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INVESTIGATIONS ON DEMERSAL FISH IN THE BARENTS SEA WINTER 2001

Detailed report

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Joint IMR-PINRO report

Investigations on demersal fish in the Barents Sea winter 2001

Detailed report

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PREFACE

Annual catch quotas and other regulations of the Barents Sea fisheries are set through negotiations between Norway and Russia. Assessment of the state of the stocks and quota advices are given by the International Council for the Exploration of the Sea (ICES). Their work is based on survey results and the international landings statistics. The results from this demersal fish winter survey in the Barents Sea are an important source of information for the annual stock assessment.

These surveys started in the mid 1970-ies, focused on acoustic measurements of cod and haddock. Since 1981 the survey has been designed to give both acoustic and swept area estimates of fish abundance. Some development has taken place since then, both in terms of area coverage and in terms of methodology. The development is described in more detail by Jakobsen et al. (1997). At present this survey provides the main data input for a number of projects at Institute of Marine Research, Bergen:

- monitoring abundance of the Barents Sea demersal stocks
- mapping fish distribution in relation to climate and prey abundance
- monitoring food consumption and growth
- estimating predation mortality caused by cod

This report presents the results from the survey in February 2001. This year the Russian research vessel “Persey 4” participated in addition to the Norwegian research vessels “G.O. Sars” and “Johan Hjort”. The total duration of the survey was from 27 January to 07 March. One scientist from PINRO, Murmansk, participated onboard ”Johan Hjort”.

SUMMARY

A combined acoustic and bottom trawl survey to obtain indices of abundance and estimates of length and weight at age has been carried out each winter (4-6 weeks in January- March) since 1981 in the Barents Sea. The target species are cod and haddock, but in recent years abundance indices have also been worked out for the redfish species and Greenland halibut. Since 1993 the survey area has been extended to the north and east in order to obtain a more complete coverage of the younger age groups of cod. In winter 1997 only the Norwegian part of the Barents Sea and a small part of the Svalbard area was covered, while in 1998 also a small part of the Russian EEZ was covered. In 1999 and 2000 the vessels had full access to the Russian EEZ. In 2001 a Russian research vessel covered most of the areas where the Norwegian vessels did not have access, and a sufficient coverage was thus obtained.
The main results in 2001 were:

- the 1999 year class of **cod** is very weak and the 2000 year class is indicated to be somewhat below average. The 1998 year class is slightly higher than expected from last years survey
- the abundance indices of 4-7 year old cod (1997-1994 year classes) are around average, as expected from the last years survey
- the numbers of 8 year and older cod are very low
- length and weight at age and weight increment are improving
- the mortality rate has been reduced compared with the previous years for age group 4 and younger, while it is still high for older age groups
- for **haddock** all the year classes 1998, 1999 and 2000 are indicated to be at or above average. The 1996 year class is below average, but considerably larger than the year classes 1992-1995, which are very weak.
- length and weight at age and weight increment seem to have stabilized in 2001, after a period of increase over the years 1998-2000.
- the abundance indices of the **redfish** species are among the lowest in the time series and there are no signs of improved recruitment
- compared to the 2000-results the abundance indices of **Greenland halibut** less than 40 cm have decreased, while they have increased for most of the size groups above 40 cm. The survey covers, however, only parts of this species' normal area of distribution.

1. INTRODUCTION

The Institute of Marine Research (IMR), Bergen, has performed acoustic measurements of demersal fish in the Barents Sea since 1976. Since 1981 a bottom trawl survey has been combined with this acoustic survey. The survey area was extended in 1993. Since then the typical effort of the combined survey has been 10-14 vessel-weeks, and about 350 bottom trawl hauls have been made each year. Most years 3 vessels have participated from about 1 February to 1 March.

The purpose of the investigations is:

- Obtain acoustic abundance indices of cod, haddock and redfish
- Obtain swept area abundance indices by length (and age) groups of cod haddock, redfish and Greenland halibut.
- Map the geographical distribution of those fish stocks
- Estimate length, weight and maturity at age for those stocks
- Collect stomach samples from cod as a basis for estimating predation by cod

The results and the collected data are used both in the ICES stock assessments and by several research projects at IMR.

In the early 1990-ies the cod distribution area increased both due to improved climate and increasing stock size. In 1993 the survey area therefore was increased, and since then the survey has been aimed towards covering the whole cod distribution area outside the ice-border. In 1997 and 1998 the Norwegian research vessels were not allowed to cover the Russian EEZ, and in 1999 the coverage was partly limited by a rather unusually wide ice-extension. Adjustments, associated with large uncertainties, are applied to the estimates in 1997 and 1998 to compensate for the lack of coverage. The results for those years may therefore not be comparable to the results for other years. The coverage in 2000 and 2001 was far better then in the three previous years.

2. METHODS

2.1 Acoustic measurements

The method is explained by Dalen and Smedstad (1979, 1983), Dalen and Nakken (1983), MacLennan and Simmonds (1991) and Jakobsen *et al*. (1997). The acoustic equipment has been continuously improved. Since the early 1990-ies a Simrad EK500 echo sounder and Bergen Echo Integrator (BEI, Knudsen 1990) has been used. In the mid 1990-ies the echo sounder transducers were moved from the hull to a protrudable centreboard. This latter change has largely reduced the signal loss due to air bubbles close to the ship's hull.

Acoustic backscattering values (s_A) are stored at high resolution in the BEI-system. After scrutinizing and allocating the values to species or species groups, the values are stored with 10m vertical resolution and 1 nautical mile horizontal resolution. The procedure for allocation by species is based on:

- composition in trawl catches (pelagic and demersal hauls)
- the appearance of the echo recordings
- inspection of target strength distributions

For each trawl catch the relative s_A-contribution from each species is calculated (Korsbrekke 1996) and used as a guideline for the allocation. In these calculations the fish length dependent catching efficiency of cod and haddock in the bottom trawl (Aglen and Nakken 1997) is taken into account. If the trawl catch gives the true composition of the species contributing to the observed s_A value, those catch-based s_A -proportions could be used directly for the allocation. In the scrutinizing process the scientists have to evaluate to what extent these catch-based s_A -proportions are reasonable, or if they should be modified on the basis of knowledge about the fish behaviour and the catching performance of the gear.

Estimation procedures

The area is divided into rectangles of 1/2±latitude and 1±longitude. For each rectangle and each species an arithmetic mean s_A is calculated for the demersal zone (less than 10m above bottom) and the pelagic zone (more than 10m above bottom). Each of those acoustic densities by rectangle are then converted to fish densities by the equation:

$$\overline{\sigma}_A > \frac{\overline{s}_A}{\overline{\tau}_A} \quad (1)$$

$\overline{\sigma}_A$ is average fish density (number of fish / square n.mile) by rectangle
$\overline{s}_A$ is average acoustic density (square m / square n.mile) by rectangle
$\overline{\tau}_A$ is average backscattering cross-section (square m) by rectangle

For cod, haddock and redfish the backscattering cross-section (τ), target strength (TS) and fish length (L cm) is related by the equation (Foote, 1987):

$$\mathrm{TS} > 10 \log\left(\frac{\tau}{4\theta}\right) > 20 \log(L) . \ 68 \quad (2)$$

From 1992 onward the following target strength function has been applied for cod, haddock and redfish:

$$\mathrm{TS} > 21.8 \log(L) . \ 74.9 \quad (3)$$

The data for the period 1981-1992 has been recalculated (Aglen and Nakken 1997) for taking account of:

-changed target strength function

-changed bottom trawl gear (Godø and Sunnanå 1992)

-size dependant catching efficiency for cod and haddock (Dickson 1993a,b).

In 1999 some errors in the time series were discovered and corrected (Bogstad *et al.* 1999). Those errors related to cod for the years 1983-1998 and for haddock for the years 1985-1998.

Combining equations 1,2 and 3 gives:

$$\overline{\sigma}_A > 5.021 \cdot 10^5 \cdot \overline{s}_A / \overline{L^2} \quad (3)$$

$\overline{L^2}$ is average squared fish length by rectangle and by depth channels (i.e., pelagic and bottom)

As a basis for estimating $\overline{L^2}$ trawl catches considered to be representative for each rectangle and depth zone are selected (Anon. 1998). This is a partly subjective process, and in some cases catches from neighbouring rectangles are used. Only bottom trawl catches are used for the demersal zone. Obtaining a sufficient number of useful pelagic catches requires huge effort, and uncertainties concerning the fish behaviour relative to the pelagic trawl often lead

to doubts about the representativity of the pelagic catches. Therefore, both pelagic and bottom trawl catches are applied to the pelagic zone. Length frequency by 5cm length groups form the basis for calculating mean squared length. The bottom trawl catches are normalised to 1 nautical mile towing distance and adjusted for length dependant fishing efficiency (Aglen and Nakken 1997, see below). Pelagic catches are applied unmodified.

Let f_i be the (adjusted) catch by length group *i* and let L_i be the midpoint (cm) of the length interval *i*. Then:

$$\overline{L^2} > \frac{\sum_{i>i_{\min}}^{i_{\max}} f_i L_i^2}{\sum_{i>i_{\min}}^{i_{\max}} f_i} \qquad (4)$$

For each species the total density ($\overline{\sigma}_A$) by rectangle and depth zone is calculated by equation (3). This total density is then split on length groups according to the estimated length distributions. These densities are further converted to abundance by multiplying with the area of the rectangle. The estimated abundance by rectangle is then added for defined main areas (Figure 3.2). Estimates by length are converted to estimates by age by using an age length key for each main area derived from the age sampling during the survey.

2.2 Swept area measurements

All vessels were equipped with the standard research bottom trawl Campelen 1800 shrimp trawl with 80 mm (stretched) mesh size in the front. Until and including 1993 a cod-end with 35-40 mm (stretched) mesh size and a cover net with 70 mm mesh size were used. Since this mesh size may lead to considerable escapement of 1 year old cod, the cod ends were in 1994 replaced by cod-ends with 22 mm mesh size. At present a cover net with 116 mm meshes is mostly used. The ground gear has also been changed during the time series. The trawl is now equipped with a rockhopper ground gear. Until and including 1988 a bobbins gear was used, and the cod and haddock indices from the time period 1981-1988 have since been recalculated to 'rockhopper indices' and adjusted for fish length dependent fishing or sweep width (Godø and Sunnanå 1992, Aglen and Nakken 1997). The sweep wire length is 40 m, plus 10 m wire for connection to the doors. Vaco doors (6m^2, 1500kg), which are considered to be the best compromise when doing both pelagic and bottom trawling, have earlier been used as standard trawldoors on board the research vessels. On hired vessels V-type doors (ca 7 m^2) have been

used. In 2001, R/V "Johan Hjort" and R/V "G.O.Sars" used Vaco doors ($6m^2$, 1500kg), while R/V "Persey 4" used a V-type door ("Steinshamn W-9", $7.1m^2$, 2050kg). In order to achieve constant sampling width of a trawl haul independent of e.g. depth and wire length, a 10 m rope "locks" the distance between the trawl wires 150-180 m in front of the trawl doors. This is called "strapping". The distance between the trawl doors then become almost constant of 48-52 m (Engås and Ona 1993, Engås 1995). The trawl's catchability of different species and length groups then becomes independent of bottom depth. Without strapping, the distance between the doors is 50-60 m and increasing with increasing wire length, and thereby with increasing depth. In 1993 strapping was used on board the research vessels, in 1994 on every third haul, in 1995-1997 on every second haul on all vessels, and since 1998 on all hauls when weather conditions allow for it. Standard tow duration is 30 minutes (until 1985 the tow duration was 60 min.). On all trawl stations the trawl performance is constantly monitored by Scanmar trawl sensors, i.e., distance between the doors, vertical opening of the trawl and bottom contact control.

The geographical position of the trawl stations are pre-defined and kept fixed from year to year. When the swept area investigations started in 1981 the investigated area was divided into four main areas (A, B, C og D) and 35 strata (smaller and, by experience, more uniform biotops). During the first years the number of trawl stations in each stratum was set based on expected fish distribution in order to reduce the variance, i.e., more hauls in strata with high and variable fish density. In recent years the trawl stations have been spread out more evenly, although the distance between stations in the central cod distribution area is shorter (20 n.miles) compared to the more marginal areas (30 n.miles). In 2001 the strata close to the Finnmark coast was covered by a 15 n.mile grid. Considerable amounts of young cod were during the 1990-ies distributed outside the initial four main areas, and in 1993 the investigated area was therefore enlarged by areas D', E, and the ice-free part of Svalbard (S) (Fig. 3.2 and Table 3.1), altogether 28 new strata. In the 1993- and 1994 survey reports, the Svalbard area was included in A' and the western (west of 30±E) part of area E. Since 1996 the number of strata has been 23. The main reason for reducing the number of strata was the necessity to get a sufficient number of trawl stations in each stratum to get reliable estimates of density and variance.

Swept area fish density estimation

Swept area fish density estimates ($\sigma_{s,l}$) by species (s) and length (l) were estimated for each bottom trawl haul by the equation:

$$\sigma_{s,l} = \frac{f_{s,l}}{a_{s,l}}$$

$\sigma_{s,l}$ number of fish of length l per n.m.^{2} observed on trawl station s

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

$a_{s,l}$ swept area:

$$a_{s,l} = \frac{d_s \cdot EW_l}{1852}$$

d_s towed distance (n.mile)

EW_l length dependent effective fishing width:

$$EW_l = \beta \cdot l^{\chi} \text{ for } l_{\min} = l = l_{\max}$$
$$EW_l = EW_{l_{\min}} = \beta \cdot l_{\min}^{\chi} \text{ for } l < l_{\min}$$
$$EW_l = EW_{l_{\max}} = \beta \cdot l_{\max}^{\chi} \text{ for } l > l_{\max}$$

The parameters are given in the text table below:

Species	β	χ	$l_{\min}$	$l_{\max}$
Torsk	5.91	0.43	15 cm	62 cm
Hyse	2.08	0.75	15 cm	48 cm

The fishing width was previously fixed to 25 m = 0.0135 nm. Based on Dickson (1993a,b), length dependent effective fishing width for cod and haddock was included in the calculations in 1995 (Korsbrekke *et al*., 1995). Aglen and Nakken (1997) have adjusted both the acoustic and swept area time series back to 1981 for this length dependency based on mean-length-at-age information. In 1999, the swept area 1983-1995 time series was recalculated for cod and haddock using the new area and strata divisions (Bogstad *et al.* 1999).

For redfish, Greenland halibut and other species, a fishing width of 25 m was applied, independent of fish length.

Observations of fish density by length are summed together in 5 cm length-groups $\sigma_{s,l}$ where l is the length-group. Stratified indices by length-group and stratum will then be:

$$L_{p,l} > \frac{A_p}{S_p} \neg \sum_{s \text{ in stratum } p} \sigma_{s,l}$$

$L_{p,l}$ index, stratum *p,* length-group *l*
A_p area (n.m.^{2}) of stratum *p* (or the part of the stratum covered by the survey)
S_p number of trawl stations in stratum *p*

The coverage of the northern- and easternmost strata differs from year to year. The strata area is therefore recalculated when necessary by multiplying the total stratum area by the ratio of trawl stations taken. Indices are estimated for each stratum within the main areas A, B, C, D, D', E and S. Total number of fish in each 5 cm length group in each main area is estimated by adding all strata within the area. Total number of fish at age is estimated by using an age-length key constructed for each main area. Total indices on length and age are estimated adding all main areas.

