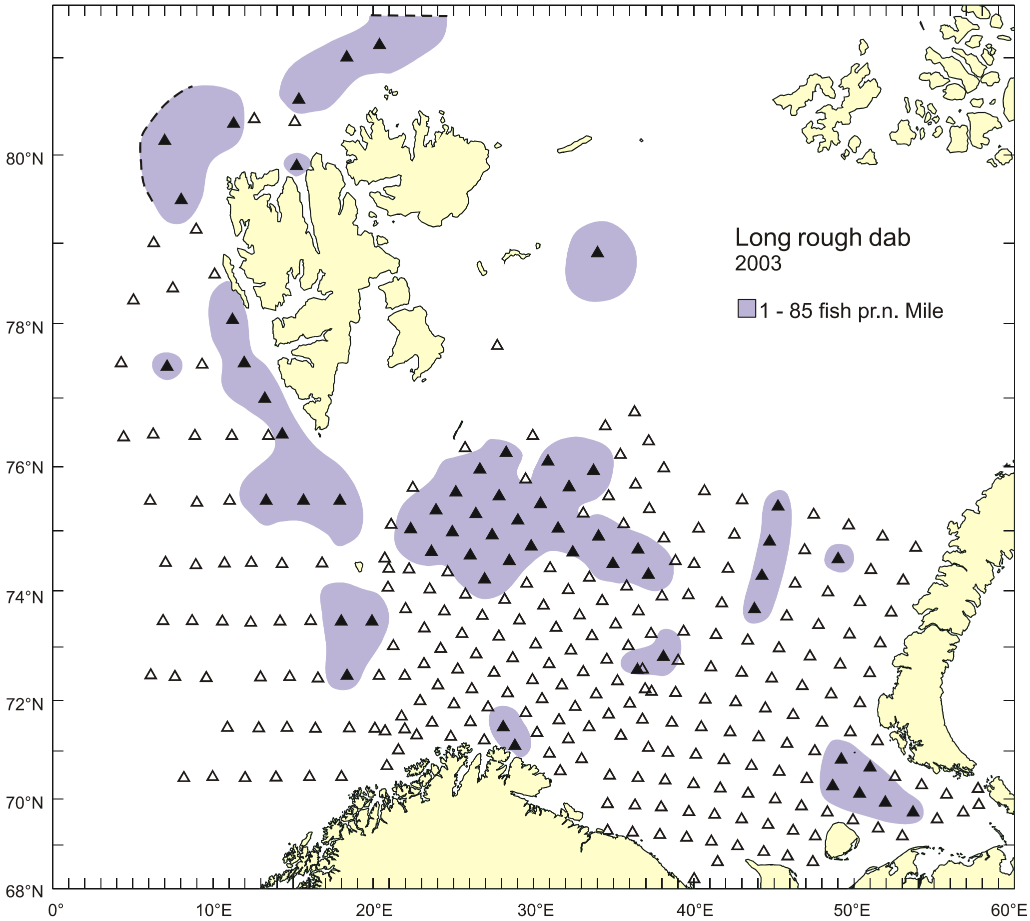

Figure 2.2.9. Distribution of 0-group Long rough dab August - September 2003.

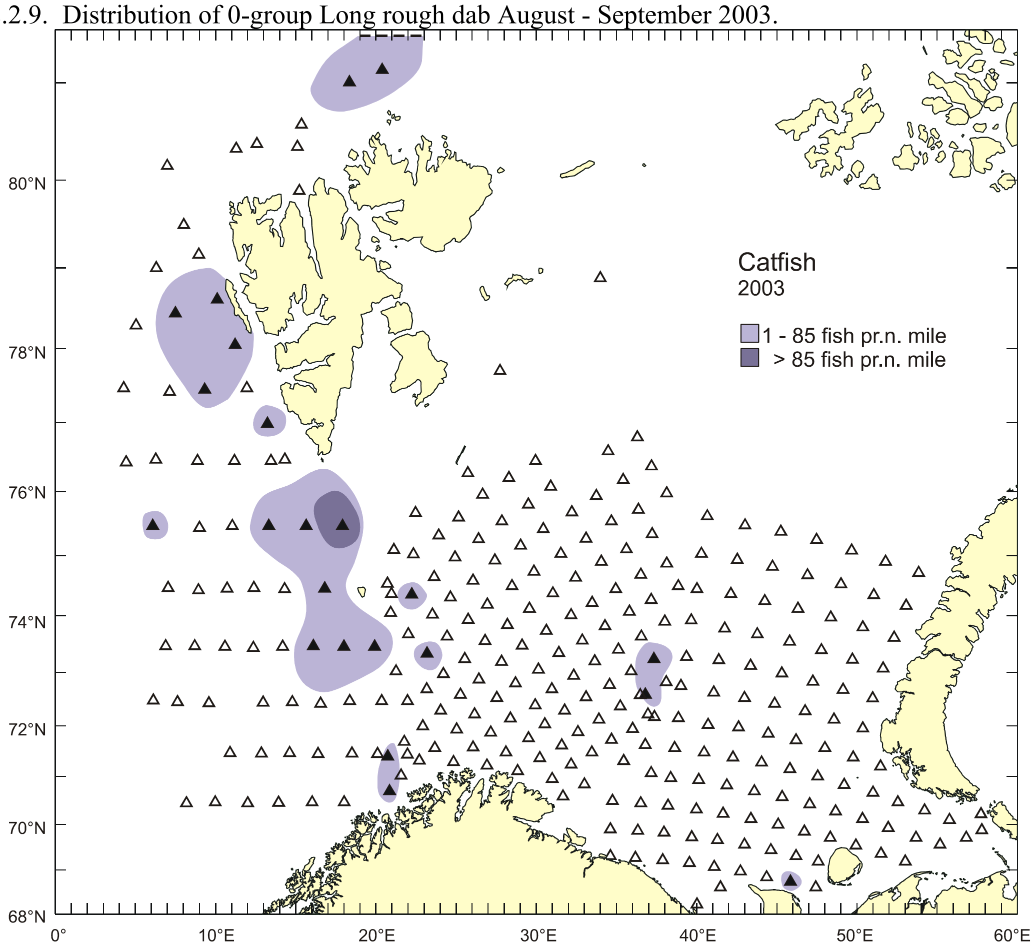

Figure 2.2.10.Distribution of 0-group Catfish 2003.

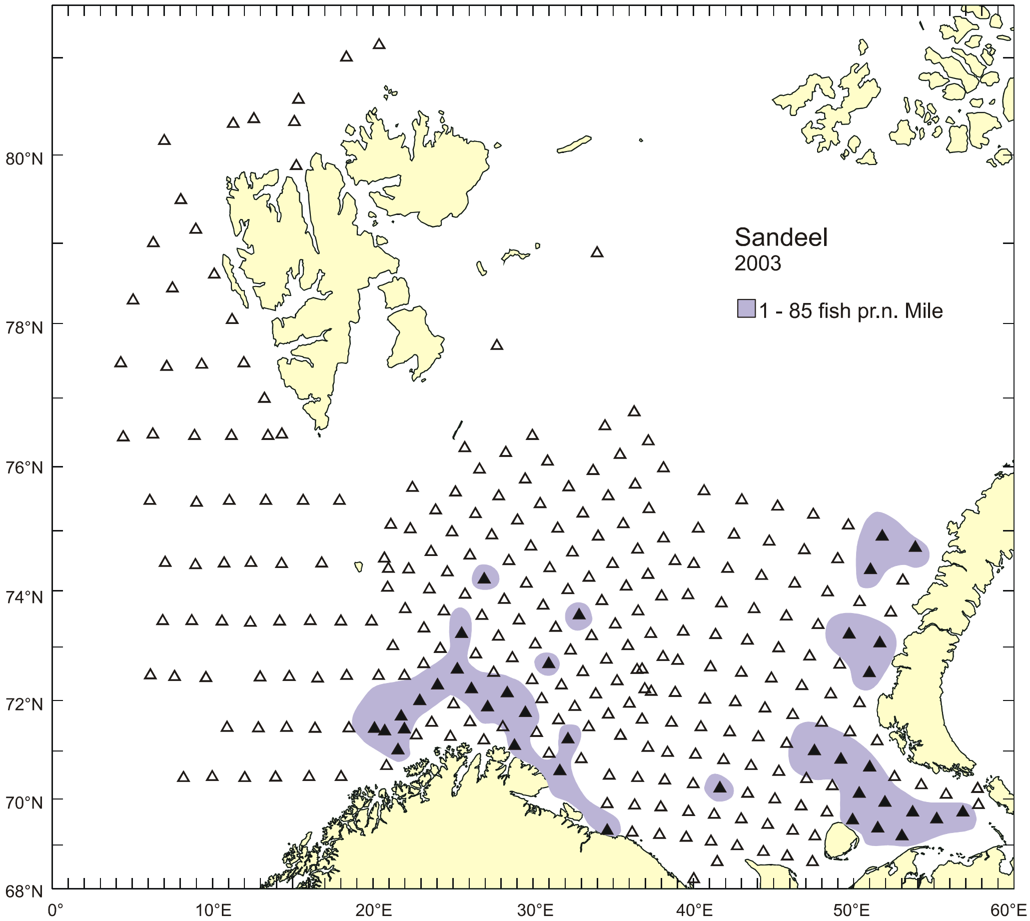

Figure 2.2.11.Distribution of 0-group Sandeel 2003.