2.3 Sampling of catch and age-length keys.

Sorting, weighing, measuring and sampling of the catch are done according to instructions given in Fotland *et al*. (2000). Since 1999 all data except age are recorded electronically by Scantrol Fishmeter, a measuring board connected to stabilized scales. The whole catch or a representative sub sample of most species was length measured on each station.

On each bottom and pelagic trawl station age (otoliths) and stomach were sampled from 1 cod per 5 cm length-group. All cod above 90 cm were sampled. The stomach samples were frozen and analysed after the survey. From haddock age was sampled from 1 specimen per 5 cm length-group. Regarding the redfish species, *Sebastes marinus* and *S. mentella*, otoliths for age determination were sampled from 2 fish in every 5 cm length-group on every station. This regular sampling was supplied with extra samples from hauls with big redfish catches. Greenland halibut were sorted by sex before length measurement and age (otolith) sampling. From this species otoliths were collected from 5 fish per 5 cm length group for each sex on all stations. Table 3.2 gives an account of the sampled material.

One age-length key is constructed for each main area. All age samples are included and weighted according to:

$$w_{p,l} > \frac{L_{p,l}}{n_{p,l}}$$

$w_{p,l}$ - weighting factor

$L_{p,l}$ - swept area index of number fish in length-group l in stratum p

$n_{p,l}$ - number of age samples in length-group l and stratum p

Fractions are estimated according to:

$$P_a^{(l)} > \frac{\sum_p n_{p,a,l} \cdot w_{p,l}}{\sum_p n_{p,l} \cdot w_{p,l}}$$

$p_a^{(l)}$ - weighted fraction of age a in length-group l and stratum p

$n_{p,a,l}$ - number of age samples of age a in length-group l and stratum p

Number of fish by age is then estimated following the equation:

$$N_a > \sum_p \sum_l L_{p,l} \cdot P_a^{(l)}$$

Mean length and –weight by age is then estimated according to (only shown for weight):

$$W_a > \frac{\sum_p \sum_l \sum_j W_{a,p,l,j} \cdot w_{p,l}}{\sum_p \sum_l \sum_j w_{p,l}}$$

$W_{a,p,l,j}$ - weight of sample j in length-group l, stratum p and age a

3. SURVEY OPERATION

The survey in 2001 was conducted with R/V "G.O. Sars" 27.01-07.03 (BEI-survey no. 2001002, series no. 80001-80178), R/V "Johan Hjort"29.01-01.03 (BEI-survey no. 2001202, series no. 80201-80375), and R/V “Persey 4” from PINRO 07.02-17.02 (series no. 80401-80439). Fig. 3.1 shows survey tracks and trawl stations, and fig. 3.2 shows the survey area with the main areas A, B, C, D, D', E and S (part of the Svalbard area). Tabell 3.1 shows the area in square n.miles of each main area covered by the survey every year. Altogether 360 hydrographical (CTD) stations and 399 trawl stations were taken (fig. 3.2); of these were 352 fixed, pre-defined, bottom trawl stations included in the calculation of swept area indices. 22 of the trawl stations were pelagic trawl hauls using Åkrahamn pelagic trawl (3200 mm mesh size in front and 20 mm in the cod end; see Valdemarsen and Misund 1995) in order to get more samples and information to improve the echo scrutinizing by species and fish length**.** “Persey4” and “Johan Hjort” made 6 parallel bottom trawl tows for comparison. The comparisons are reported in chapter 10.

One scientist from PINRO, Murmansk, participated onboard ”Johan Hjort” as long as the vessels were working in Russian EEZ.

Table 3.2 gives an account of sampled length- and age material from fixed and free (set out on echo registration) bottom trawl stations as well as pelagic trawl stations.

Table 3.1. Area (n.miles^2) covered in the bottom trawl surveys in the Barents Sea winter 1981-2001.

	Main Area							Sum	
Year	A	B	C	D	D'	E	S	ABCD	Total
1981-1992	23299	8372	5348	51116	-	-	-	88135	88135
1993	23929	8372	5348	51186	23152	8965	16690	88835	137642
1994	27131	8372	5348	51186	24975	12576	14252	92037	143840
1995	27131	8372	5348	51186	56822	14859	22836	92037	186554
1996	25935	9701	5048	53932	53247	5818	11600	94616	165281
1997	27581	9701	5048	23592	2684	1954	16989	65922	87549
1998	27581	9701	5048	23592	5886	3819	23587	65922	99214
1999	27581	9701	5048	43786	7961	5772	18470	86116	118319
2000	27054	9701	5048	52836	28963	14148	24685	94639	162435
2001	26469	9701	5048	53932	29376	15717	23857	95150	164100

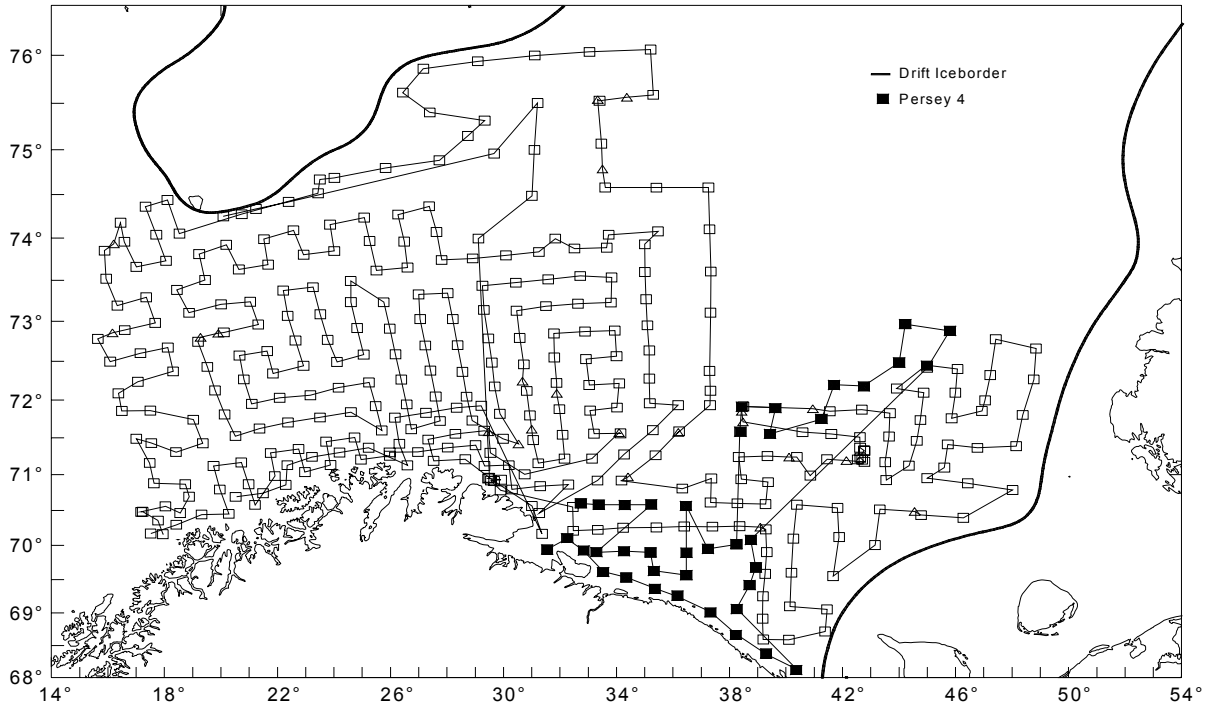

Figure 3.1. Survey tracks and trawl stations; R/V "G.O. Sars", R/V "Johan Hjort" and R/V "Persey 4" 7.2-17.2.2001.

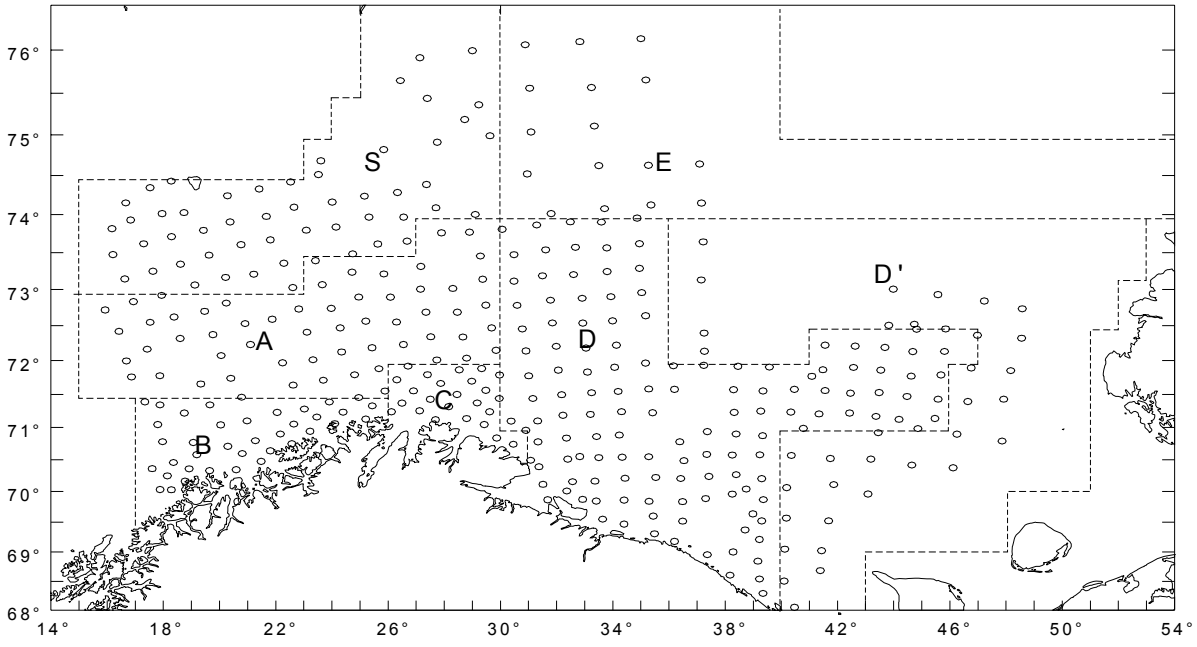

Figure 3.2. Bottom trawl stations used in the swept area estimation in 2001, and borders for the main areas.

Table 3.2. Number of trawl stations, fish measured for length (L) and age (A) for main areas and trawl types in the Barents Sea winter 2001. B1=fixed bottom trawl, B2=other bottom trawl, P=pelagic trawl.

Area	Trawl type	No of hauls	Cod		Haddock		*S.marinus*		*S. mentella*		*Greenland halibut*	
			L	A	L	A	L	A	L	A	L	A
	B1	63	2820	597	3629	370	100	68	3838	566	47	44
A	B2	8	0	0	0	0	0	0	0	0	0	0
	P	3	1	0	1	0	0	0	0	0	0	0
	B1	37	1111	299	3218	318	430	126	243	16	2	2
B	B2	2	0	0	0	0	0	0	0	0	0	0
	P	0	0	0	0	0	0	0	0	0	0	0
	B1	24	2889	276	2224	190	52	21	827	129	1	1
C	B2	1	0	0	0	0	0	0	0	0	0	0
	P	1	0	0	0	0	0	0	0	0	0	0
	B1	129	19289	1075	18040	581	374	80	812	186	120	79
D	B2	10	1081	0	879	0	1	0	0	0	0	0
	P	13	198	23	96	14	0	0	0	0	1	0
	B1	33	2133	124	1015	68	3	0	2	0	8	6
D'	B2	1	50	0	34	0	0	0	0	0	0	0
	P	1	0	0	0	0	0	0	0	0	0	0
	B1	15	1239	107	50	4	1	0	49	9	159	94
E	B2	0	0	0	0	0	0	0	0	0	0	0
	P	3	0	0	0	0	0	0	0	0	0	0
	B1	51	5630	485	1685	105	212	56	1552	346	161	124
S	B2	3	348	12	47	4	0	0	0	0	0	0
	P	1	0	0	3	3	0	0	0	0	0	0
	B1	352	35111	2963	29861	1636	1172	351	7323	1252	498	350
Total	B2	25	1479	12	960	4	1	0	0	0	0	0
	P	22	199	23	100	17	0	0	0	0	1	0
Sum		399	36789	2998	30921	1657	1173	351	7323	1252	499	350

4. HYDROGRAPHY

Measurements of temperature and salinity where recorded for the whole water column on all fixed trawl stations. In addition, the standard hydrographical section ”Sem Islands – north” was taken by ”Johan Hjort” (fig. 4.1).

Fig. 4.2 shows the drift ice border and temperature distribution close to surface, at 100 m depth and at the bottom. As in 2000 the ice border in 2001 was far to the east and north and hampered only to a minor extent the survey coverage. The Barents Sea was slightly warmer in 2000 compared to the year before. This was especially noticeable by the extension of the 2º C isotherm at bottom, which extended far to the northeast and southeast.

The standard hydrographical sections ”Fugløya-Bjørnøya” and “Vardø-north” which were taken one week before the fish survey, showed moderate changes in mean temperature at 50-200 m depth, compared to 1999 and 2000. The observed mean temperature at the Sem Islands section was also close to the observation in 2000. This section was not covered in the 1997-1999.

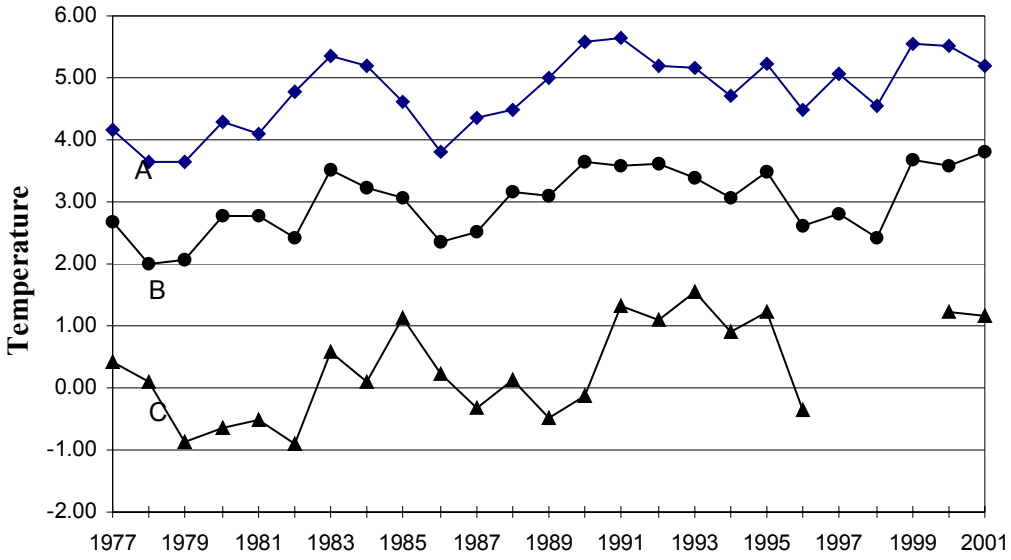

Fig.4.1. Mean temperatures in 50-200 m depth in 1977-2001. A) "Fugløya-Bjørnøya" in March, B) "Vardø-Nord" in March, C) Sem Islands in January-February.

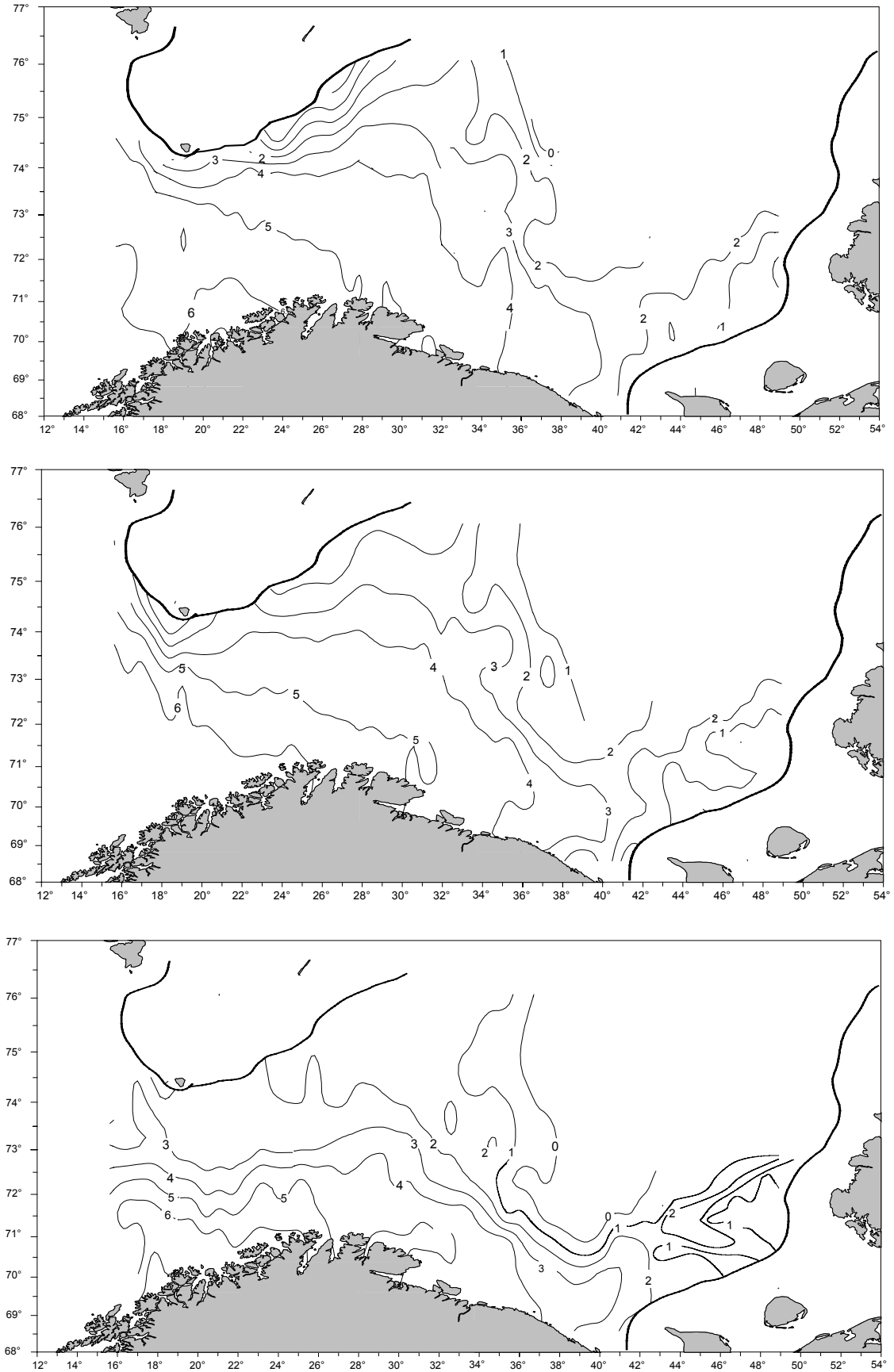

Figure 4.2. Temperature distribution February 2001. A) surface, B) 100 m depth, C) bottom.

5. TOTAL ECHO ABUNDANCE OF COD AND HADDOCK

5.1 Horizontal distribution

The geographical distributions of total echo abundance of cod and haddock are shown in fig. 5.1 and 5.2, respectively, where also the drift ice border is drawn. The distribution of cod was rather similar to the one observed in 2000. Very scattered recordings of cod were observed over most of the area covered by the survey, while the areas with dense recordings were quite limited.

Haddock had a wider distribution to the north than usual. The densest recordings were observed from Skolpen Bank to the Murman coast.

Table 5.1 shows the echo abundance (echo density multiplied by area) distributed on main areas as well as on pelagic versus bottom channels. Compared to the 2000 survey (Aglen et al. 2001) the echo abundance has decreased in all main areas except A, and the total value for cod has decreased by about 25%. For haddock there was an increase in main area D and decrease in A and C, while the total was similar to the 2000-value. For redfish there was some increase in main area S and a small decrease in other areas, resulting in about 10% increase in total value.

Table 5.2 presents the time series of total echo abundance of cod and haddock in the investigated areas. The 2001 values for cod and haddock are above those from the late 90-ies, but considerably below the values observed in the mid 90-ies. The relative echo abundance for cod in the bottom channel (0-10 m above bottom) increased from 23% in 2000 to 34% in 2001, and for haddock it increased from 23% to 43%.

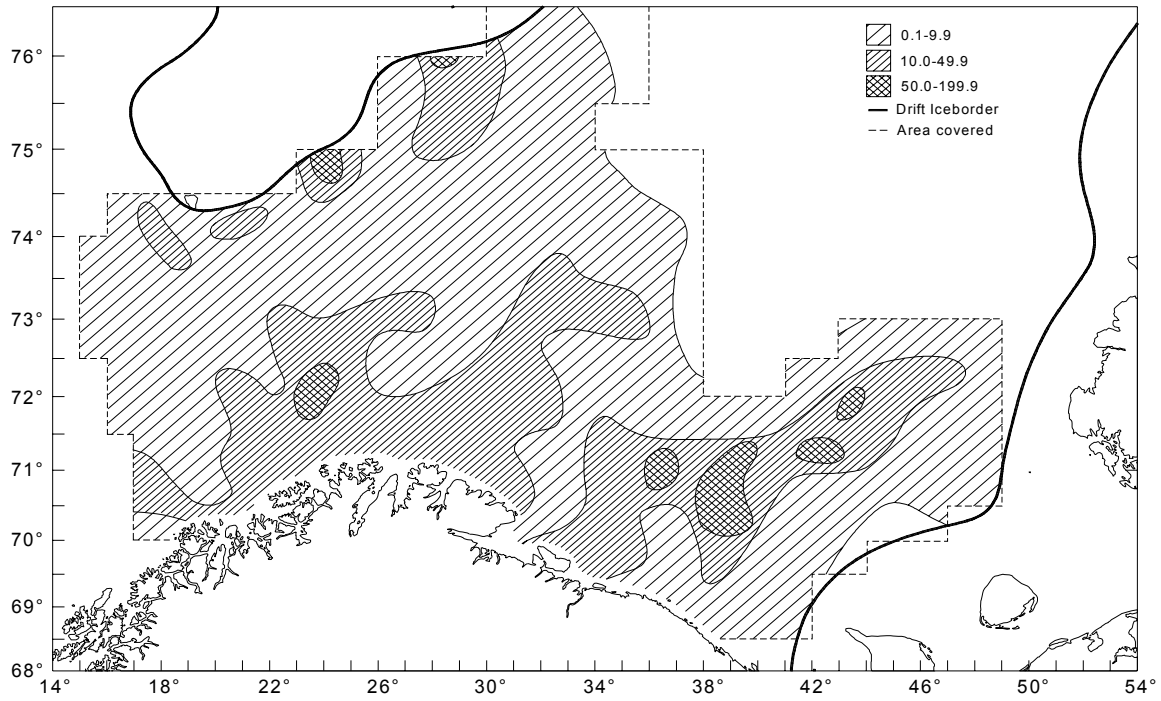

Figure 5.1. COD. Distribution of total echo abundance winter 2001. Unit is area back scattering surface (s_A) per square nautical mile (m^2/n.mile^2).

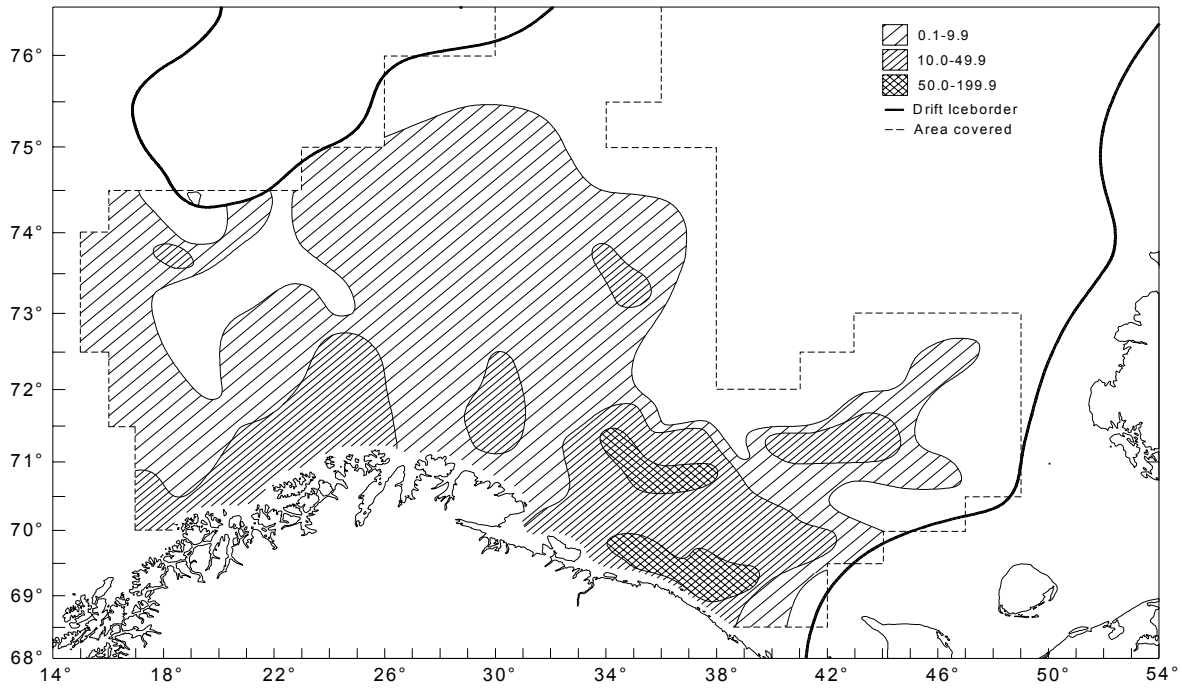

Figure 5.2. HADDOCK. Distribution of total echo abundance winter 2001. Unit is area back scattering surface (s_A) per square nautical mile (m^2/n.mile^2).

Table 5.1. Echo abundance of cod, haddock and redfish in the pelagic layer (P) and in the 10 m layer above the bottom (B) in main areas of the Barents Sea winter 2001 (m^2 reflecting surface · 10^{-3}).

Area	Cod			Haddock			Redfish		
	P	B	Total	P	B	Total	P	B	Total
A	255	98	353	76	50	126	282	92	374
B	79	94	173	81	88	169	38	32	70
C	55	35	90	23	13	36	29	6	35
D	787	277	1064	600	418	1018	20	14	34
D'	32	40	72	33	25	58	0	0	0
E	11	38	49	2	3	5	0	1	1
S	167	116	283	10	18	28	235	41	276
Total	1387	698	2085	825	615	1440	603	185	788

Table 5.2. Cod and haddock. Total echo abundance and echo abundance in the 10 m layer above the bottom from acoustic surveys in the Barents Sea winter 1981-2001 (m^2 reflecting surface · 10^{-3}). 1981 – 1992 includes mainly areas A, B, C and D.

Year	Echo abundance								
	Total			Bottom			Bottom/Total		
	Cod	Haddock	Sum	Cod	Haddock	Sum	Cod	Haddock	Sum
1981			2097			799			0.38
1982			686			311			0.45
1983			597			169			0.28
1984			2284			604			0.26
1985			5187			736			0.14
1986			5990			820			0.14
1987			2676			608			0.23
1988			1696			579			0.34
1989			914			308			0.34
1990			1355			536			0.40
1991			2706			803			0.30
1992			4128			951			0.23
1993	3905	2854	6759	1011	548	1559	0.26	0.19	0.23
1994	5076	3650	8726	1201	609	1810	0.24	0.17	0.21
1995	4125	3051	7176	1525	651	2176	0.37	0.21	0.30
1996	2729	1556	4285	1004	626	1630	0.37	0.40	0.38
1997[1]	1354	995	2349	530	258	788	0.39	0.26	0.34
1998[1]	2406	581	2987	632	143	775	0.26	0.29	0.26
1999	1364	704	2068	389	145	534	0.29	0.21	0.26
2000	2596	1487	4083	610	343	953	0.23	0.23	0.23
2001	2085	1440	3525	698	615	1313	0.34	0.43	0.37

[1)] Norwegian EEZ and part of the Svalbard area

5.2 Vertical distribution

Tables 5.3-5.5 show the vertical distribution of echo density per meter depth for cod, haddock and redfish. It should be noticed that the values within each bottom depth interval and main area are direct averages off all observations, which means that strata with high sampling intensity are over-represented compared to those with lower sampling intensity. Results combined over bottom depth intervals or over main areas ("All" and "Total" in the tables) have been weighted by the number of observations (i.e., naut. miles). Since these values represents volume densities, they have to be multiplied by the extent of the height intervals for comparison of area densities, and, in addition, multiplied by the area for comparison of echo abundance between main areas.

The highest acoustic volume densities for **cod** (Table 5.3) were observed 0-10 m above bottom in the 150-200 m and 200-250 m bottom depth intervals. These bottom depth intervals also show the highest volume densities for the hight intervals up to 50 m above bottom. The main areas giving the highest volume densities were B, C, D and S.

Table 5.3. Average acoustic backscattering volume density (s_A per meter depth x 1000) allocated to cod by height intervals above bottom and by bottom depth intervals. The total average corresponds to the average by bottom depth intervals weighted by the number of observations (Naut. miles).

	Bottom	Height above bottom (intervals in m)										Naut.
Region	depth (m)	0- 10	10-20	20- 30	30- 50	50-100	100-150	150-200	200-250	250-300	300 -->	Miles
All	000-050	0	0	0	0							0
All	050-100	141	13	4	2	0						401
All	100-150	400	157	111	72	15	0					703
All	150-200	643	352	288	207	61	7	0				890
All	200-250	670	260	184	144	90	27	3	0			1229
All	250-300	519	196	154	135	84	27	7	1	0		1961
All	300-350	547	174	116	103	71	33	9	1	0	0	1334
All	>350	192	61	35	36	39	22	7	2	1	1	1794
All	Total	460	177	130	106	61	21	5	1	0	0	8312
A	Total	369	158	116	108	70	17	4	1	0	0	1420
B	Total	976	247	154	86	38	7	1	0	0	0	762
C	Total	695	172	122	116	75	36	12	2	0	0	634
D	Total	440	236	203	173	99	40	9	1	0	0	2682
D'	Total	141	46	25	15	3	0	0	0	0	0	905
E	Total	224	31	12	9	4	1	0	0	0	0	533
S	Total	484	161	102	75	44	14	3	2	1	0	1376

Table 5.4 shows the vertical distribution of **haddock** acoustic density per meter depth. As for cod, the highest densities for haddock were observed 0-10 m above bottom in the 150-200 m and 200-250 m bottom depth intervals. The main areas giving the highest volume densities were B and D.

Table 5.4. Average acoustic backscattering volume density (s_A per meter depth x 1000) allocated to haddock by height intervals above bottom and by bottom depth intervals. The total average corresponds to the average by bottom depth intervals weighted by the number of observations (Naut. miles).