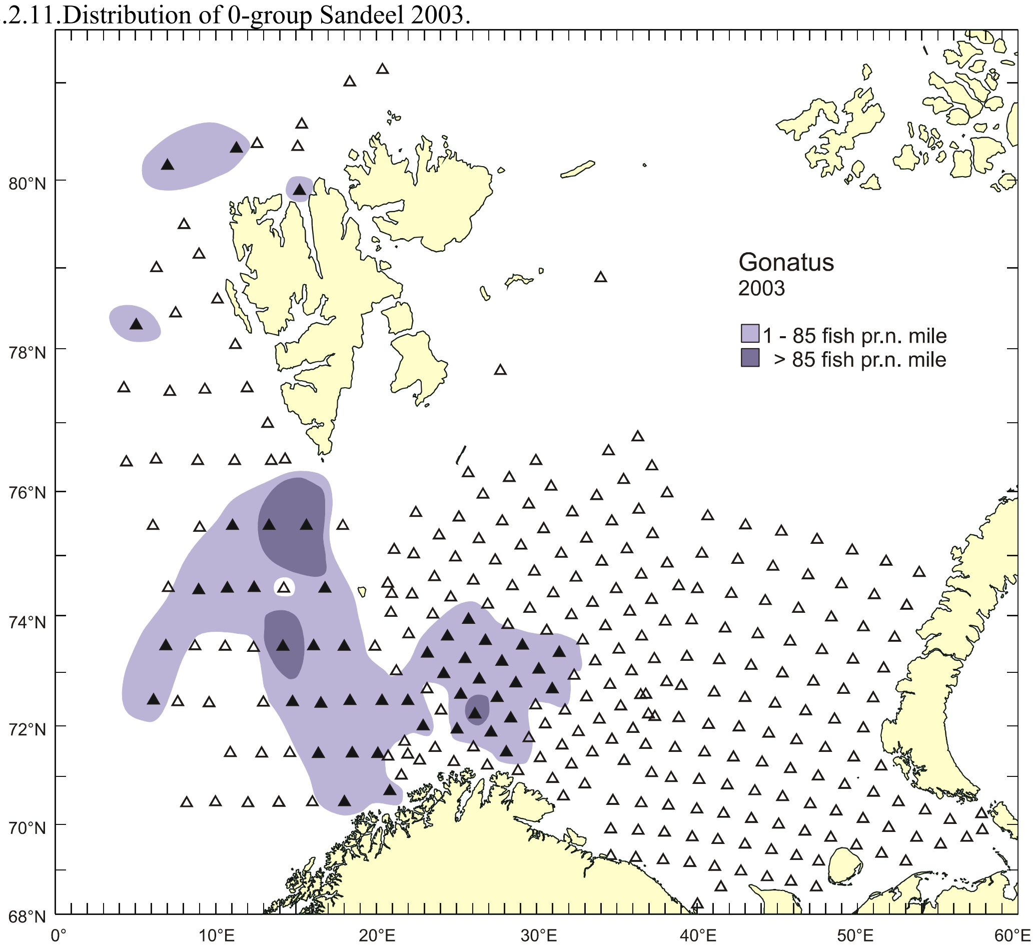

Figure 2.2.12.Distribution of 0-group Gonatus August - September 2003.

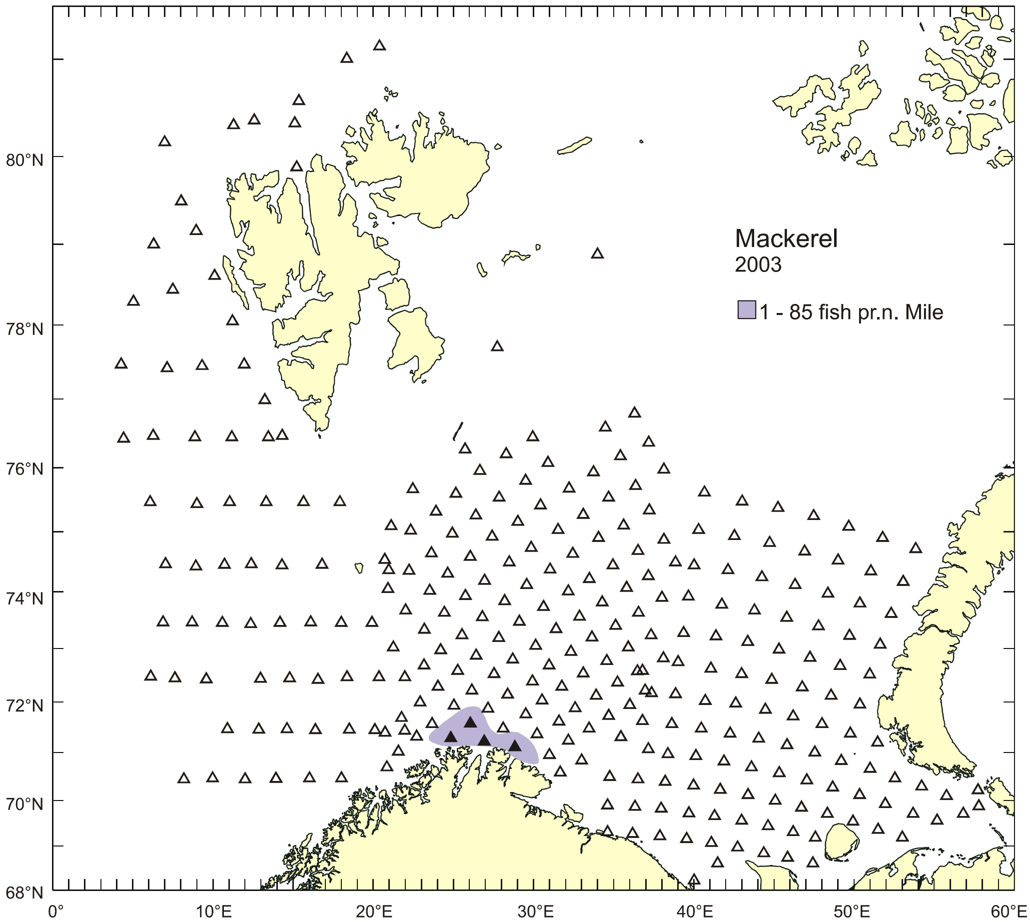

Figure 2.2.13 Distribution of 0-group Mackerel August - September 2003.

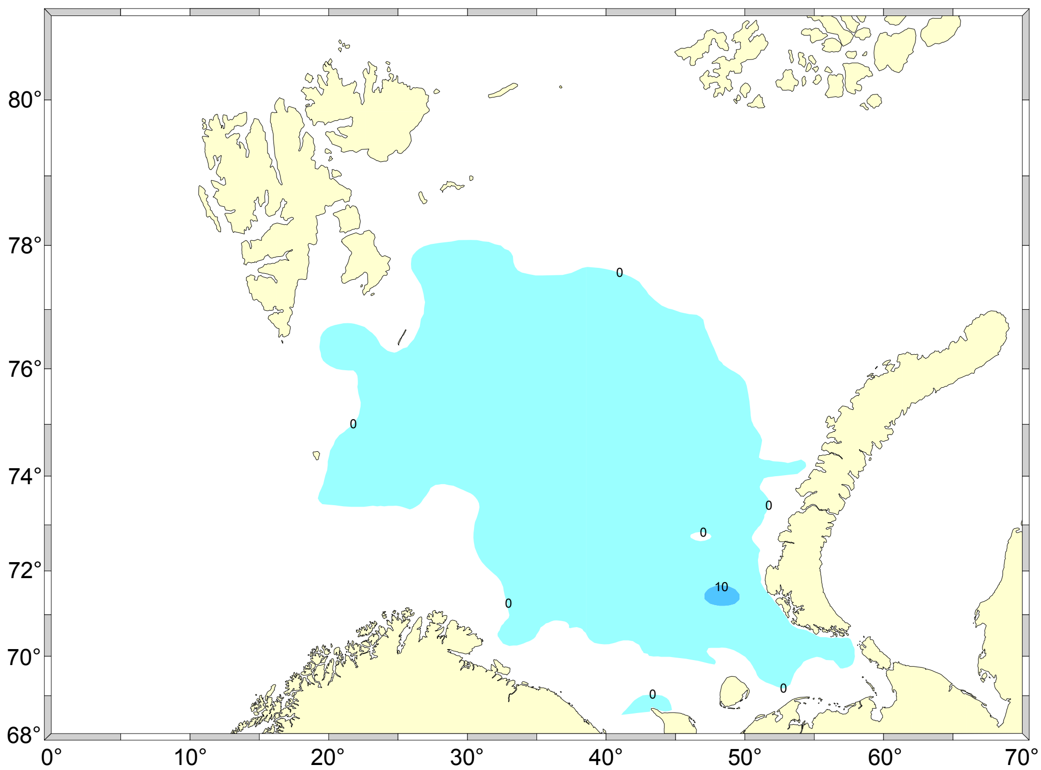

Figure 2.3.1 Estimated density distribution of one-year-old capelin (tonnes/square nautical mile) August-September 2003

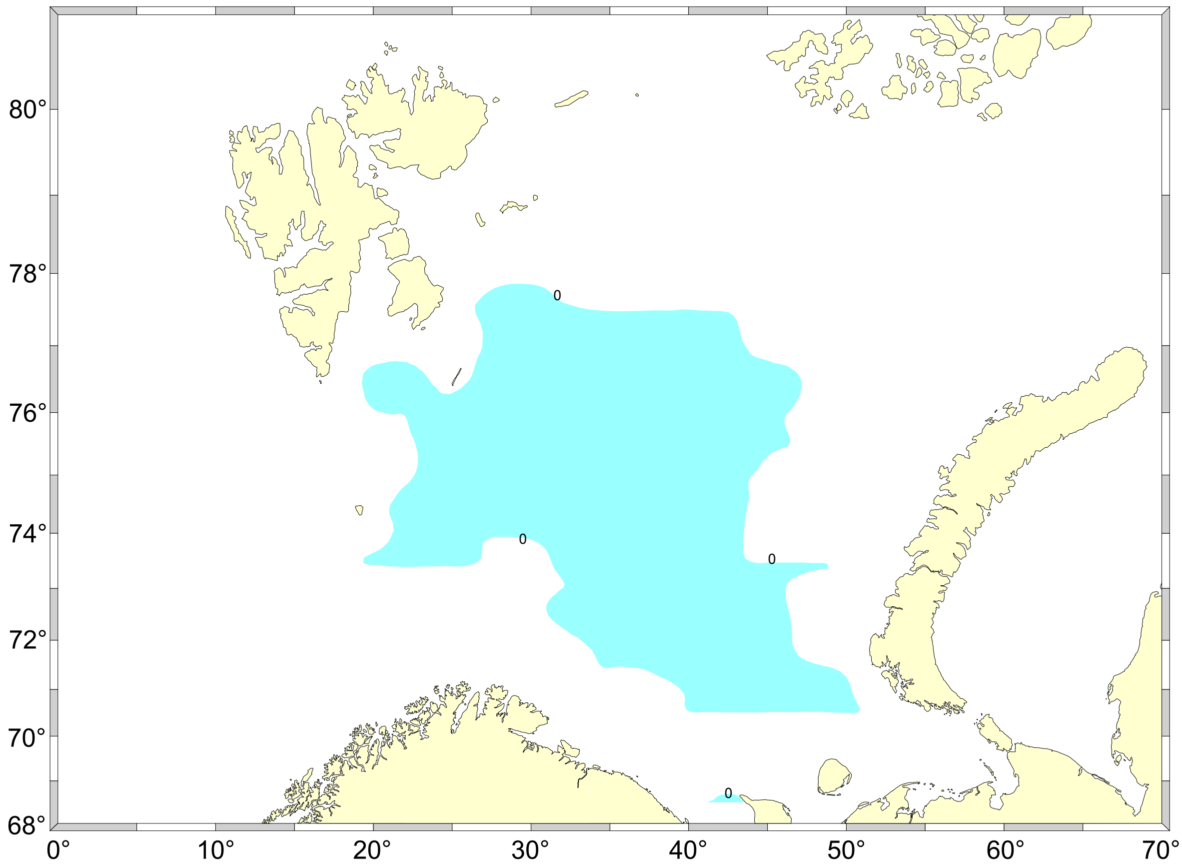

Figure 2.3.2 Estimated density distribution of two years old capelin (tonnes/square nautical mile) August-September 2003