	Bottom	Height above bottom (intervals in m)										Naut.
Region	depth (m)	0- 10	10-20	20- 30	30- 50	50-100	100-150	150-200	200-250	250-300	300 -->	Miles
All	000-050	0	0	0	0							0
All	050-100	38	5	3	0	0						401
All	100-150	333	185	126	47	9	0					703
All	150-200	747	374	296	246	62	7	0				890
All	200-250	397	218	188	111	43	8	0	0			1229
All	250-300	259	126	101	70	37	7	1	0	0		1961
All	300-350	198	65	42	39	28	11	3	1	0	0	1334
All	>350	68	19	11	13	9	4	1	0	0	1	1794
All	Total	276	132	103	72	29	6	1	0	0	0	8312
A	Total	189	73	48	40	16	2	0	0	0	0	1420
B	Total	887	267	162	82	43	13	3	1	1	1	762
C	Total	258	75	60	56	33	12	4	1	0	0	634
D	Total	359	239	213	156	59	11	1	0	0	0	2682
D’	Total	139	74	48	25	3	0	0	0	0	0	905
E	Total	16	4	2	2	1	0	0	0	0	0	533
S	Total	65	16	8	5	3	1	0	0	0	0	1376

Table 5.5 shows the vertical distribution of **redfish** acoustic density per meter depth. The highest densities for redfish were observed 0-10 m above bottom deeper than 350 m bottom depth. Among the main areas, B and A showed the highest values. In those areas the pelagic recordings tended to be dominated blue whiting, and there were rather few pelagic tows. Therefore, the acoustic values allocated to redfish are regarded to be uncertain.

Table 5.5. Average acoustic backscattering volume density (s_A per meter depth x 1000) allocated to redfish by height intervals above bottom and by bottom depth intervals. The total average corresponds to the average by bottom depth intervals weighted by the number of observations (Naut. miles).

	Bottom	Height above bottom (intervals in m)										Naut.
Region	depth (m)	0- 10	10-20	20- 30	30- 50	50-100	100-150	150-200	200-250	250-300	300 -->	Miles
All	000-050	0	0	0	0							0
All	050-100	4	0	0	0	0						401
All	100-150	25	4	1	1	0	0					703
All	150-200	122	12	4	1	0	0	0				890
All	200-250	64	15	8	5	1	0	0	0			1229
All	250-300	84	27	18	12	4	1	0	0	0		1961
All	300-350	146	70	56	52	29	6	1	0	0	0	1334
All	>350	313	205	143	131	105	48	24	13	3	1	1794
All	Total	136	66	46	40	29	12	5	3	1	0	8312
A	Total	360	225	153	126	75	25	8	4	2	0	1420
B	Total	297	62	28	22	18	3	1	0	0	0	762
C	Total	105	65	66	64	43	13	1	0	0	0	634
D	Total	44	10	7	7	4	1	0	0	0	0	2682
D’	Total	0	0	0	0	0	0	0	0	0	0	905
E	Total	12	0	0	0	0	0	0	0	0	0	533
S	Total	140	73	59	60	56	33	22	13	2	1	1376

6. DISTRIBUTION AND ABUNDANCE OF COD

6.1 Acoustic estimation

Surveys in the Barents Sea at this time of the year mainly cover the immature part of the cod stock. Most of the mature cod (age 7 and older) have started on its spawning migration southwards out of the investigated area, and is therefore to a lesser extent covered.

Acoustic indices by length and age are given in table 6.1. Table 6.2 shows the acoustic indices for each age group by main areas, in the pelagic layer (P) and in the 10 m layer above the bottom (B).

The time series (1981-2001) is presented in table 6.3. The indices for 1997 and 1998 are raised to also represent the Russian EEZ. Indices for the Russian EEZ in 1997 and 1998 were calculated by interpolation of the ratios found in the Russian EEZ in 1996 and 1999, age group by age group. Since the coverage of the Svalbard area (S) varies from year to year due to ice, this area has been excluded in the extrapolation of fish abundance in the Russian EEZ in 1997-1998, and just added to the total index afterwards.

The index for 2 year old cod is the lowest estimated since the survey area was extended in 1993. For age 1 and 3 the index is 40% and 56%, respectively, of the 1993-2000 average. The indices for 4-7 year olds show an increase compared to the year before, but these age groups are still at or below the average 1993-2000 level. For older fish the indices are around 30% of the 1993-2000 average.

Table 6.1. COD. Abundance indices at length and age from the acoustic survey in the Barents Sea winter 2001 (numbers in millions).

Length cm	Age (year-class) 1 (00)	2 (99)	3 (98)	4 (97)	5 (96)	6 (95)	7 (94)	8 (93)	9 (92)	10+	Sum
5-9	51.8										51.8
10-14	550.3										550.3
15-19	27.7	10.8									38.5
20-24		34.2	4.5								38.7
25-29		18.6	27.2								45.8
30-34		0.3	53.5	25.1							79.0
35-39			47.1	43.5	0.1						90.6
40-44			5.5	57.0	3.3						65.9
45-49			0.2	37.6	16.1						54.0
50-54				7.9	30.7	0.8					39.4
55-59				0.4	20.8	6.2					27.5
60-64				0.1	5.5	14.7	1.4				21.7
65-69					0.6	11.8	3.3	0.1			15.9
70-74					0.1	4.4	3.8	0.3			8.6
75-79					+	1.6	2.3	0.5	0.2		4.7
80-84					+	0.1	0.9	0.2	0.1	+	1.3
85-89						+	0.1	0.2	0.1	+	0.4
>90							0.1	0.1	0.1	0.2	0.5
Sum	629.9	63.9	138.2	171.6	77.3	39.7	11.8	1.4	0.5	0.2	1134.7

Table 6.2. COD. Acoustic abundance indices in the pelagic layer (P) and in the 10 m layer above the bottom (B) for the main areas of the Barents Sea winter 2001 (numbers in millions).

Area	Layer	Age (year-class) 1 (00)	2 (99)	3 (98)	4 (97)	5 (96)	6 (95)	7 (94)	8 (93)	9 (92)	10+	Total
A	P	26.9	1.5	3.5	8.6	11.7	10.3	3.8	0.3	0.3	+	66.8
	B	10.0	0.5	1.2	3.3	4.9	3.9	1.3	0.1	0.1	+	25.2
B	P	0.9	0.1	0.7	1.5	2.9	3.7	1.1	0.3	0.1	0.1	11.3
	B	1.1	0.2	0.7	1.5	3.1	4.6	1.4	0.4	0.1	0.1	13.2
C	P	9.7	0.6	0.9	3.2	2.9	1.5	0.4	+		+	19.3
	B	5.6	0.4	0.5	1.8	1.9	1.0	0.3	+		+	11.5
D	P	200.0	28.6	81.6	93.0	25.6	4.7	1.2	0.1	0.1		434.8
	B	128.5	11.6	21.7	24.6	9.5	3.0	0.9	0.1	0.1		200.1
D'	P	29.4	3.2	3.9	2.1	0.6	0.1	+		+	+	39.4
	B	73.7	4.6	3.3	1.5	0.4	0.1	+		+	+	83.6
E	P	4.2	0.3	0.7	0.6	0.4	0.4	0.1				6.5
	B	9.1	1.3	2.7	2.3	1.4	1.3	0.3				18.3
S	P	82.1	7.0	10.3	15.6	6.8	3.1	0.5	0.1	+	+	125.5
	B	48.7	4.3	6.4	12.1	5.2	1.9	0.3	0.1	+	+	79.0
ABCD	P	237.5	30.7	86.7	106.3	43.1	20.2	6.5	0.7	0.3	0.1	532.2
	B	145.2	12.7	24.1	31.2	20.4	12.5	3.9	0.6	0.2	0.1	250.0
Total	P	353.2	41.1	101.6	124.5	50.8	23.8	7.2	0.8	0.3	0.1	703.7
	B	276.7	22.7	36.6	47.1	26.5	15.9	4.6	0.7	0.2	0.1	431.0
	Sum	629.9	63.9	138.2	171.6	77.3	39.7	11.8	1.4	0.5	0.2	1134.7

Table 6.3. COD. Abundance indices from acoustic surveys in the Barents Sea winter 1981-2001 (numbers in millions). 1981-1992 includes mainly areas A, B C and D.

Year	Age										Total
	1	2	3	4	5	6	7	8	9	10+	
1981	8.0	82.0	40.0	63.0	106.0	103.0	16.0	3.0	1.0	1.0	423.0
1982	4.0	5.0	49.0	43.0	40.0	26.0	28.0	2.0	+	0.0	197.0
1983	60.5	2.8	5.3	14.3	17.4	11.1	5.6	3.0	0.5	0.1	120.5
1984	745.4	146.1	39.1	13.6	11.3	7.4	2.8	0.2	0.0	0.0	966.0
1985	69.1	446.3	153.0	141.6	19.7	7.6	3.3	0.2	0.1	0.0	840.9
1986	353.6	243.9	499.6	134.3	65.9	8.3	2.2	0.4	0.1	0.0	1308.2
1987	1.6	34.1	62.8	204.9	41.4	10.4	1.2	0.2	0.7	0.0	357.3
1988	2.0	26.3	50.4	35.5	56.2	6.5	1.4	0.2	0.0	0.0	178.4
1989	7.5	8.0	17.0	34.4	21.4	53.8	6.9	1.0	0.1	0.1	150.1
1990	81.1	24.9	14.8	20.6	26.1	24.3	39.8	2.4	0.1	0.0	234.1
1991	181.0	219.5	50.2	34.6	29.3	28.9	16.9	17.3	0.9	0.0	578.7
1992	241.4	562.1	176.5	65.8	18.8	13.2	7.6	4.5	2.8	0.2	1092.9
1993	1074.0	494.7	357.2	191.1	108.2	20.8	8.1	5.0	2.3	2.5	2264.0
1994	858.3	577.2	349.8	404.5	193.7	63.6	12.1	3.7	1.7	0.9	2465.4
1995	2619.2	292.9	166.2	159.8	210.1	68.8	16.7	2.1	0.7	1.0	3537.4
1996	2396.0	339.8	92.9	70.5	85.8	74.7	20.6	2.8	0.3	0.4	3083.8
1997[1]	1623.5	430.5	188.3	51.7	49.3	37.2	22.3	4.0	0.7	0.1	2407.5
1998[1]	3401.3	632.9	427.7	182.6	42.3	33.5	26.9	13.6	1.7	0.3	4762.8
1999	358.3	304.3	150.0	96.4	45.1	10.3	6.4	4.1	0.8	0.3	976.0
2000	154.1	221.4	245.2	158.9	142.1	45.4	9.6	4.7	3.0	1.1	985.4
2001	629.9	63.9	138.2	171.6	77.3	39.7	11.8	1.4	0.5	0.2	1134.7

1) Indices raised to also represent the Russian EEZ.

6.2 Swept area estimation

Figs. 6.1-6.4 show the geographic distribution of bottom trawl catch rates (number of fish per 3 naut.mile, corresponding to 1 hours towing) for cod for each of the size groups < 20 cm, 20-34 cm, 35-49 cm and > 50 cm. As in previous years the greatest concentrations of the smallest cod (<20 cm) were found in the eastern part of the survey area within the Russian EEZ. Also the size groups 20-34 cm and 35-49 cm show highest densities in this eastern area. Bigger cod were only caught in small numbers with no dense concentrations.

Table 6.4 presents the abundance indices by length groups for each main area. Standard error and coefficient of variation (CV) are also given. The CV is lowest in the size range 45-69 cm and is below 14% for the whole size range between 10 and 79 cm. Age-length distribution of the total swept area index as well as the distribution of the index by main area and age is given in tables 6.5 and 6.6, respectively. Both the age distribution and the distribution between main areas are similar to the acoustic observations (Tables 6.1 and 6.2).

The time series (1981-2001) is shown in table 6.7. The indices for 1997 and 1998 are adjusted the same way as the acoustic indices to also represent the Russian EEZ. The 2001 results for age 2 is the lowest observed since the survey area was extended in 1993, and the result for age 1 and 3 is 26% and 73%, respectively, of the 1993-2000 average. The indices for age groups 4-7 are at or below the 1993-2000 average, while for older fish the indices are well below the 1993-200 average.

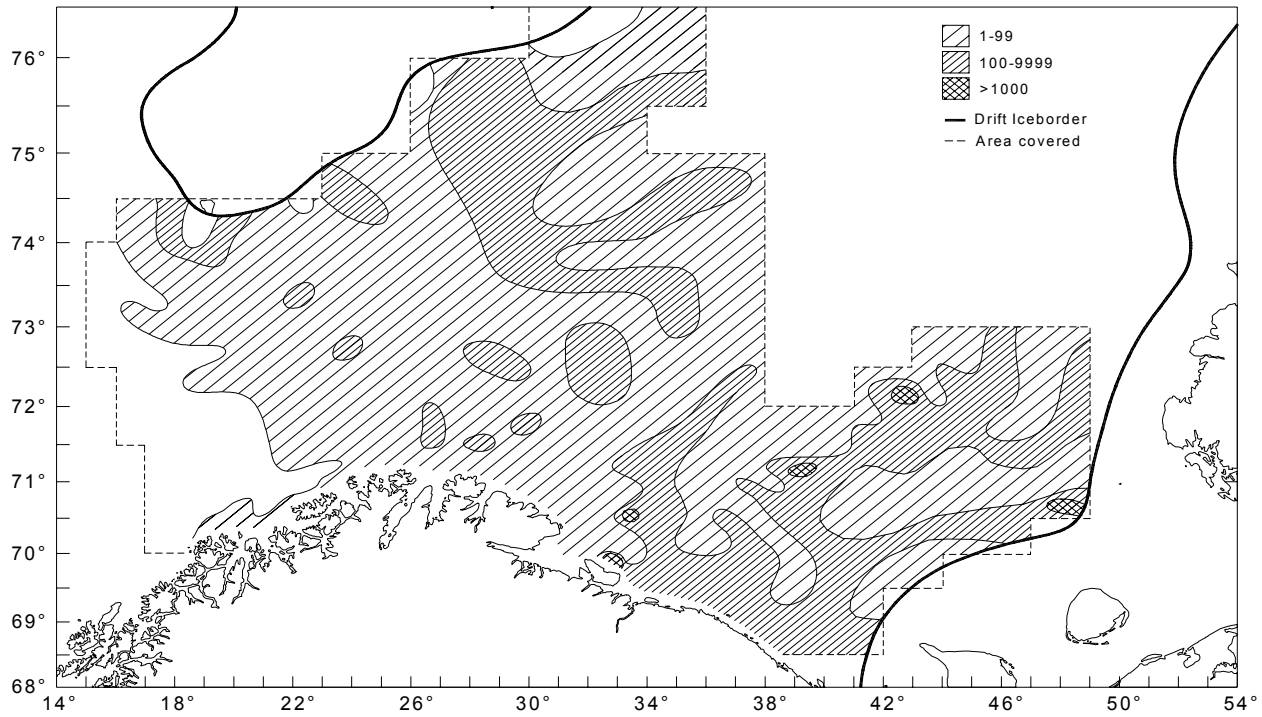

Figure 6.7. COD < 20 cm. Distribution in the trawl catches winter 2001 (number per hour trawling).