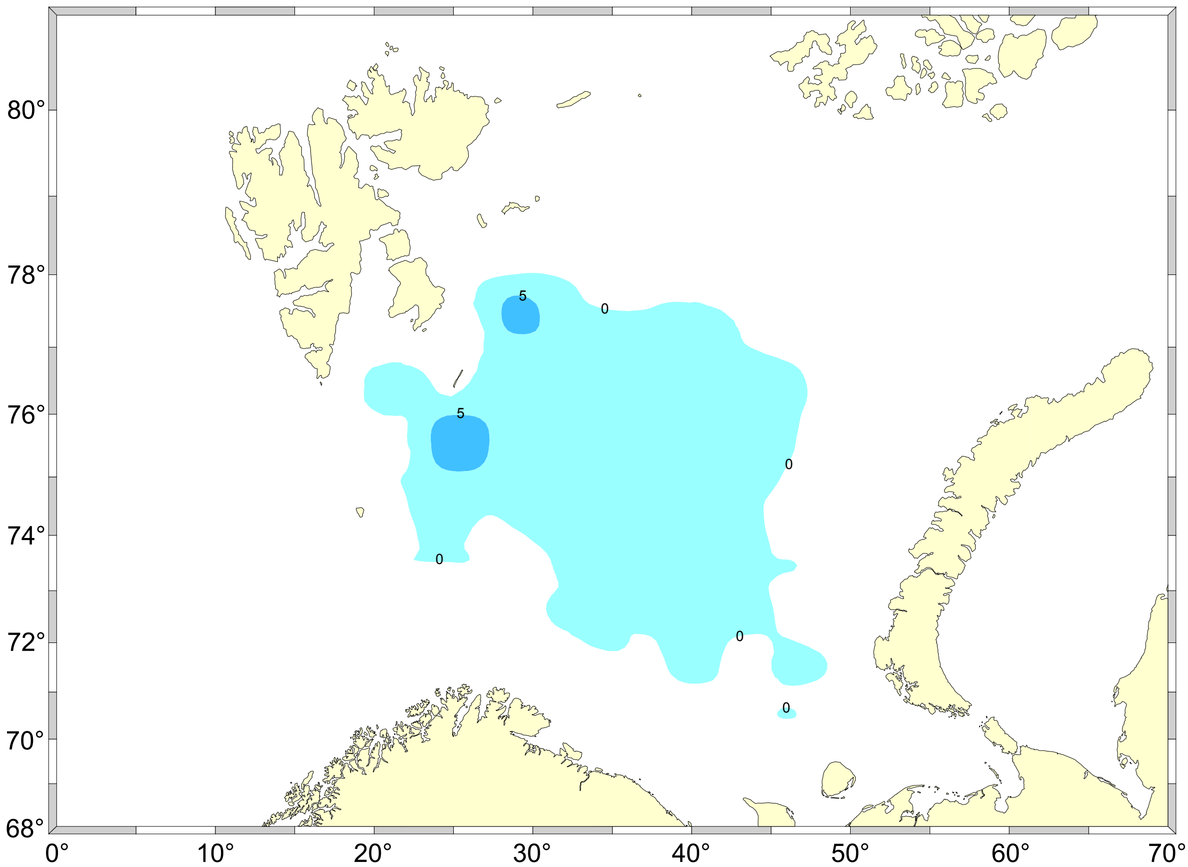

Figure 2.3.3 Estimated density distribution of three years old capelin (tonnes/square nautical mile) September - October 2003

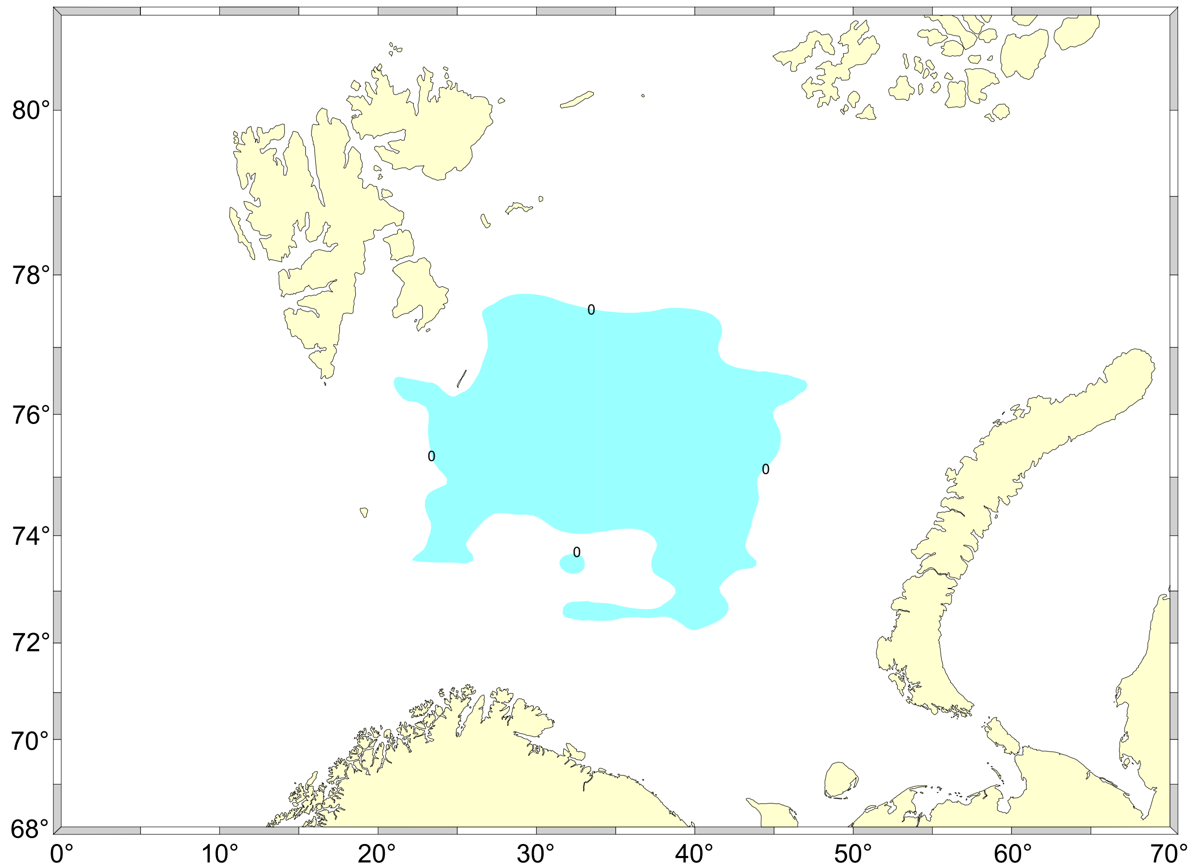

Figure 2.3.4 Estimated density distribution of four years old capelin (tonnes/square nautical mile) September - October 2003

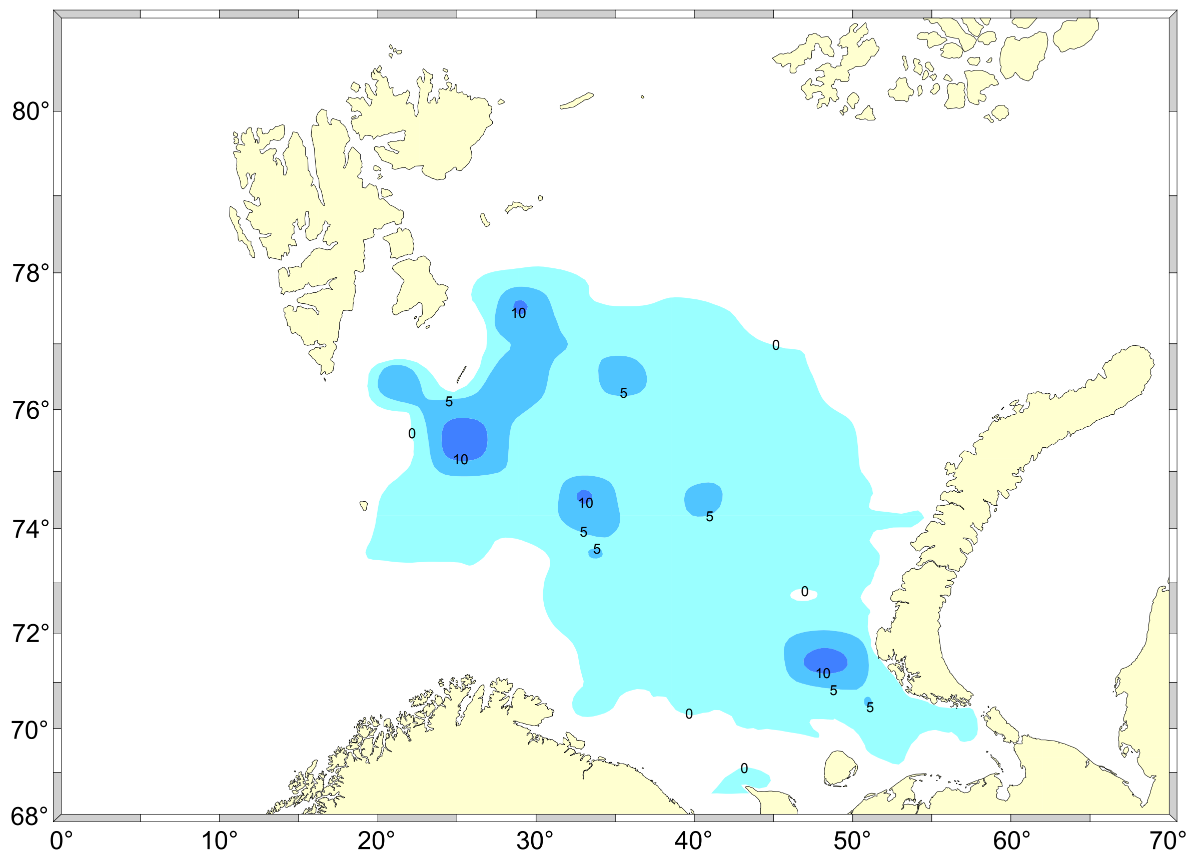

Figure 2.3.5 Estimated total density distribution of capelin (tonnes/square nautical mile) September -October 2003

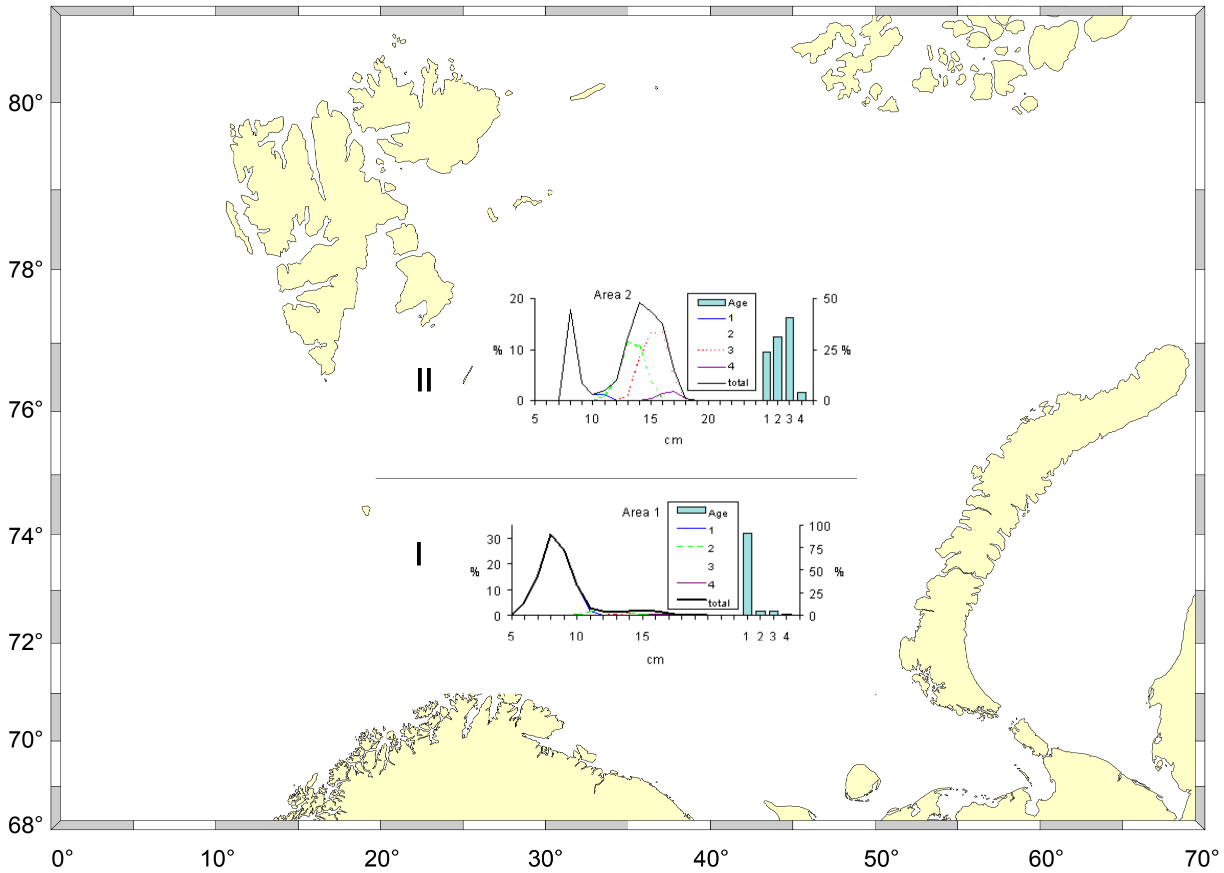

Figure 2.3.6 Age and length distribution of capelin in the two sub-areas used for stock size estimation August-September 2003

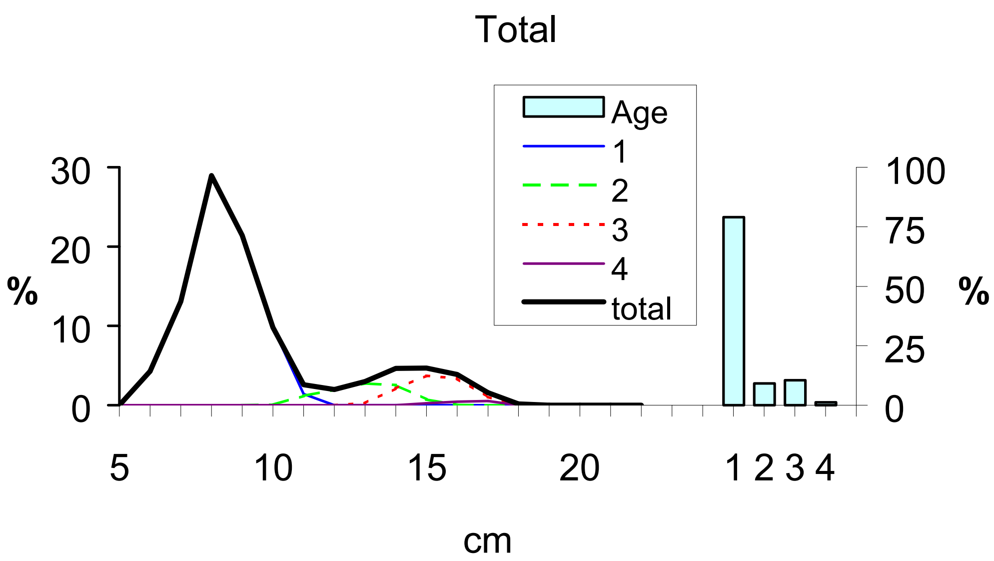

Figure 2.3.7 Total length and age distribution of capelin August-September 2003

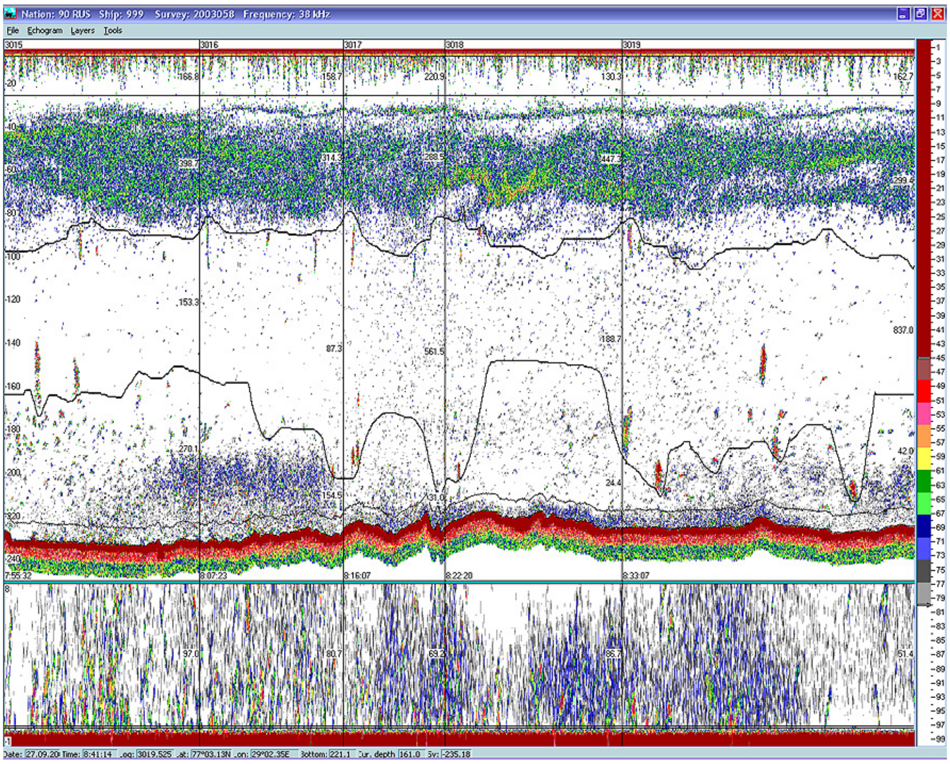

Figure 2.3.8 Echo-records of capelin schools August-September 2003. Echogram obtained at Tsivilsk.