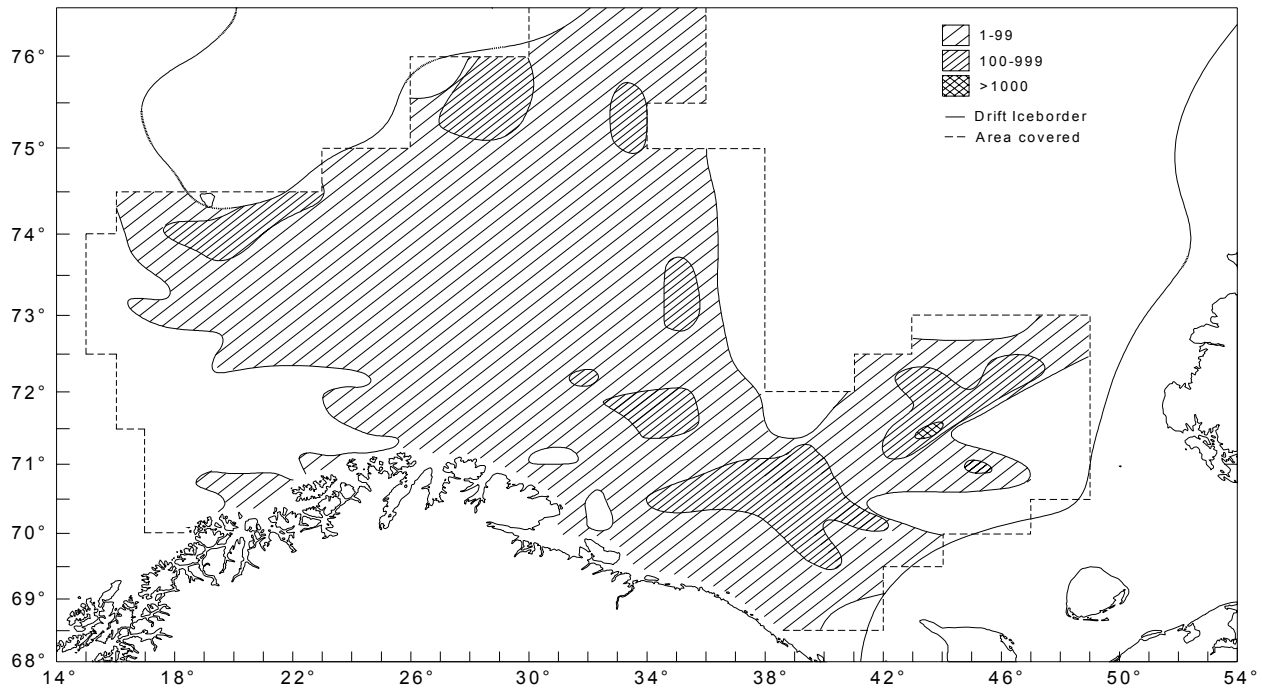

Figure 6.8. COD 20-34 cm. Distribution in the trawl catches winter 2001(number per hour trawling).

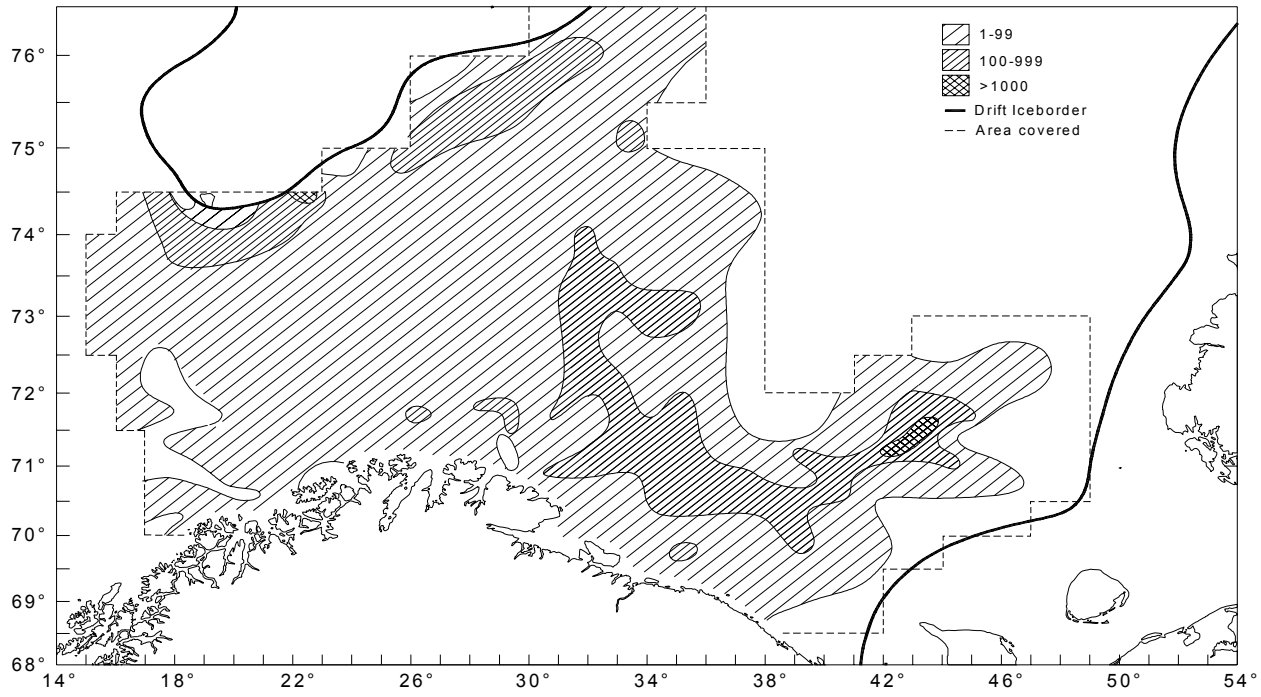

Figure 6.9. COD 35-49 cm. Distribution in the trawl catches winter 2001(number per hour trawling).

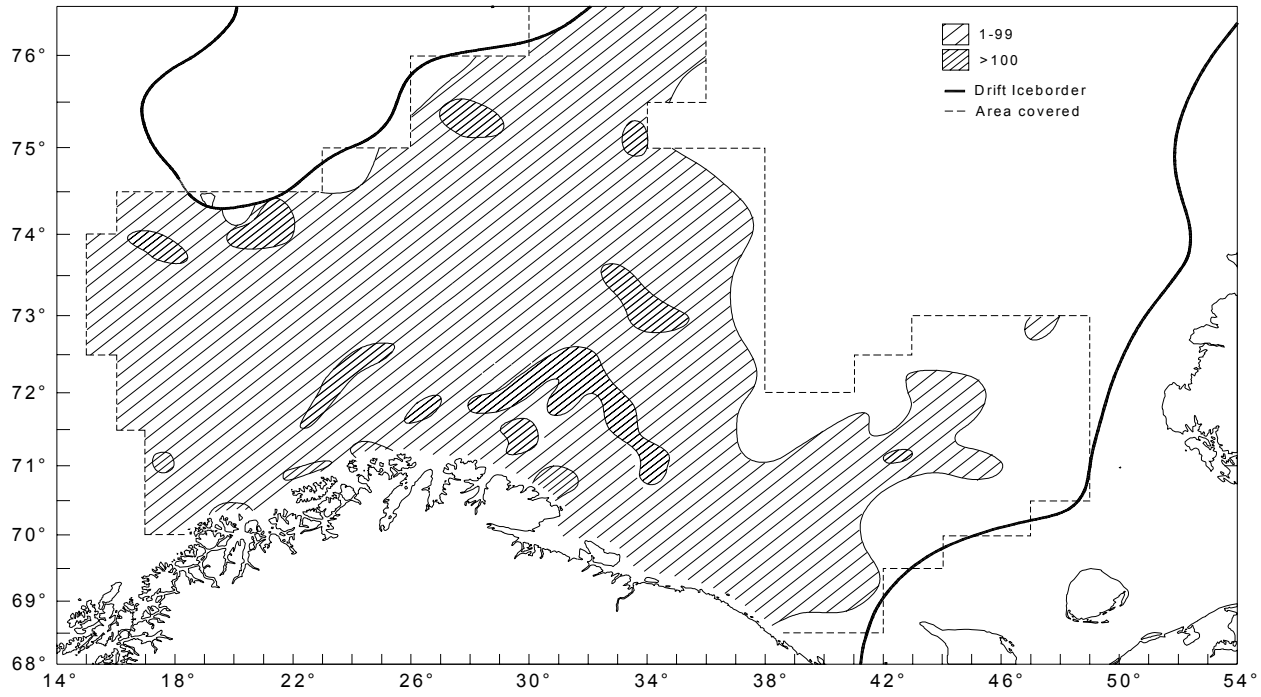

Figure 6.10. COD ? 50 cm. Distribution in the trawl catches winter 2001(number per hour trawling).

Table 6.4. COD. Abundance indices (I) at length with standard error of mean (S) from bottom trawl hauls for main areas of the Barents Sea winter 2001 (no. in millions).

Length	Area																
	A		B		C		D		D'		E		S		Total		
cm	I	S	I	S	I	S	I	S	I	S	I	S	I	S	I	S	CV (%)
5-9	2.6	0.5	0.1	+	0.5	0.2	11.7	1.9	15.3	6.4	0.8	0.5	7.5	2.5	38.5	7.2	18.7
10-14	20.1	2.7	0.8	0.2	10.7	2.3	290.1	44.2	156.7	36.6	47.6	12.4	66.5	12.5	592.5	60.1	10.1
15-19	0.2	0.1	+	+	0.2	0.1	15.5	2.9	5.6	2.5	4.3	1.1	15.4	4.0	41.3	5.7	13.8
20-24	0.9	0.2	+	+	0.4	0.2	22.5	4.0	8.1	2.3	2.7	1.0	11.6	3.5	46.1	5.9	12.7
25-29	0.7	0.2	0.1	+	0.4	0.1	30.1	4.0	5.9	1.9	2.8	1.1	14.8	5.3	54.8	7.0	12.8
30-34	1.0	0.2	0.2	0.1	0.8	0.4	61.7	11.4	7.1	2.4	6.4	2.1	20.2	5.6	97.4	13.1	13.4
35-39	1.8	0.2	0.2	0.1	2.1	1.1	69.3	11.6	5.9	2.5	8.8	4.6	23.3	7.1	111.3	14.6	13.1
40-44	2.8	0.4	0.4	0.1	2.9	1.2	47.8	5.9	2.6	1.1	4.7	2.2	18.9	4.9	80.1	8.1	10.2
45-49	3.9	0.5	0.7	0.1	3.6	1.1	32.6	3.9	1.7	0.8	4.5	2.5	12.9	2.7	59.9	5.5	9.3
50-54	4.7	0.5	1.0	0.2	3.0	0.8	20.9	2.4	1.0	0.4	4.8	2.6	10.8	2.5	46.0	4.5	9.7
55-59	5.2	0.5	1.9	0.4	2.2	0.4	10.9	1.3	0.1	0.1	2.4	1.3	6.0	1.4	28.7	2.5	8.6
60-64	4.3	0.4	2.3	0.6	1.4	0.2	5.1	0.6	0.4	0.2	2.2	1.1	3.7	0.8	19.3	1.7	8.8
65-69	3.4	0.3	2.3	0.6	1.1	0.2	2.5	0.3	0.1	0.1	1.4	0.5	1.9	0.5	12.7	1.1	8.3
70-74	1.6	0.3	1.2	0.4	0.6	0.1	1.4	0.2	0.1	0.1	0.8	0.4	0.9	0.3	6.5	0.7	11.3
75-79	0.7	0.1	0.9	0.2	0.3	0.1	0.9	0.2	0.1	+	0.4	0.1	0.4	0.1	3.5	0.4	11.2
80-84	0.1	0.1	0.3	0.1	0.1	+	0.4	0.1	+	+	0.1	0.1	0.1	+	1.1	0.2	15.4
85-89	-	-	0.2	0.1	+	+	0.1	+	-	-	-	-	+	+	0.3	0.1	28.5
>90	0.1	0.1	0.2	0.1	+	+	0.2	0.1	+	+	-	-	0.1	0.1	0.6	0.2	36.4
Sum	54.2	3.0	12.5	1.1	30.2	3.2	623.5	48.1	210.7	37.6	94.8	14.3	214.8	18.5	1240.6	65.5	5.3

Table 6.5. COD. Abundance indices at length and age from the bottom trawl survey in the Barents Sea winter 2001 (numbers in millions).

Length (cm)	Age (year-class) 1 (00)	2 (99)	3 (98)	4 (97)	5 (96)	6 (95)	7 (94)	8 (93)	9 (92)	10+	Sum
5-9	38.5										38.5
10-14	592.5										592.5
15-19	26.9	14.4									41.3
20-24		41.3	4.8								46.1
25-29		20.2	34.6								54.8
30-34		0.7	82.6	14.1							97.4
35-39			61.6	49.1	0.6						111.3
40-44			7.2	69.1	3.8						80.1
45-49			0.2	40.5	19.1						59.9
50-54				8.9	35.0	2.1					45.6
55-59				0.9	20.0	7.8					28.7
60-64				0.2	4.1	13.7	1.2				19.3
65-69					0.6	9.6	2.4	0.1			12.7
70-74					0.1	3.5	2.6	0.3			6.5
75-79					+	1.4	1.7	0.3	0.2		3.5
80-84					+	0.1	0.8	0.2	0.1	0.2	1.1
85-89						+	0.1	0.2	+		0.3
>90							0.1	0.2	0.2		0.6
Sum	657.9	76.6	191.1	182.8	83.4	38.2	8.9	1.1	0.4	0.2	1240.6

Table 6.6. COD. Abundance indices from bottom trawl hauls for main areas of the Barents Sea winter 2001 (numbers in millions.)

Area	Age (year-class) 1 (00)	2 (99)	3 (98)	4 (97)	5 (96)	6 (95)	7 (94)	8 (93)	9 (92)	10+	Total
A	22.9	1.1	2.7	7.1	9.5	8.4	2.2	0.2	0.1	+	54.2
B	0.9	0.1	0.5	1.2	3.1	4.5	1.7	0.4	0.1	0.1	12.5
C	11.2	0.7	2.4	6.9	5.8	2.4	0.7	+		+	30.2
D	311.9	41.2	121.3	102.9	34.9	9.0	1.8	0.2	0.2		623.5
D'	174.9	13.0	14.6	4.8	2.9	0.4	0.1		+	+	210.7
E	51.4	5.0	10.3	14.9	6.3	5.9	1.0				94.8
S	84.7	15.7	39.3	45.1	20.8	7.6	1.4	0.2	0.1	0.1	214.8
ABCD	521.8	56.1	141.5	122.9	56.2	24.7	6.5	0.9	0.3	0.1	931.1
Total	657.9	76.6	191.1	182.8	83.4	38.2	8.9	1.1	0.4	0.2	1240.6

Table 6.7. COD. Abundance indices from bottom trawl surveys in the Barents Sea winter 1981-2001 (numbers in millions). 1981-1992 includes only main areas A, B, C and D).