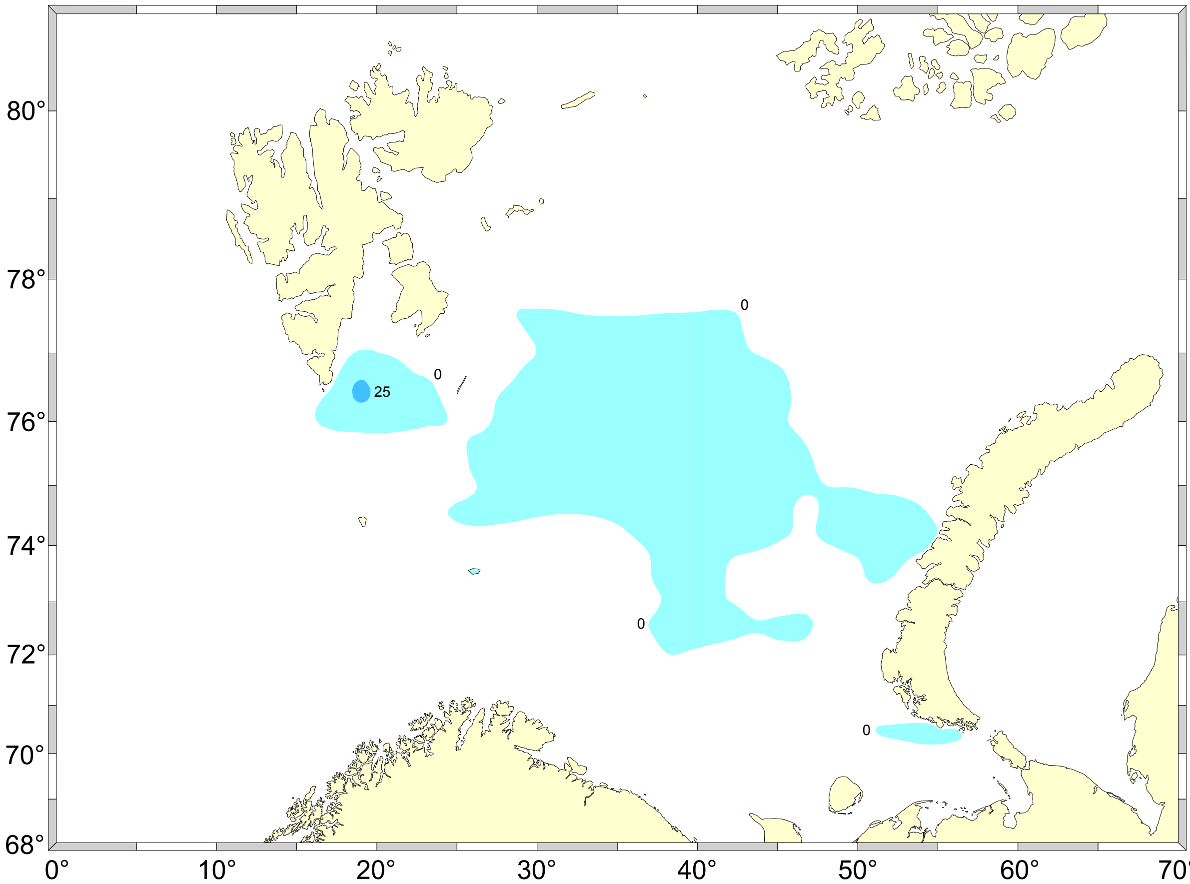

Figure 2.3.9 Estimated density distribution of one year old polar cod (tonnes/square nautical mile) August-September 2003

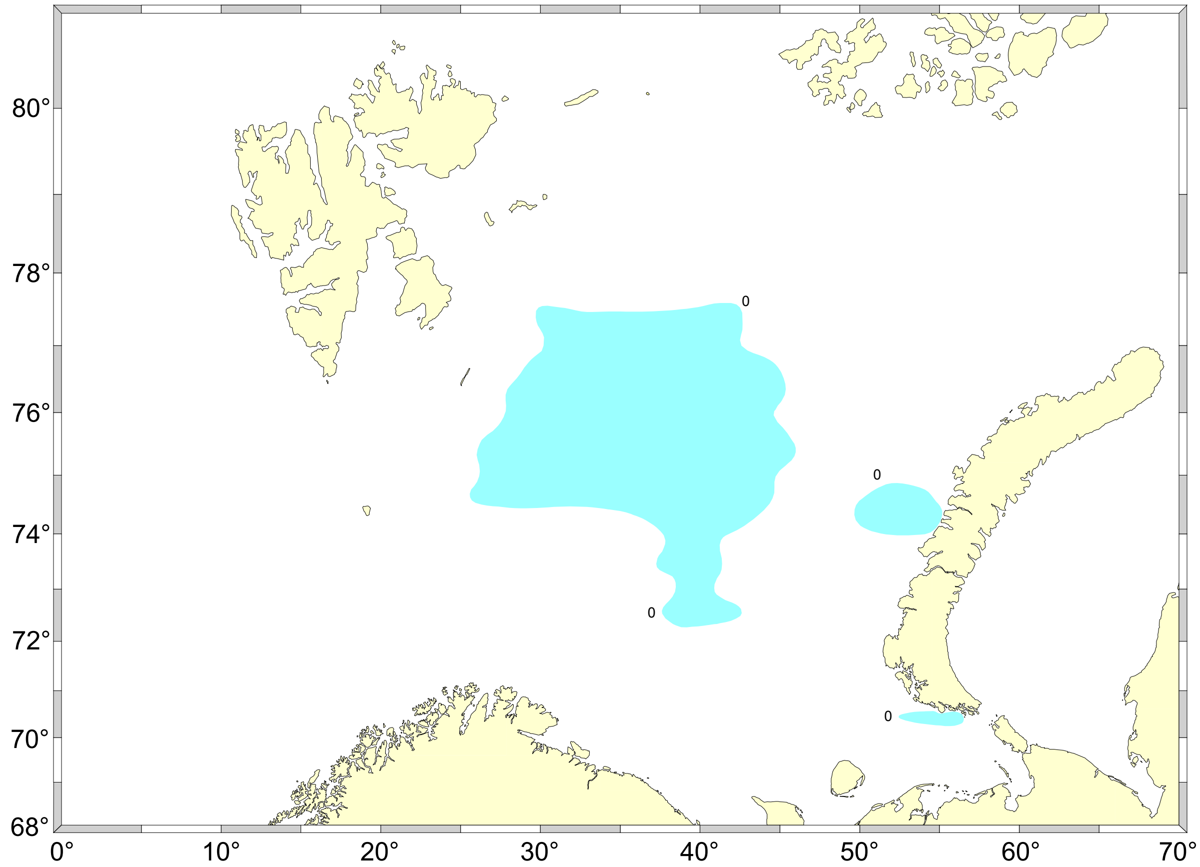

Figure 2.3.10 Estimated density distribution of two years old polar cod (tonnes/square nautical mile) August-September 2003

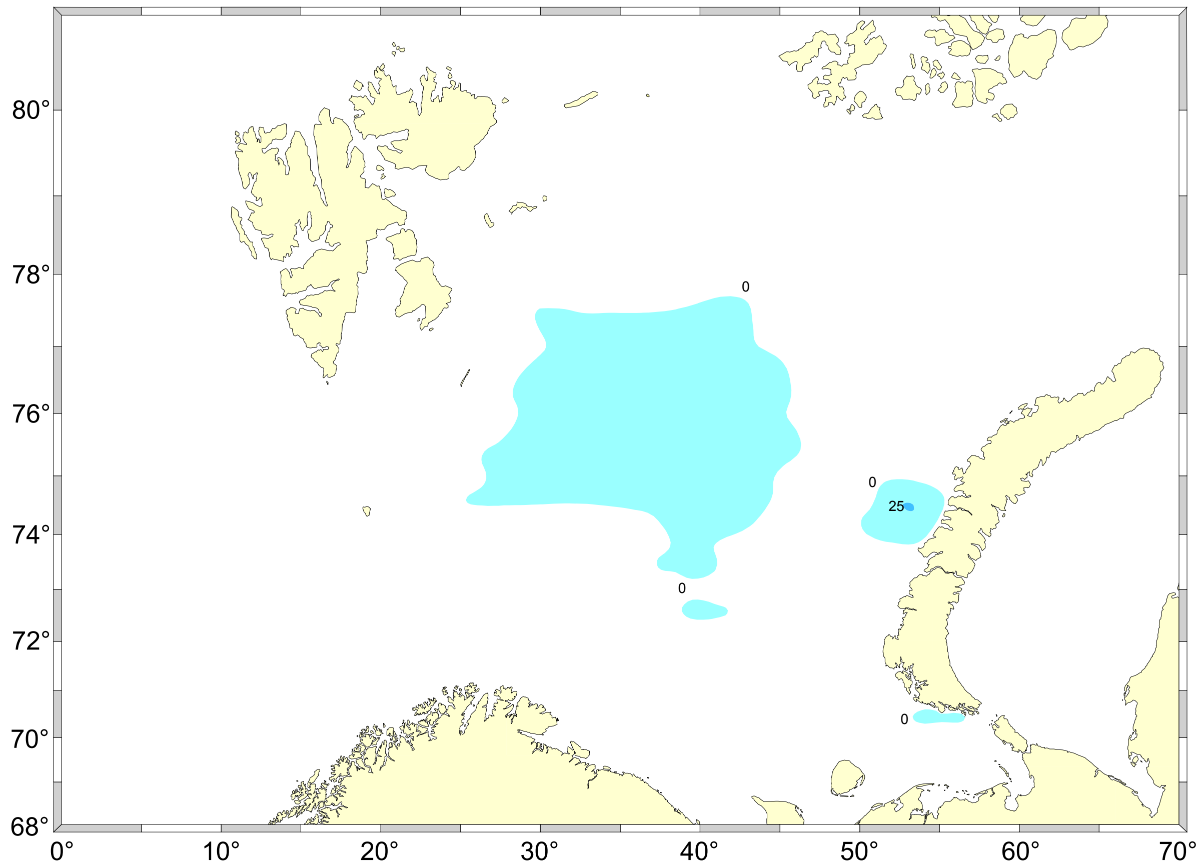

Figure 2.3.11 Estimated density distribution of three years old polar cod (tonnes/square nautical mile) August-September 2003

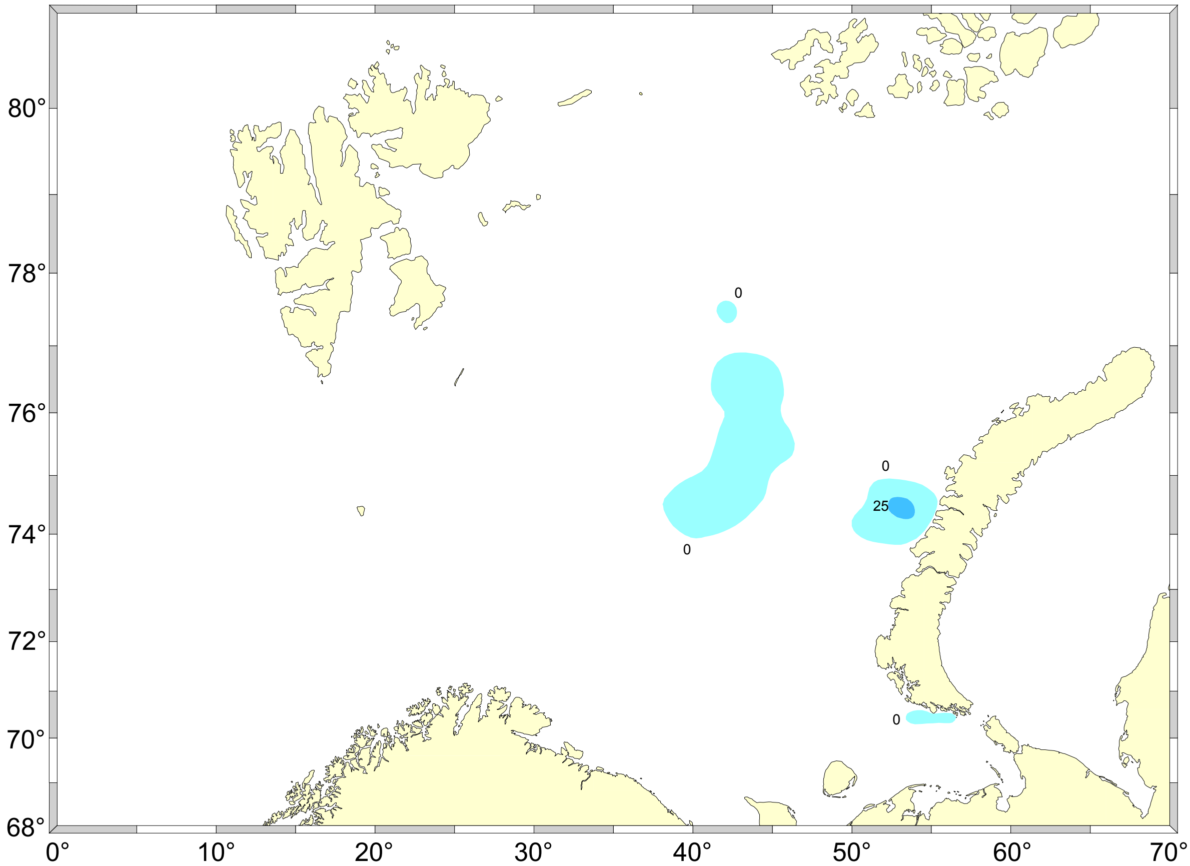

Figure 2.3.12 Estimated density distribution of four years old polar cod (tonnes/square nautical mile) August-September 2003

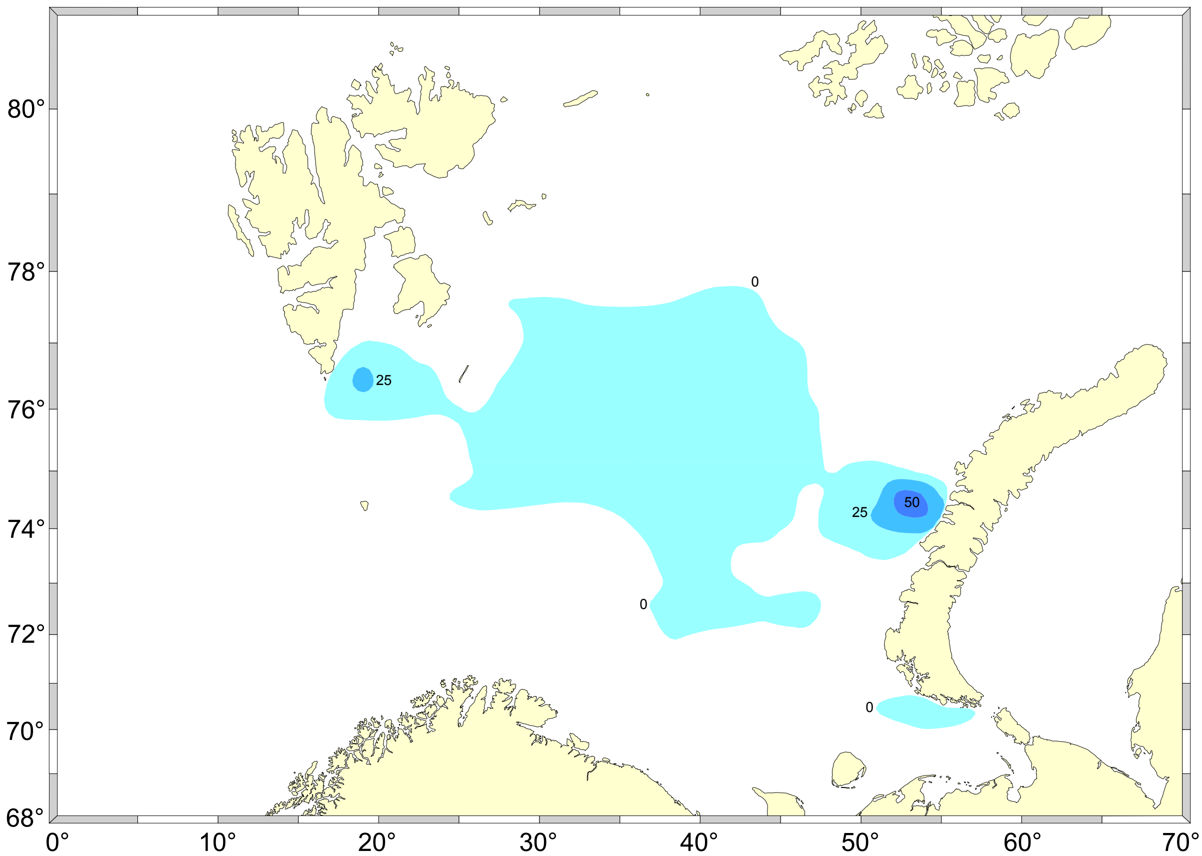

Figure 2.3.13 Estimated total density distribution of polar cod (tonnes/square nautical mile) August-September 2003

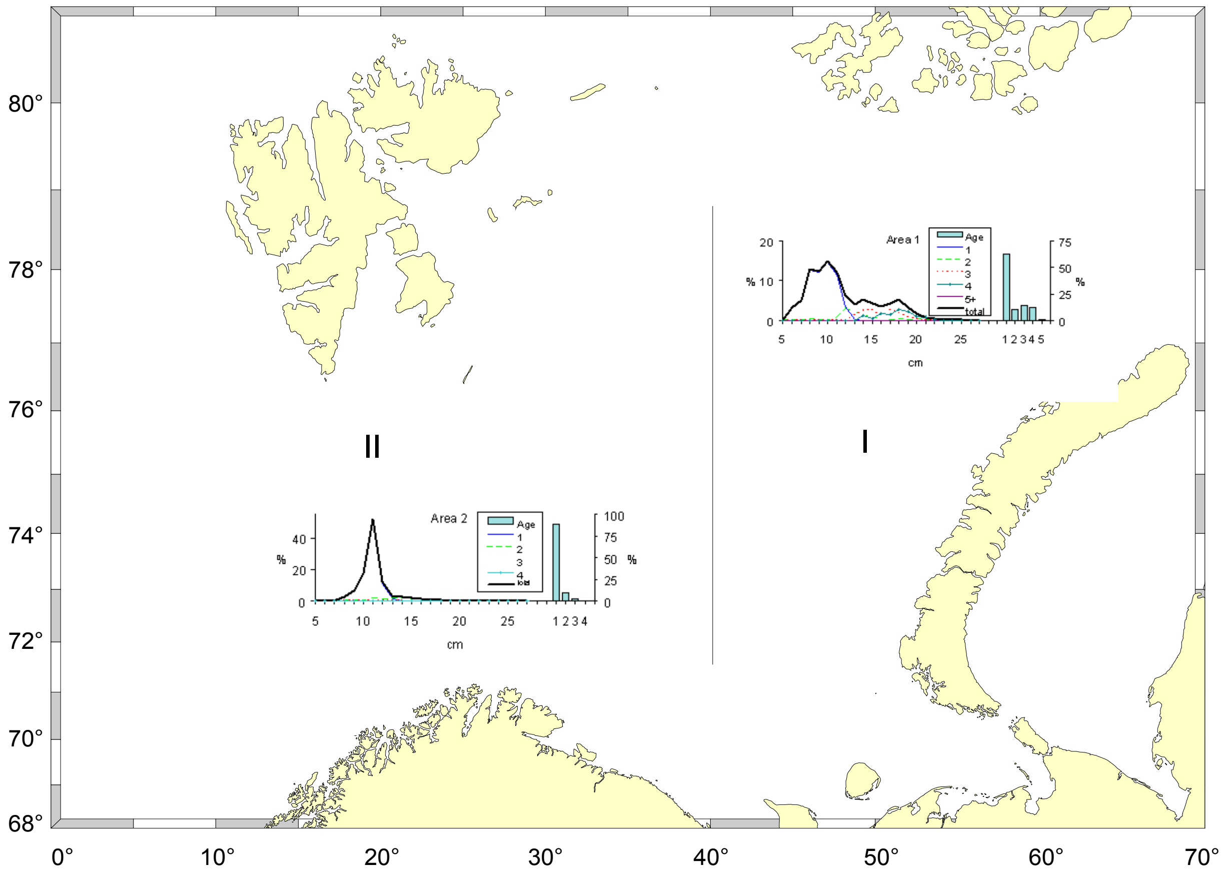

Figure 2.3.14 Length and age distribution of polar cod in the two sub-areas used for stock size estimation August- October 2003

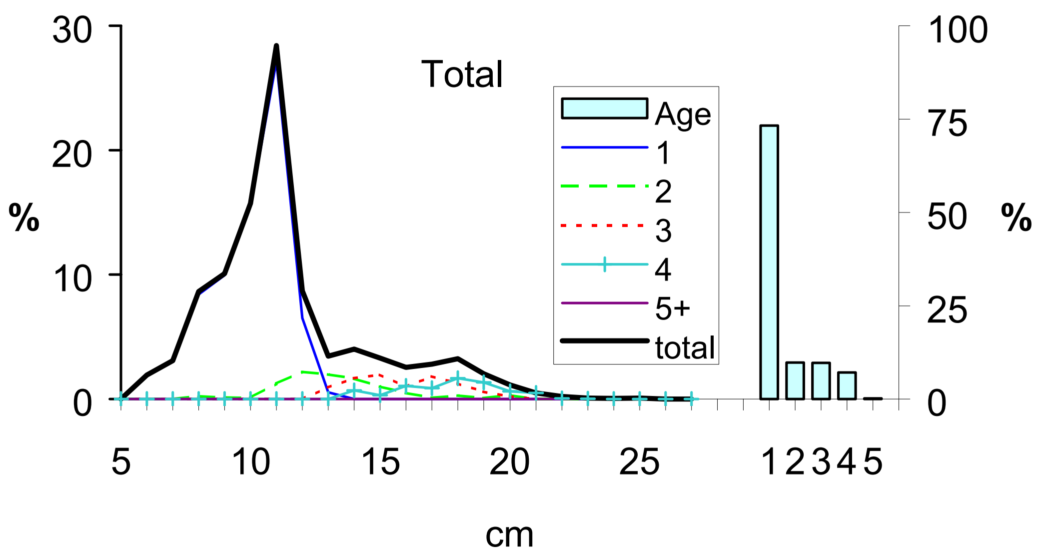

Figure 2.3.15 Total length and age distribution of polar cod August-September 2003.