Year	Age										Total
	1	2	3	4	5	6	7	8	9	10+	
1981	4.6	34.3	16.4	23.3	40.0	38.4	4.8	1.0	0.3	0.0	163.1
1982	0.8	2.9	28.3	27.7	23.6	15.5	16.0	1.4	0.2	0.0	116.4
1983	152.9	13.4	25.0	52.3	43.3	17.0	5.8	3.2	1.0	0.1	313.9
1984	2755.0	379.1	97.5	28.3	21.4	11.7	4.1	0.4	0.1	0.1	3297.7
1985	49.5	660.0	166.8	126.0	19.9	7.7	3.3	0.2	0.1	0.1	1033.6
1986	665.8	399.6	805.0	143.9	64.1	8.3	1.9	0.3	0.0	0.0	2089.1
1987	30.7	445.0	240.4	391.1	54.3	15.7	2.0	0.5	0.0	0.0	1179.8
1988	3.2	72.8	148.0	80.5	173.3	20.5	3.6	0.5	0.0	0.0	502.5
1989	8.2	15.6	46.4	75.9	37.8	90.2	9.8	0.9	0.1	0.1	285.0
1990	207.2	56.7	28.4	34.9	34.6	20.6	27.2	1.6	0.4	0.0	411.5
1991	460.5	220.1	45.9	33.7	25.7	21.5	12.2	12.7	0.6	0.0	832.7
1992	126.6	570.9	158.3	57.7	17.8	12.8	7.7	4.3	2.7	0.2	959.0
1993	534.5	420.4	273.9	140.1	72.5	15.8	6.2	3.9	2.2	2.4	1471.9
1994	1035.9	535.8	296.5	310.2	147.4	50.6	9.3	2.4	1.6	1.3	2391.0
1995	5253.1	541.5	274.6	241.4	255.9	76.7	18.5	2.4	0.8	1.1	6666.2
1996	5768.5	707.6	170.0	115.4	137.2	106.1	24.0	2.9	0.4	0.5	7032.5
1997[1]	4815.5	1045.1	238.0	64.0	70.4	52.7	28.3	5.7	0.9	0.5	6321.1
1998[1]	2418.5	643.7	396.0	181.3	36.5	25.9	17.8	8.6	1.0	0.5	3729.8
1999	484.6	340.1	211.8	173.2	58.1	13.4	6.5	5.1	1.2	0.4	1294.4
2000	128.8	248.3	235.2	132.1	108.3	26.9	4.3	2.0	1.2	0.4	887.5
2001	657.9	76.6	191.1	182.8	83.4	38.2	8.9	1.1	0.4	0.2	1240.6

1) Indices raised to also represent the Russian EEZ.

6.3 Growth

Table 6.8 and 6.10 show length and weight by age for each main area. In most years the largest fish at age has been observed in the south-western main areas (A, B and C). This pattern was less evident in 2001. For the oldest fish there are few observations in some of the areas, and those mean lengths and weights are therefore more uncertain. Tables 6.9 and 6.11 present the time series (1978-2001) for mean length and weight at age for the entire investigated area. Mean length and weight for ages 2 and 3 showed a considerable increase from 2000 to 2001, and for older fish there is a moderate increase. Weights at age have been fairly low in the period 1995-2000, but seem now to approach the values observed in 1994. The annual weight increments observed over the last year are comparable to those observed between 1992 and 1993 (Table 6.12).

Table 6.8. COD. Length (cm) at age in main areas of the Barents Sea winter 2001.

Area	Age (year-class)							
	1 (00)	2 (99)	3 (98)	4 (97)	5 (96)	6 (95)	7 (94)	8 (93)
A	11.5	22.7	34.2	44.4	54.1	63.8	71.3	76.7
B	10.9	24.4	37.1	47.1	57.8	66.2	72.9	80.4
C	11.6	22.2	35.4	44.4	53.8	64.4	71.8	80.7
D	11.8	23.2	33.9	41.8	52.2	63.0	71.2	80.3
D'	11.9	22.1	32.3	42.8	46.4	64.7	77.0	98.0
E	12.5	22.2	32.4	40.2	51.1	62.1	69.4	-
S	12.5	21.3	30.8	40.7	51.1	61.2	69.7	78.0
Total	12.0	22.5	33.1	41.6	52.2	63.1	71.2	79.2

Table 6.9. COD. Length (cm) at age in the Barents Sea from the investigations winter 1978 - 2001.

Year	Age							
	1	2	3	4	5	6	7	8
1978	14.2	23.1	32.1	45.9	54.2	64.6	67.6	76.9
1979	12.8	22.9	33.1	40.0	52.3	64.4	74.7	83.0
1980	17.6	24.8	34.2	40.5	52.5	63.5	73.6	83.6
1981	17.0	26.1	35.5	44.7	52.0	61.3	69.6	77.9
1982	14.8	25.8	37.6	46.3	54.7	63.1	70.8	82.9
1983	12.8	27.6	34.8	45.9	54.5	62.7	73.1	78.6
1984	14.2	28.4	35.8	48.6	56.6	66.2	74.1	79.7
1985	16.5	23.7	40.3	48.7	61.3	71.1	81.2	85.7
1986	11.9	21.6	34.4	49.9	59.8	69.4	80.3	93.8
1987	13.9	21.0	31.8	41.3	56.3	66.3	77.6	87.9
1988	15.3	23.3	29.7	38.7	47.6	56.8	71.7	79.4
1989	12.5	25.4	34.7	39.9	46.8	56.2	67.0	83.3
1990	14.4	27.9	39.4	47.1	53.8	60.6	68.2	79.2
1991	13.6	27.2	41.6	51.7	59.5	67.1	72.3	77.6
1992	13.2	23.9	41.3	49.9	60.2	68.4	76.1	82.8
1993	11.3	20.3	35.9	50.8	59.0	68.2	76.8	85.8
1994	12.0	18.3	30.5	44.7	55.4	64.3	73.5	82.4
1995	12.7	18.7	29.9	42.0	54.1	64.1	74.8	80.6
1996	12.6	19.6	28.1	41.0	49.3	61.4	72.2	85.3
1997[1]	11.4	18.8	28.0	40.4	49.9	59.3	69.1	80.6
1998[1]	10.9	17.4	28.7	40.0	50.5	58.9	67.5	76.3
1999	12.1	18.8	29.0	40.6	50.6	59.9	70.3	78.0
2000	13.0	21.0	28.7	39.7	51.5	61.6	70.5	75.7
2001	12.0	22.5	33.1	41.6	52.2	63.1	71.2	79.2

[1)] Adjusted lengths (Mehl 1999)

Table 6.10. COD. Weight (g) at age in main areas of the Barents Sea winter 2001.

Area	Age (year-class)							
	1 (00)	2 (99)	3 (98)	4 (97)	5 (96)	6 (95)	7 (94)	8 (93)
A	12	97	354	756	1311	2106	2983	4314
B	11	138	488	959	1709	2590	3439	4651
C	13	97	405	794	1349	2253	3337	4786
D	13	113	366	679	1289	2211	3278	4550
D'	14	97	328	792	956	2711	4250	-
E	16	106	335	643	1244	2188	2816	-
S	17	81	250	581	1132	1960	2953	4143
Total	14	103	338	664	1257	2186	3145	4463

Table 6.11. COD. Weight (g) at age in the Barents Sea from the investigations winter 1983-2001.

Year	Age							
	1	2	3	4	5	6	7	8
1983	-	190	372	923	1597	2442	3821	4758
1984	23	219	421	1155	1806	2793	3777	4566
1985	-	171	576	1003	2019	3353	5015	6154
1986	-	119	377	997	1623	2926	3838	7385
1987[1]	21	65	230	490	1380	2300	3970	-
1988	24	114	241	492	892	1635	3040	4373
1989	16	158	374	604	947	1535	2582	4906
1990	26	217	580	1009	1435	1977	2829	4435
1991	18	196	805	1364	2067	2806	3557	4502
1992	20	136	619	1118	1912	2792	3933	5127
1993	9	71	415	1179	1743	2742	3977	5758
1994	13	55	259	788	1468	2233	3355	4908
1995	16	54	248	654	1335	2221	3483	4713
1996	15	62	210	636	1063	1999	3344	5514
1997[2]	12	54	213	606	1112	1790	2851	4761
1998[2]	10	47	231	579	1145	1732	2589	3930
1999	13	55	219	604	1161	1865	2981	3991
2000	17	77	210	559	1189	1978	2989	3797
2001	14	103	338	664	1257	2186	3145	4463

[1)] Estimated weights [2)] Adjusted weights (Mehl 1999)

Table 6.12. COD. Yearly weight increment (g) from the investigations in the Barents Sea winter 1983 - 2001.

Year	Age						
	1-2	2-3	3-4	4-5	5-6	6-7	7-8
1983-84	-	231	783	883	1196	1335	745
1984-85	148	357	582	864	1547	2222	2377
1985-86	-	206	421	620	907	485	2370
1986-87	-	111	113	383	677	1044	-
1987-88	93	176	262	402	255	740	403
1988-89	134	260	363	455	643	947	1866
1989-90	201	422	635	831	1030	1294	1853
1990-91	170	588	784	1058	1371	1580	1673
1991-92	118	423	313	548	725	1127	1570
1992-93	51	279	560	625	830	1185	1825
1993-94	46	188	373	289	490	613	931
1994-95	41	193	395	547	753	1250	1358
1995-96	46	156	388	409	664	1123	2031
1996-97	39	151	396	476	727	852	1417
1997-98	35	177	366	539	621	799	1079
1998-99	45	172	373	582	720	1249	1402
1999-00	64	155	340	585	817	1124	816
2000-01	86	261	454	698	997	1167	1474

6.4 Considerations and conclusion

When using the abundance indices for stock assessment it is important to be aware of all the technical changes introduced during the time series. Better acoustic equipment after 1990 has increased the quality of the indices for all age groups. The survey area was enlarged in 1993. This led to higher indices, especially for the youngest age groups, and the indices also became more accurate all over. The introduction of more fine meshed cod-ends in 1994 and fish length dependent fishing width of the trawl (the time series is adjusted for this) did also lead to more small fish relative to larger fish.

Table 6.13 gives the time series of survey based mortalities (log ratios between survey indices of the same year class in two successive years) since 1993. These mortalities are influenced both by natural and fishing mortality, as well as the true catchability at age for the survey. In the period 1993-1999 there was an increasing trend in the survey mortalities. The trend appears most consistent for the age groups 3-7 in the swept area estimates. The two latest surveys indicate that since 1999 the mortalities have decreased, at least for ages 1-4. Presumably the mortality of the youngest age groups (ages 1-3) is mainly caused by predation,

while for the older age groups it is mainly caused by the fishery. The survey mortalities for age 4 and older are well above the mortalites estimated in the ICES assessment. Decreasing survey catchability at increasing age could be one reason for this. Another possible reason could be that the assessment does not include all sources of mortality, like discards, unreported catches, or poorly quantified predation.

The observed mortality rates in the acoustic investigations have been more variable. This is explained by changes in fish behaviour and how available the fish is for acoustic registration. During the winter survey 1998 the relative abundance of cod in the bottom channel was lower than the years before, and hence the fish were more available for acoustic registration. This led to lower mortality rates of all year classes from 1997 to 1998 in the acoustic series compared with the swept area series. A similar situation is observed in 2000 compared with 1999.

Table 6.13. Total mortality observed for cod during the winter survey in the Barents Sea in 1993-2001.

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Year	Age							
	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9
	Acoustic investigations							
1993-94	0.62	0.35	-0.12	-0.01	0.53	0.54	0.78	1.08
1994-95	1.08	1.24	0.78	0.66	1.04	1.34	1.75	1.67
1995-96	2.04	1.15	0.86	0.62	1.03	1.21	1.79	1.95
1996-97	1.72	0.59	0.59	0.36	0.84	1.21	1.64	1.39
1997-98	0.94	0.01	0.03	0.20	0.39	0.32	0.49	0.86
1998-99	2.41	1.44	1.49	1.40	1.41	1.66	1.88	2.83
1999-00	0.48	0.22	-0.06	-0.39	-0.01	0.07	0.31	0.31
2000-01	0.88	0.47	0.36	0.72	1.28	1.35	1.93	2.24
	Bottom trawl investigations							
1993-94	0.00	0.35	-0.12	-0.05	0.36	0.53	0.95	0.89
1994-95	0.65	0.67	0.21	0.19	0.65	1.01	1.35	1.10
1995-96	2.00	1.16	0.87	0.57	0.88	1.16	1.85	1.79
1996-97	1.71	1.09	0.98	0.49	0.96	1.32	1.44	1.17
1997-98	2.01	0.97	0.27	0.56	1.00	1.09	1.19	1.74
1998-99	1.96	1.11	0.83	1.14	1.00	1.38	1.25	1.97
1999-00	0.67	0.37	0.47	0.47	0.77	1.14	1.18	1.45
2000-01	0.52	0.26	0.25	0.46	1.04	1.11	1.36	1.61

7. DISTRIBUTION AND ABUNDANCE OF HADDOCK

The survey does not cover the total distribution of this stock. An unknown, but presumably low, proportion of the stock is distributed to the south-west of the area surveyed, and in addition there are indications that the distribution of age groups 1 and 2 in some years are concentrated in coastal areas not well covered by the survey.

7.1 Acoustic estimation

The acoustic observations of haddock are uncertain, because large amounts may hide in the bottom dead zone. It is rather common, particularly in shallow waters, to have good bottom trawl catches of haddock in cases when the acoustic recordings are very low.

This year small haddock was widely distributed, and was found unusually far to the north. This might be caused by rather favourably hydrographic conditions far to the north (Figure 4.2).

Table 7.1 shows the acoustic abundance indices by length and age, and table 7.2 presents the indices by age within the main areas for the pelagic layer and the bottom layer. As in most of the previous years the highest abundance was observed in main area D.

The time series (1981-2001), with adjusted indices for 1997 and 1998, is presented in table 7.3. The indices for ages 1, 2 and 3 are all above the 1993-2000 average, while the indices are well below this average for all older age groups.

Table 7.1. HADDOCK. Abundance indices at length and age from the acoustic survey in the Barents Sea winter 2001 (numbers in millions).

Length (cm)	Age (year-class) 1 (00)	2 (99)	3 (98)	4 (97)	5 (96)	6 (95)	7 (94)	8 (93)	9 (91)	10+	Sum
5-9	0.7										0.7
10-14	497.5										497.5
15-19	472.1	33.7									505.8
20-24	6.1	195.0	4.1								205.2
25-29		85.3	54.2	0.1							139.5
30-34		1.6	85.5	5.4							92.5
35-39			64.3	10.1	0.5						74.9
40-44			1.6	6.5	2.9	0.1					11.1
45-49			+	0.6	7.8	0.2	+				8.6
50-54				0.4	7.9	0.7	+	0.1		0.3	9.5
55-59					2.4	0.1	0.5				3.0
60-64					0.1	0.1	0.3	+	+	0.1	0.6
65-69							+		+	0.1	0.1
70-74									+	0.1	0.1
75-79											
80-84							+	+	+	+	+
85-89											
>90											
Sum	976.5	315.6	209.6	23.1	21.6	1.3	0.9	0.1	+	0.5	1549.1

Table 7.2. HADDOCK. Acoustic abundance indices in the pelagic layer (P) and in the 10 m layer above the bottom (B) for the main areas of the Barents Sea winter 2001 (numbers in millions).