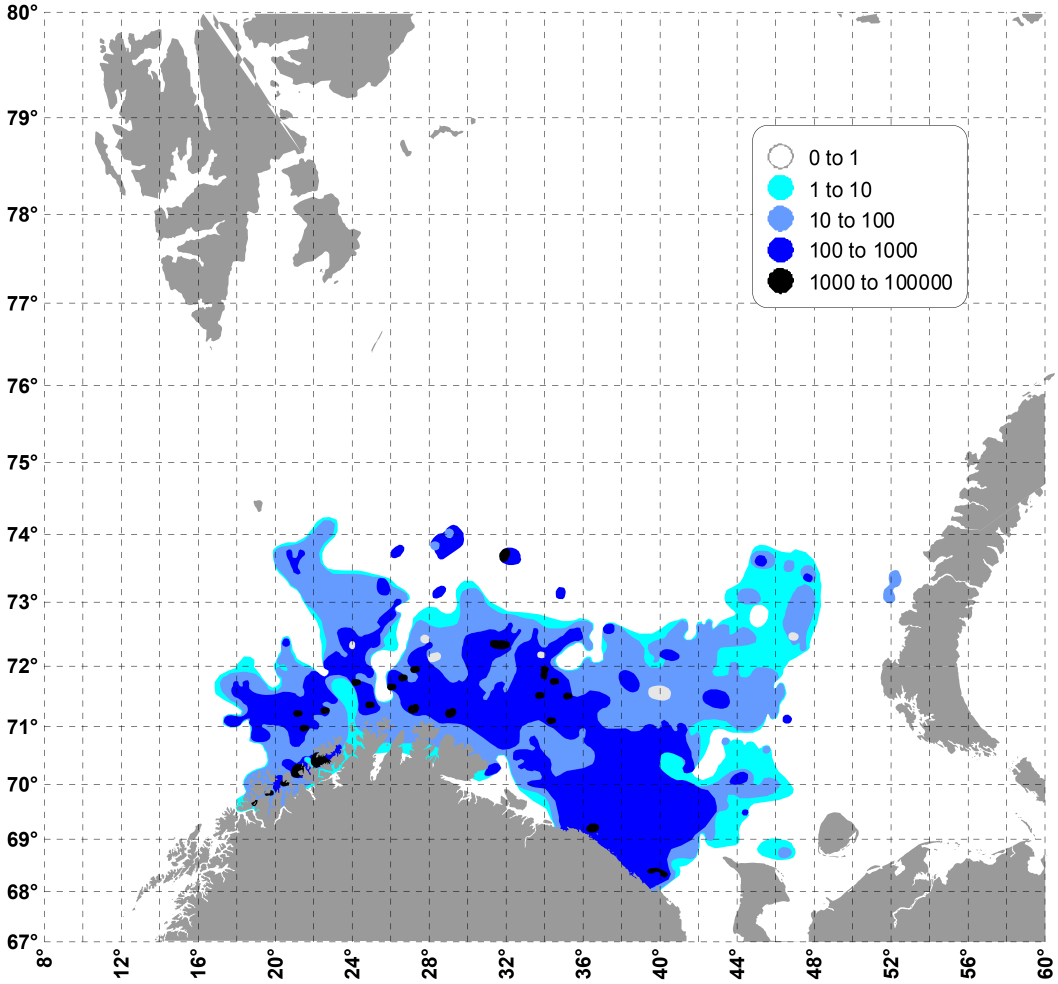

Figure 2.3.16 Estimated density distribution of young herring (s_A-values) August-September 2003.

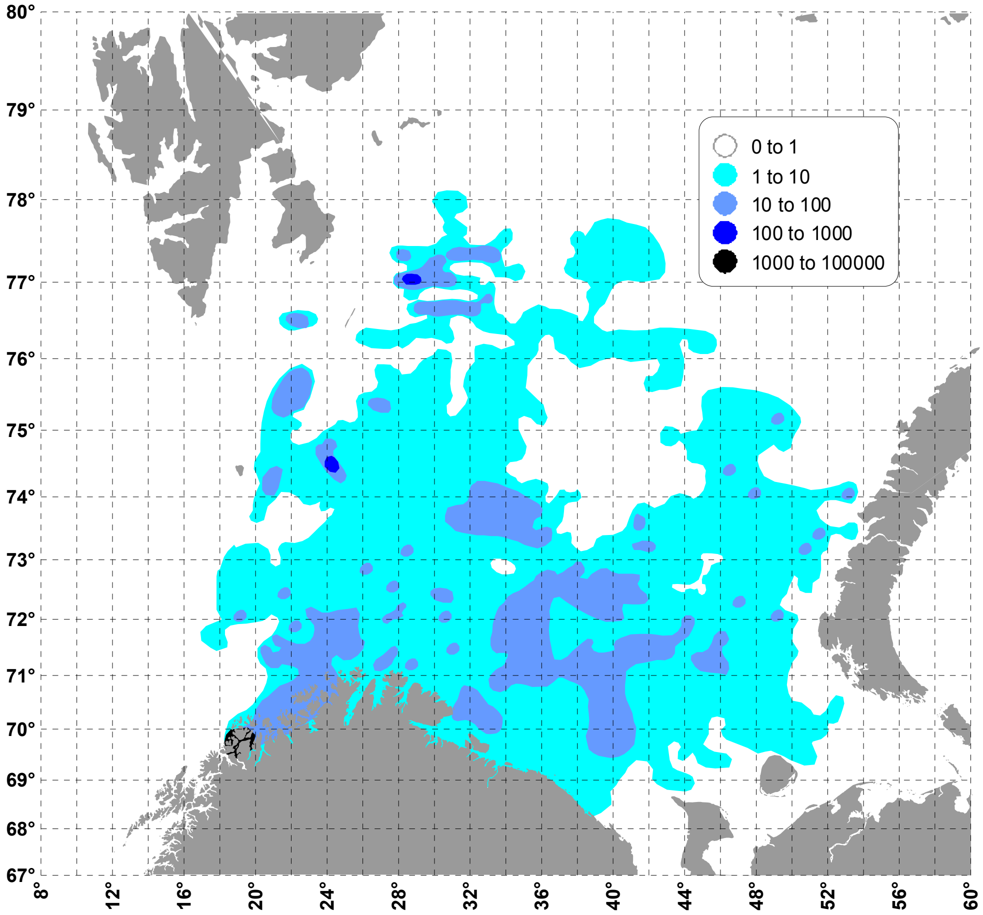

Figure 2.4.1 Estimated density distribution of cod (s_A-values) August-September 2003.

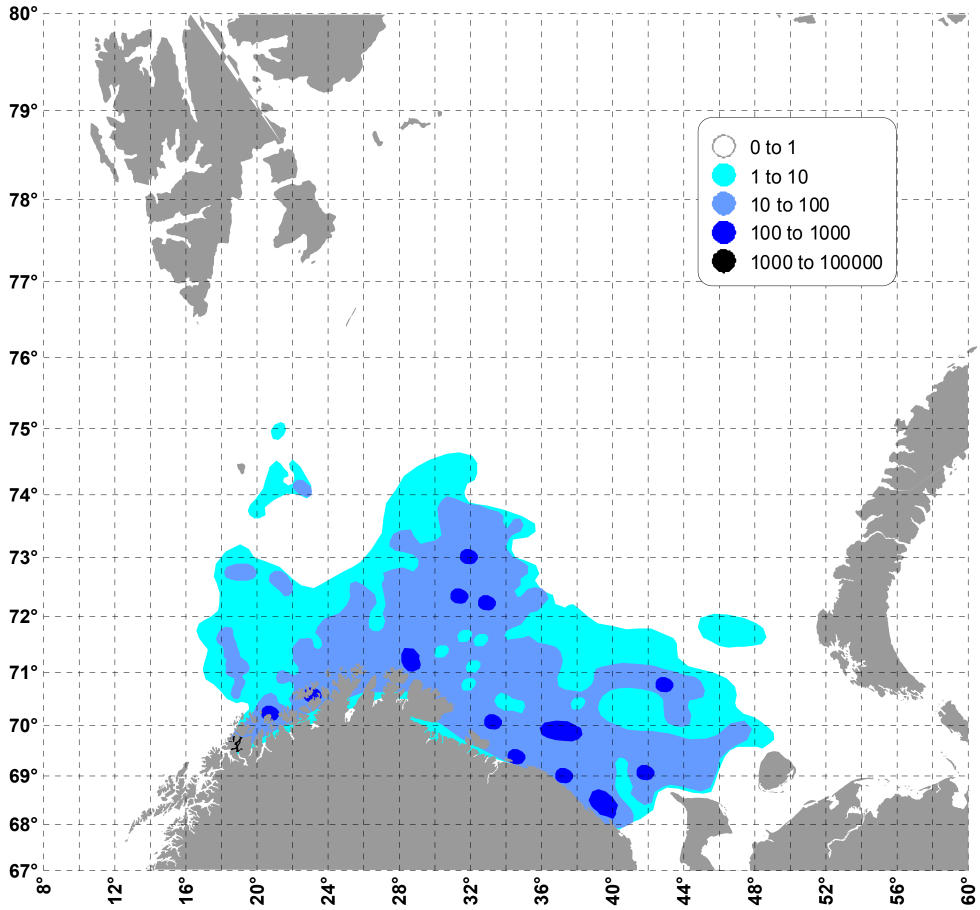

Figure 2.4.2 Estimated density distribution of haddock (s_A-values) August-September 2003.

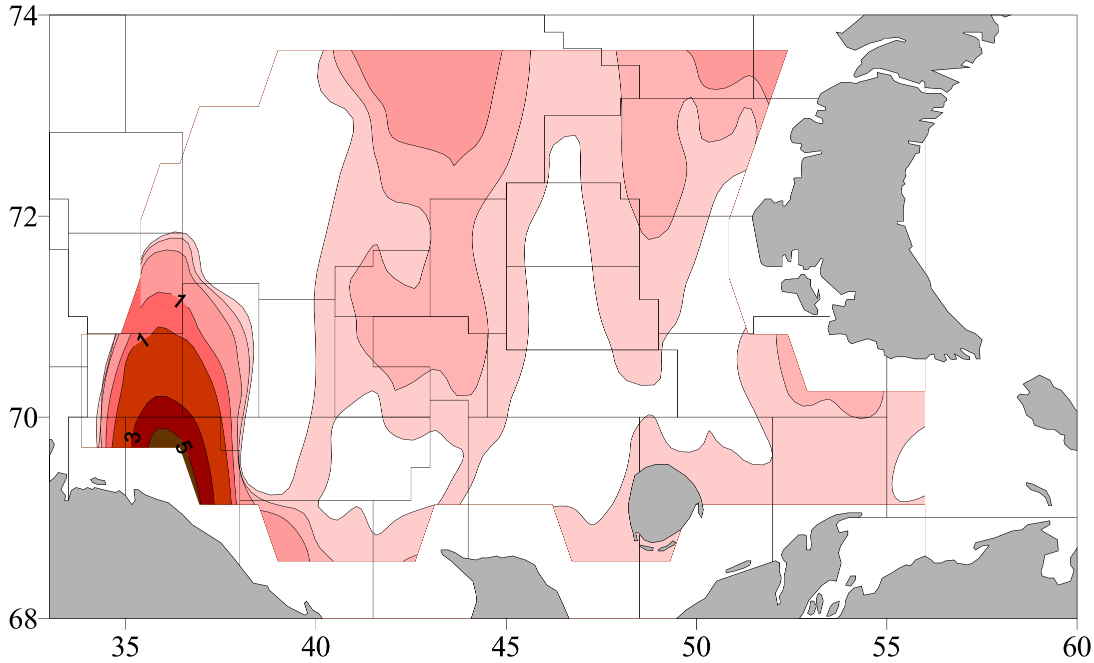

Figure 2.5.1 Distribution of krill abundance (ind./m^3) size fraction >2000 µm from the bottom to the surface during August-September 2003. Data from Smolensk.

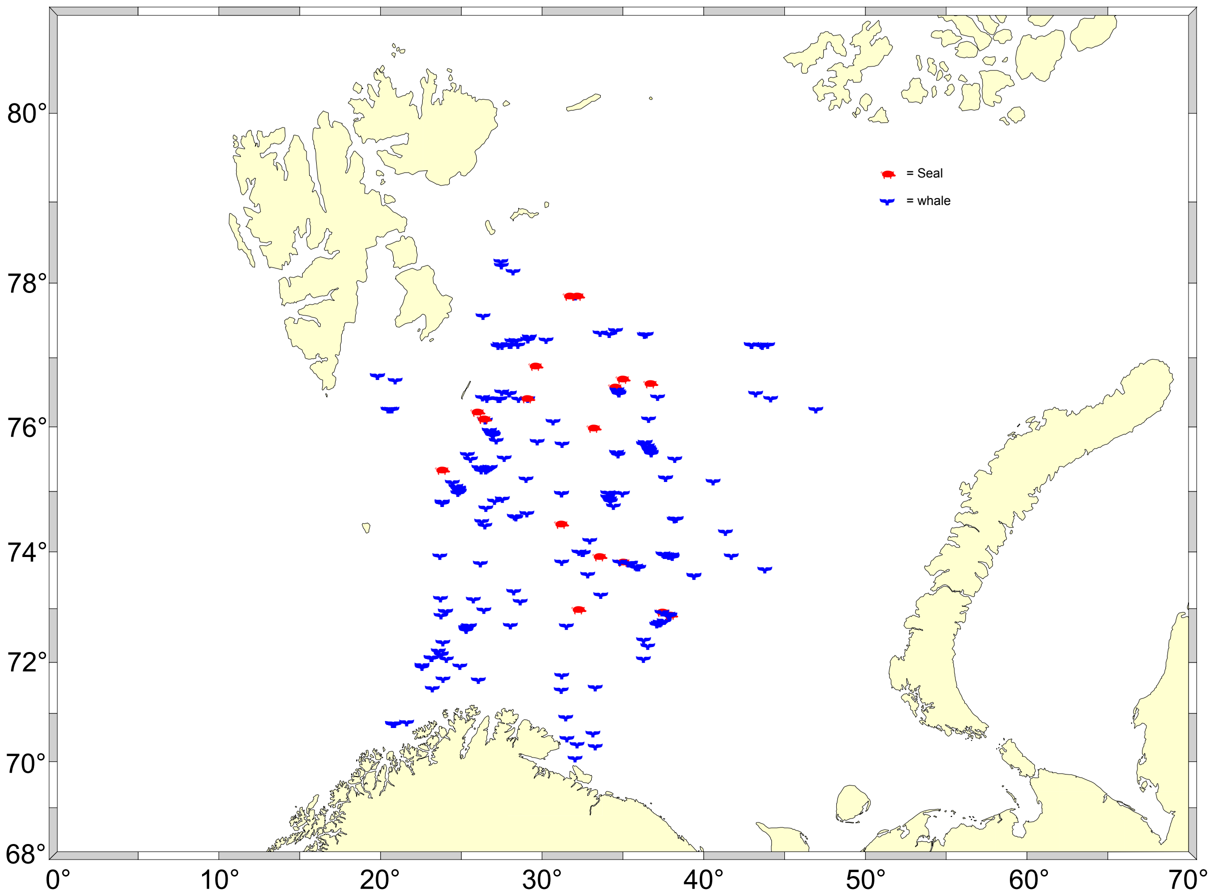

Figure 2.6.1 Distribution of marine mammals, data from Johan Hjort and Tsivilsk, August-September 2003

Appendix I

Research vessel	Participants
"Tsivilsk"	A. Astakov, S. Ivanov, O. Kirillova, A. Kuzmitchev, T. Prokhorova, D. Prozorkevich (cruise leader), S. Ratushnyy, V. Sergeev, A. Trofimov, O. Vavilina, G. Zuikov, N.Zuikova
"Smolensk"	V. Chizhikov, T. Dmitieva, O. Dolgaja, I. Dolgolenko (cruise leader), V. Guzenko, V. Kapralov, S. Kharlin, A. Lukmanov, S. Rusjaev, T. Sergeeva, P. Shatalov, T. Yusupov, N. Zhukova
"G.O. Sars"	K. Gjertsen, T. Haugland, B. Hoffstad, Å. Høines (cruise leader), E. Meland, K. Michalsen, E. Osland, R. Pettersen, S. Ånes
"J. Hjort"	**Part 1**: J. Alvarez, J. Andersen, P. Fossum, K. Hansen, E. Holm, J. Johannesen, F. Midtøy, M. Mjanger, O. Nakken (cruise leader), G. Nesje, G. Tveit, L. Rey, J. Welcker **Part 2**: J. Andersen, J. DeLange, B. Endresen, O. Fossheim, P. Fossum (cruise leader), F. Midtøy, J-E Nygård, B. Skjold, A. Storaker, G. Tveit, J. Welcker, K. Westrheim **Part 3**: J. Andersen, G. Dingsør, B. Endresen, O. Fossheim, P. Fossum (cruise leader), D. Howell, E. Meland, J-E Nygård, B. Skjold, J. Welcker **Part 4**: J. Alvarez, J. Andersen, V. Anthonypillai, A. Bratishkin, K.A. Fagerheim, H. Gjøsæter (cruise leader), T. Hovland, M. Johannesen, R. Korneliussen, J.H. Nilsen, R. Pettersen, B. Røttingen, N.G. Ushakov, C. Vallebona, J. Wangensten
"Jan Mayen"	I. Ahlquist, H. Larsen (cruise leader), E. Hermansen, E. Rafter, W. Richardsen, T. Wenneck,

Appendix II

SPHERE CALIBRATION OF ECHOSOUNDERS EK-500
(on copper sphere CU60, TS=33,6 dB, at frequency 38 kHz)

Research vessel	Johan Hjort	G.O.Sars	Tsivilsk	Smolensk
Type of echosounder	EK60	EK60	EK60	EK500
Date	18.09.2003		07.09.2003	29.06.2003
Place	70º47'N, 23º25'E Akkarfjord, Sørøya		69º49´N,32º00´E, Bolshaja Volokovaja	65º37´N,23º32´W (2 times at the same position)
Bottom depth (m)	42		47	62/62
Depth to sphere (m)	30		20.3	27.5/28.0
Temperature (°C)	8.96		9.4	9.5/9.5
Salinity (‰)	34.01			34.0/34.0
TS of phere (dB)	-33.6		-33.6	-33.6/-33.6
Transducer type	ES38B		ES38B (split)	ES38B/ ES38B
Transducer depth (m)	6			
Real sphere depth (m)	36		20.3	27.5/28.0
Sound velocity (m/sec)	1485.4		1488	1482/1482
Absorption coefficient (dB/km)	10.19			10/10
Pulse length (Short/Med./Long, ms)	1.024			Med./Long
Bandwidth (Wide/Narrow)	2.43kHz			Wide/Narrow
Maximum power (W)	2000		2000	2000/2000
Transmit power (W)	2000		2000	2000/2000
Angle sensitivity	21.9		21.9	21.9/21.9
2-way Beam Angle (10lgψ, dB)	-21.0		-20.76	-20.9/-20.9
Adjusted Sv Transducer Gain (dB)				26.72/26.87
Adjusted TS Transducer Gain (dB)	27.31		24.51	26.59/27.01
3-dB Beamwidth Alongship (deg.)	7.02		6.96	
3-dB Beamwidth Athwartship (deg.)	7.60		7.00	(Transversal)
Alongship (fore/aft.) Offset (deg.)	-0.17		-0.03	
Athwartship Offset (deg.)	-0.09		-0.08	
Theoretical Sa (m^2/nm^2)	2631			3061/2952
Measured Sa (m^2/nm^2)				3083/2595
	$Sa= \sigma * 1852^2 /(r^2 \psi)$		$\sigma = 4\pi * 10^{0,1 TS}$	