Area	Layer	Age (year-class) 1 (00)	2 (99)	3 (98)	4 (97)	5 (96)	6 (95)	7 (94)	8 (93)	9 (91)	10+	Total
A	P	68.1	20.2	4.3	0.1	2.8	0.1	0.1	+		+	95.9
	B	43.0	12.7	2.9	0.1	2.0	0.1	0.1	+		+	61.0
B	P	57.8	12.3	8.0	0.9	3.8	0.2	0.1	+	+	0.1	83.2
	B	65.5	13.3	8.6	1.0	4.0	0.2	0.1	+		0.1	92.8
C	P	22.0	3.1	1.2	0.2	1.1	+	+	+	+	+	27.8
	B	12.4	1.7	0.7	0.1	0.6	+	+	+	+	+	15.6
D	P	414.7	148.7	88.3	10.8	3.8	0.3	0.1		+	0.1	666.9
	B	245.1	89.2	72.2	9.2	3.4	0.3	0.1		+	0.1	419.6
D'	P	8.9	3.9	11.0	0.2	+	+					24.1
	B	10.3	2.6	7.5	0.2	+	+					20.5
E	P	2.4	0.4	0.2	+	+	+					3.1
	B	3.4	0.8	0.3	+	+	+					4.5
S	P	12.2	2.3	1.0	+	+	+	+				15.6
	B	10.5	4.3	3.5	0.1	+	+	+				18.4
ABCD	P	562.6	184.3	101.8	12.0	11.5	0.6	0.3	0.1	+	0.3	873.8
	B	366.0	116.9	84.4	10.4	10.0	0.6	0.3	+	+	0.2	589.0
Total	P	586.2	191.1	114.0	12.4	11.5	0.7	0.4	0.1	+	0.3	916.7
	B	390.3	124.5	95.7	10.7	10.0	0.6	0.4	+	+	0.2	632.5
	Sum	976.5	315.6	209.6	23.1	21.6	1.3	0.9	0.1	+	0.5	1549.1

Table 7.3. HADDOCK. Abundance indices from acoustic surveys in the Barents Sea winter 1981-2001 (numbers in millions). 1981-1992 includes mainly areas A, B, C and D.

Year	Age										Total
	1	2	3	4	5	6	7	8	9	10+	
1981	7	14	5	21	60	18	1	+	+	+	126
1982	9	2	3	4	4	10	6	+	+	+	38
1983	0	5	2	3	1	1	4	2	+	+	18
1984	1685	173	6	2	1	+	+	+	+	+	1867
1985	1530	776	215	5	+	+	+	+	+	+	2526
1986	556	266	452	189	+	+	+	+	+	+	1463
1987	85	17	49	171	50	+	+	+	0	+	372
1988	18	4	8	23	46	7	+	0	0	+	106
1989	52	5	6	11	20	21	2	0	0	0	117
1990	270	35	3	3	4	7	11	2	+	+	335
1991	1890	252	45	8	3	3	3	6	+	0	2210
1992	1135	868	134	23	2	+	+	1	2	+	2165
1993	947	626	563	130	13	+	+	+	+	3	2282
1994	562	193	255	631	111	12	+	+	+	+	1764
1995	1379	285	36	111	387	42	2	+	+	+	2242
1996	249	229	44	31	76	151	8	+	0	+	788
1997[1]	693	24	51	17	12	43	43	2	+	+	885
1998[1]	220	122	20	28	12	5	13	16	1	+	437
1999	856	46	57	13	14	4	1	2	2	+	994
2000	1024	509	32	65	19	11	2	1	2	+	1664
2001	976	316	210	23	22	1	1	+	+	1	1549

1) Indices raised to also represent the Russian EEZ.

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7.2 Swept area estimation

Figs. 7.1 - 7.4 show the geographic distribution of bottom trawl catch rates (number of fish per 3 naut.mile, corresponding to 1 hours towing) for haddock for each of the size groups < 20 cm, 20-34 cm, 35-49 cm and > 50 cm. It is seen that, compared to the previous years, the distribution extends further to the north, especially for the size groups <20 cm and 20-34 cm.

Table 7.4 presents the abundance indices by length groups for each main area. Standard error and coefficient of variation (CV) are also given. The CVs for haddock are generally higher than those for cod. Within the size range 10-59 cm all CVs are below 18%. Table 7.5 show the abundance indices by age- and length groups, and table 7.6 presents the indices for each age group by main areas. The time series (1981-2001) is shown in table 7.7. The indices for 1997 and 1998 are adjusted the same way as for cod to also represent the Russian EEZ. The

swept area results show the same pattern as the acoustic results; ages 1-3 above the 1993-2000 average and older ages well below.

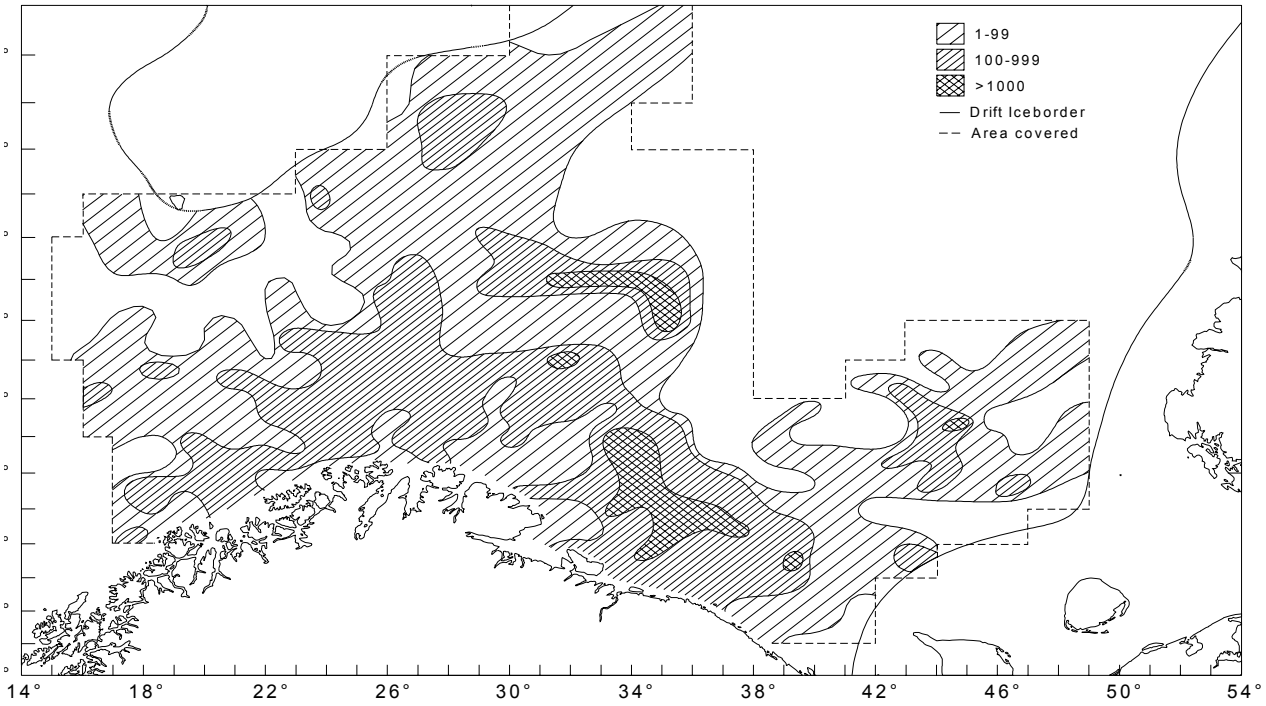

Figure 7.7. HADDOCK < 20 cm. Distribution in the trawl catches winter 2001(number per hour trawling).

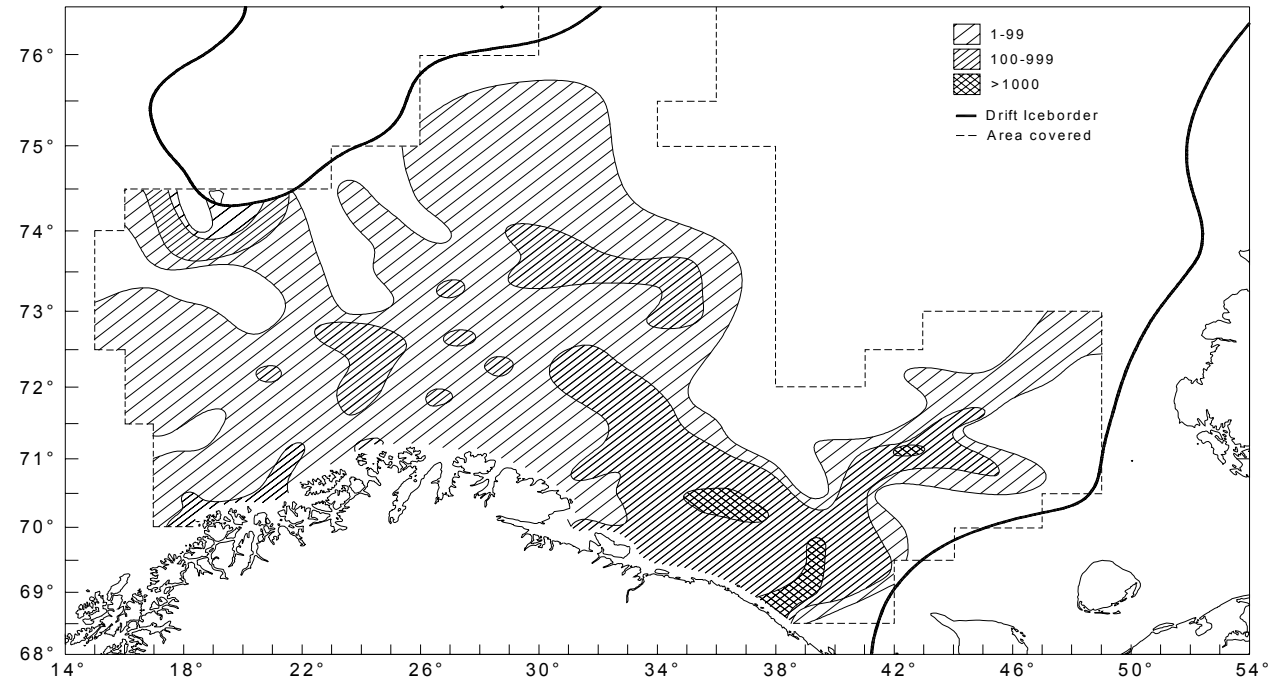

Figure 7.8. HADDOCK 20-34 cm. Distribution in the trawl catches winter 2001 (number per hour trawling).

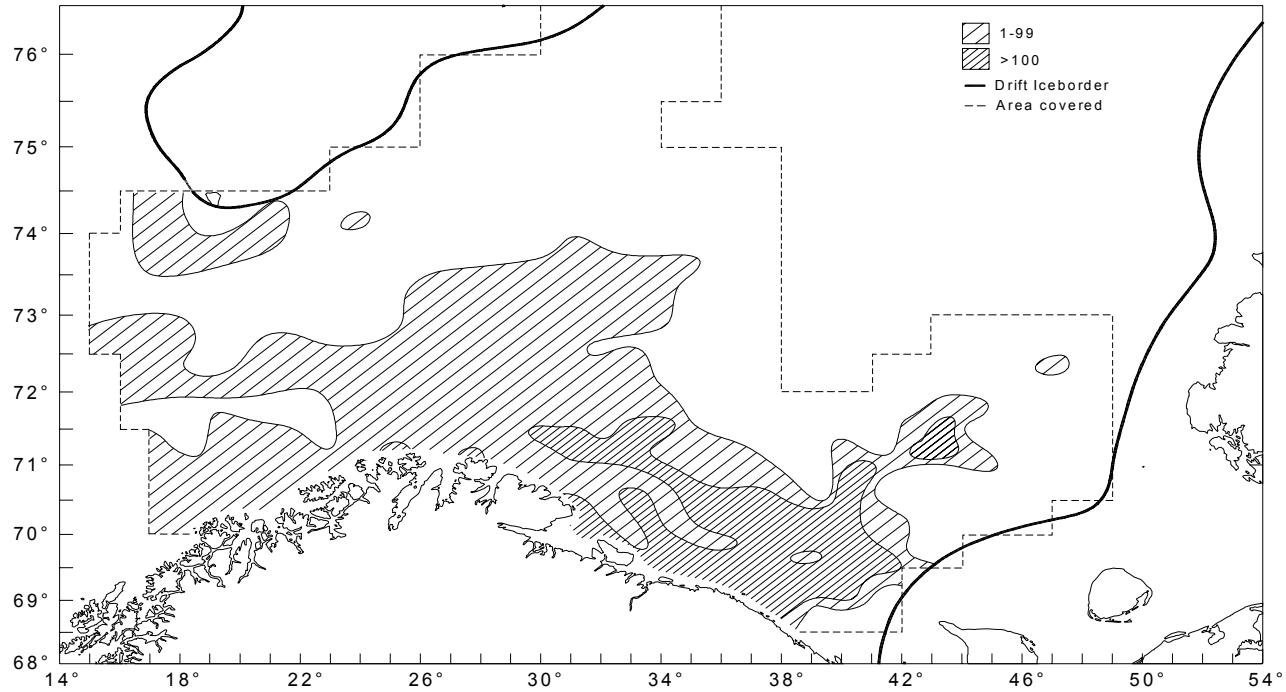

Figure 7.9. *HADDOCK 35-49 cm. Distribution in the trawl catches winter 2001 (number per hour trawling).*

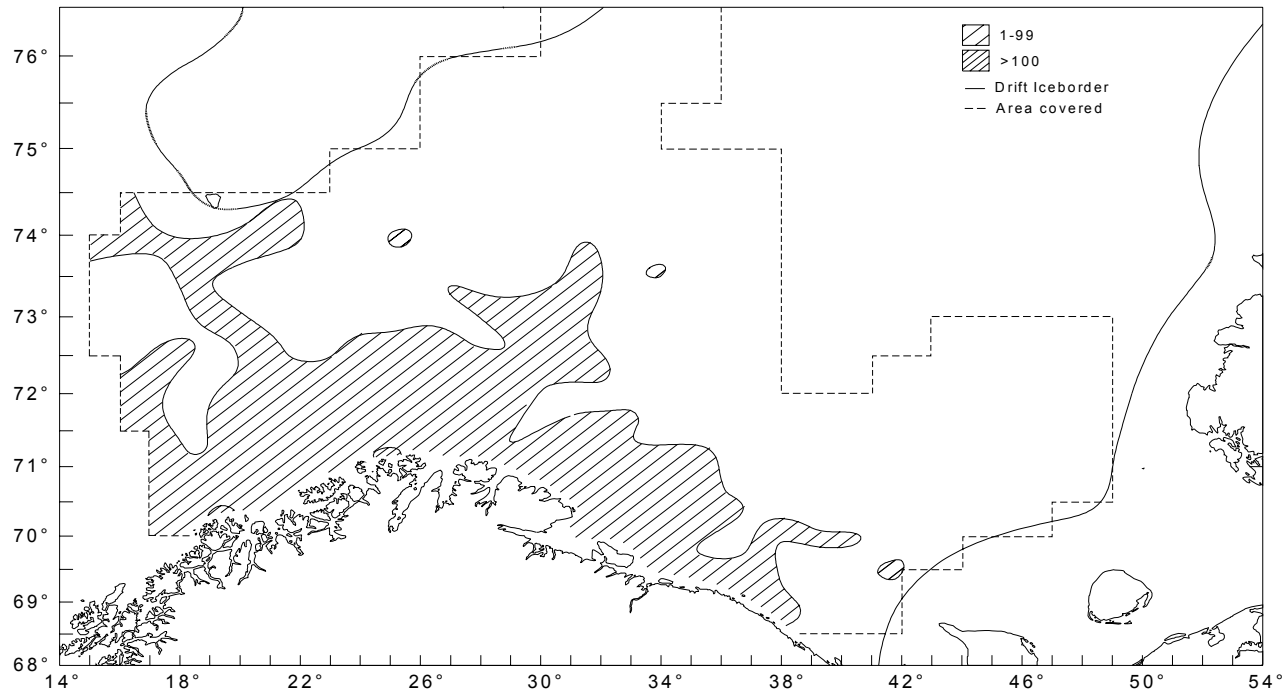

Figure 7.10. HADDOCK > 50 cm. Distribution in the trawl catches winter 2001 (number per hour trawling).

Table 7.4. HADDOCK. Abundance indices (I) at length with standard error of mean (S) from bottom trawl hauls for main areas of the Barents Sea winter 2001 (no. in mill).

Length	Area																
	A		B		C		D		D'		E		S		Total		
cm	I	S	I	S	I	S	I	S	I	S	I	S	I	S	I	S	CV (%)
5-9							0.8	0.8							0.8	0.8	100.0
10-14	36.9	6.0	14.0	2.9	15.8	3.4	558.6	98.8	16.2	4.1	1.7	0.9	23.2	7.3	666.4	99.5	14.9
15-19	105.5	16.7	49.9	9.9	25.7	5.9	423.0	62.6	18.4	5.9	1.1	0.5	25.4	6.6	648.9	66.4	10.2
20-24	19.8	3.2	10.9	2.4	2.6	0.6	213.1	39.0	8.5	3.2	0.6	0.3	10.2	2.7	265.6	39.4	14.8
25-29	6.7	1.1	6.2	1.5	0.9	0.2	142.5	27.6	21.3	8.7	0.3	0.2	3.9	1.2	181.8	29.0	16.0
30-34	2.7	0.6	3.4	0.7	0.5	0.1	86.4	14.3	25.7	10.6			3.4	1.1	122.2	17.9	14.6
35-39	1.5	0.3	1.0	0.2	0.9	0.3	78.0	11.7	26.0	10.2			0.9	0.5	108.2	15.5	14.4
40-44	0.6	0.2	0.8	0.2	0.6	0.2	12.5	2.8	1.4	0.6			0.1	+	15.9	2.9	17.9
45-49	1.3	0.3	1.5	0.4	1.0	0.2	6.0	1.7					0.1	+	9.9	1.8	17.7
50-54	1.9	0.4	2.3	0.6	1.1	0.2	2.9	0.6	0.2	0.1			0.1	+	8.6	0.9	10.8
55-59	0.8	0.2	0.8	0.2	0.3	0.1	0.8	0.2					0.1	+	2.7	0.3	12.7
60-64	0.1	+	0.1	0.1	+	+	0.3	0.2					0.1	0.1	0.6	0.2	38.5
65-69	+	+	+	+			+	+							0.1	+	43.8
70-74	+	+	+	+			+	+							0.1	+	54.8
75-79																	
80-84	+	+													+	+	71.1
85-89																	
>90																	
Sum	177.9	18.1	91.1	10.8	49.3	6.9	1524.9	127.8	117.7	18.8	3.6	1.1	67.3	10.3	2031.7	131.4	6.5

Table 7.5. HADDOCK. Abundance indices at length and age from the bottom trawl survey in the Barents Sea winter 2001 (numbers in millions).

Length (cm)	Age (year-class) 1 (00)	2 (99)	3 (98)	4 (97)	5 (96)	6 (95)	7 (94)	8 (93)	9 (92)	10+	Sum
5-9	0.8										0.8
10-14	666.4										666.4
15-19	546.5	102.5									648.9
20-24	2.8	256.4	6.4								265.6
25-29		98.5	83.0	0.2							181.8
30-34		3.0	113.1	6.2							122.2
35-39			90.8	14.5	3.0						108.2
40-44			3.7	7.7	4.4	0.2					15.9
45-49				0.7	8.7	0.5	+				9.9
50-54				0.3	7.2	0.8	0.1	0.1		0.1	8.6
55-59					2.1	0.2	0.4				2.7
60-64					0.1	+	0.4	+	+	0.1	0.6
65-69							+			0.1	0.1
70-74									+	0.1	0.1
75-79										+	+
Sum	1216.5	460.4	297.0	29.4	25.4	1.7	0.9	0.1	0.1	0.3	2031.7

Table 7.6 HADDOCK. Abundance indices from bottom trawl hauls for main areas of the Barents Sea winter 2001 (numbers in millions).

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Area	Age (year-class) 1 (00)	2 (99)	3 (98)	4 (97)	5 (96)	6 (95)	7 (94)	8 (93)	9 (92)	10+	Total
A	111.4	52.3	8.8	0.3	4.3	0.2	0.2	0.1		0.1	177.9
B	60.5	14.1	10.0	1.4	4.7	0.2	0.2	+		0.1	91.1
C	38.3	6.1	2.0	0.4	2.4	0.1	+	+	+	+	49.3
D	920.9	362.2	203.7	22.5	13.9	1.1	0.4		0.1	0.1	1524.9
D'	33.9	13.1	65.8	4.7	0.1	0.1					117.7
E	2.8	0.6	0.3								3.6
S	48.7	11.8	6.4	0.1	0.1	0.1	0.1				67.3
ABCD	1131.1	434.7	224.5	24.6	25.3	1.6	0.8	0.1	0.1	0.3	1960.8
Total	1216.5	460.4	297.0	29.4	25.4	1.7	0.9	0.1	0.1	0.3	2031.7

Table 7.7. HADDOCK. Abundance indices from bottom trawl surveys in the Barents Sea winter 1981-2001 (numbers in millions). 1981-1992 includes only main areas A, B, C and D.

Year	Age										
	1	2	3	4	5	6	7	8	9	10+	Total
1981	3.1	7.3	2.3	7.8	1.8	5.3	0.5	0.2	0.0	0.0	163.1
1982	3.9	1.5	1.7	1.8	1.9	4.8	2.4	0.2	0.0	0.0	116.4
1983	2919.3	4.8	3.1	2.4	0.9	1.9	2.5	0.7	0.0	0.0	2935.5
1984	3832.6	514.6	18.9	1.5	0.8	0.2	0.1	0.4	0.1	0.0	4369.2
1985	1901.1	1593.8	475.9	14.7	0.5	0.5	0.1	0.1	0.4	0.3	3987.4
1986	665.0	370.3	384.6	110.8	0.6	0.2	0.1	0.1	0.1	0.1	1531.9
1987	163.8	79.9	154.4	290.2	52.9	0.0	0.0	0.0	0.0	0.3	741.6
1988	35.4	15.3	25.3	68.9	116.4	13.8	0.1	0.0	0.0	0.0	275.0
1989	81.2	9.5	14.1	21.6	34.0	32.7	3.4	0.1	0.0	0.0	196.5
1990	644.1	54.6	4.5	3.4	5.0	9.2	11.8	1.8	0.0	0.0	734.5
1991	2006.0	300.3	33.4	5.1	4.2	2.7	1.7	4.2	0.0	0.0	2357.7
1992	1659.4	1375.5	150.5	24.4	2.1	0.6	0.7	1.6	2.3	0.0	3217.0
1993	727.9	599.0	507.7	105.6	10.5	0.6	0.4	0.3	0.4	1.1	1953.4
1994	603.2	228.0	339.5	436.6	49.7	3.4	0.2	0.1	0.2	0.6	1661.5
1995	1463.6	179.3	53.6	171.1	339.5	34.5	2.8	0.0	0.1	0.0	2244.6
1996	309.5	263.6	52.5	48.1	148.6	252.8	11.6	0.9	0.0	0.1	1087.6
1997[1]	1268.0	67.9	86.1	28.0	19.4	46.7	62.2	3.5	0.1	0.0	1581.8
1998[1]	212.9	137.9	22.7	33.2	13.2	3.4	8.0	8.1	0.7	0.1	440.0
1999	1244.9	57.6	59.8	12.2	10.2	2.8	1.0	1.7	1.1	0.0	1391.4
2000	847.2	452.2	27.2	35.4	8.4	4.0	0.8	0.3	0.7	0.2	1376.6
2001	1216.5	460.4	297.0	29.4	25.4	1.7	0.9	0.1	0.1	0.3	2031.7

1) Indices raised to also represent the Russian EEZ.

7.3 Growth

Mean length and weight at age for each main area are shown in table 7.8 and 7.10. For some age groups mean length and weight at age are greatest in the east.

The time series (1983-2001, tables 7.9 and 7.11), with adjusted values for 1997 and 1998, shows that the slightly increasing trend over the years 1997-2000 has stopped, and for several age groups a decrease was observed in 2001.

Table 7.8. HADDOCK. Length (cm) at age in main areas of the Barents Sea winter 2001.

Area	Age (year-class)							
	1 (00)	2 (99)	3 (98)	4 (97)	5 (96)	6 (95)	7 (94)	8 (93)
A	15.5	20.4	29.5	41.2	50.0	50.6	59.5	51.0
B	15.9	21.4	28.8	38.6	50.2	51.1	55.7	62.0
C	15.3	20.7	33.1	42.2	49.4	56.0	56.0	62.0
D	14.4	22.4	32.4	38.2	44.9	50.6	59.9	-
D'	14.9	23.7	32.6	35.1	51.0	53.0	-	-
E	14.8	23.0	27.0	-	-	-	-	-
S	15.0	22.8	30.7	41.6	51.4	56.0	57.5	-
Total	14.6	22.2	32.2	37.8	47.2	51.3	58.6	53.9

Table 7.9. HADDOCK. Length (cm) at age in the Barents Sea from the investigations winter 1983 – 2001.

Year	Age						
	1	2	3	4	5	6	7
1983	16.8	25.2	34.9	44.7	52.5	58.0	62.4
1984	16.6	27.5	32.7	-	56.6	62.4	61.8
1985	15.7	23.9	35.6	41.9	58.5	61.9	63.9
1986	15.1	22.4	31.5	43.0	54.6	-	-
1987	15.4	22.4	29.2	37.3	46.5	-	-
1988	13.5	24.0	28.7	34.7	41.5	47.9	54.6
1989	16.0	23.2	31.1	36.5	41.7	46.4	52.9
1990	15.7	24.7	32.7	43.4	46.1	50.1	52.4
1991	16.8	24.0	35.7	44.4	52.4	54.8	55.6
1992	15.1	23.9	33.9	45.5	53.1	59.2	60.6
1993	14.5	21.4	31.8	42.4	50.6	56.1	59.4
1994	14.7	21.0	29.7	38.5	47.8	54.2	56.9
1995	15.4	20.1	28.7	34.2	42.8	51.2	55.8
1996	15.4	21.6	28.6	37.8	42.0	46.7	55.3
1997[1]	16.1	21.1	27.7	35.4	39.7	47.5	50.1
1998[1]	14.4	22.9	29.2	35.8	41.3	48.4	50.9
1999	14.7	20.8	32.3	39.4	45.5	52.3	54.6
2000	15.8	22.5	30.3	41.6	47.7	50.8	51.1
2001	14.6	22.2	32.2	37.8	47.2	51.3	58.6

[1)] Adjusted lengths *Justerte lengder*

Table 7.10. HADDOCK. Weight (g) at age in main areas of the Barents Sea winter 2001.

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Area	Age (year-class)							
	1 (00)	2 (99)	3 (98)	4 (97)	5 (96)	6 (95)	7 (94)	8 (93)
A	31	79	251	684	1302	1370	2132	1440
B	34	89	228	614	1290	1329	1793	2375
C	29	87	363	785	1223	1763	1940	2925
D	26	110	341	568	948	1400	2179	-
D'	34	138	360	454	1370	1600	-	-
E	29	100	175	-	-	-	-	-
S	31	115	293	690	1469	1879	2089	-
Total	28	106	337	557	1100	1439	2073	1746

Table 7.11. HADDOCK. Weight (g) at age in the Barents Sea from the investigations winter 1983 - 2001.

Year	Age						
	1	2	3	4	5	6	7
1983	52	133	480	1043	1641	2081	2592
1984	36	196	289	964	1810	2506	2240
1985	35	138	432	731	1970	2517	-
1986	47	100	310	734	-	-	-
1987[1]	24	91	273	542	934	-	-
1988	23	139	232	442	743	1193	1569
1989	43	125	309	484	731	1012	1399
1990	34	148	346	854	986	1295	1526
1991	41	138	457	880	1539	1726	1808
1992	32	136	392	949	1467	2060	2274
1993	26	93	317	766	1318	1805	2166
1994	25	86	250	545	1041	1569	1784
1995	30	71	224	386	765	1286	1644
1996	30	93	220	551	741	1016	1782
1997[2]	35	88	200	429	625	1063	1286
1998[2]	25	112	241	470	746	1169	1341
1999	27	85	333	614	947	1494	1616
2000	32	108	269	720	1068	1341	1430
2001	28	106	337	557	1100	1439	2073

1) Estimated weights
2) Adjusted weights

Table 7.12. HADDOCK. Yearly weight increment (g) from the investigations in the Barents Sea winter 1983 - 2001.

Year	Age					
	1-2	2-3	3-4	4-5	5-6	6-7
1983-84	144	156	484	767	865	159
1984-85	102	236	442	1006	707	-
1985-86	65	172	302	-	-	-
1986-87	44	173	232	200	-	-
1987-88	115	141	169	201	259	-
1988-89	102	170	252	289	269	206
1989-90	105	221	545	502	564	514
1990-91	104	309	534	685	740	513
1991-92	95	254	492	587	521	548
1992-93	61	181	374	369	338	106
1993-94	60	157	228	275	251	-
1994-95	46	138	136	220	245	75
1995-96	63	149	327	355	251	496
1996-97	58	107	209	74	322	270
1997-98	77	153	270	316	544	277
1998-99	60	221	373	477	748	447
1999-00	81	184	387	464	394	-64
2000-01	74	229	288	380	371	732

7.4 Conclusion

Survey mortalities based on the acoustic indices (tables 7.13) have varied between years, and for most age groups there are no obvious trend. Mortalities based on the swept area indices show a decreasing trend since 1998 (table 7.13).

Concerning the abundance indices it can be concluded that the recruitment to the stock is improving. The year classes 1998, 1999 and 2000 are above average. The indices for the older age groups are, however, rather low. Mean lengths and weights at age were close to previous year's values.

Table 7.13. Total mortality observed for haddock during the winter survey in the Barents Sea for the period 1993-2001.

Year	Age						
	1-2	2-3	3-4	4-5	5-6	6-7	7-8
	Acoustic investigations						
1993-94	1.59	0.90	-0.11	0.16	0.08	-	-
1994-95	0.68	1.68	0.83	0.49	0.97	1.79	-
1995-96	1.80	1.87	0.15	0.38	0.94	1.66	-
1996-97	2.34	1.50	0.95	0.95	0.57	1.26	1.39
1997-98	1.74	0.18	0.60	0.35	0.88	1.20	0.99
1998-99	1.59	0.76	0.43	0.69	1.10	1.61	1.87
1999-00	0.52	0.36	-0.13	-0.38	0.24	0.69	0.00
2000-01	1.18	0.89	0.33	1.08	2.94	2.40	-
	Bottom trawl investigations						
1993-94	1.16	0.57	0.15	0.75	1.13	1.10	1.39
1994-95	1.21	1.45	0.69	0.25	0.37	0.19	-
1995-96	1.71	1.23	0.11	0.14	0.29	1.09	1.13
1996-97	1.52	1.12	0.63	0.91	1.16	1.40	1.20
1997-98	2.22	1.10	0.95	0.75	1.74	1.76	2.04
1998-99	1.31	0.84	0.62	1.18	1.55	1.22	1.55
1999-00	1.01	0.75	0.52	0.37	0.94	1.25	1.20
2000-01	0.61	0.42	-0.08	0.33	1.60	1.49	2.08

8. DISTRIBUTION AND ABUNDANCE OF REDFISH

8.1 Acoustic estimation

Fig. 8.1 shows the geographic distribution of combined echo abundance of the three redfish species golden redfish (*Sebastes marinus*), deep-sea redfish (*S. mentella*) and smaller redfish (*S. viviparus*). The distribution pattern was similar to recent years.

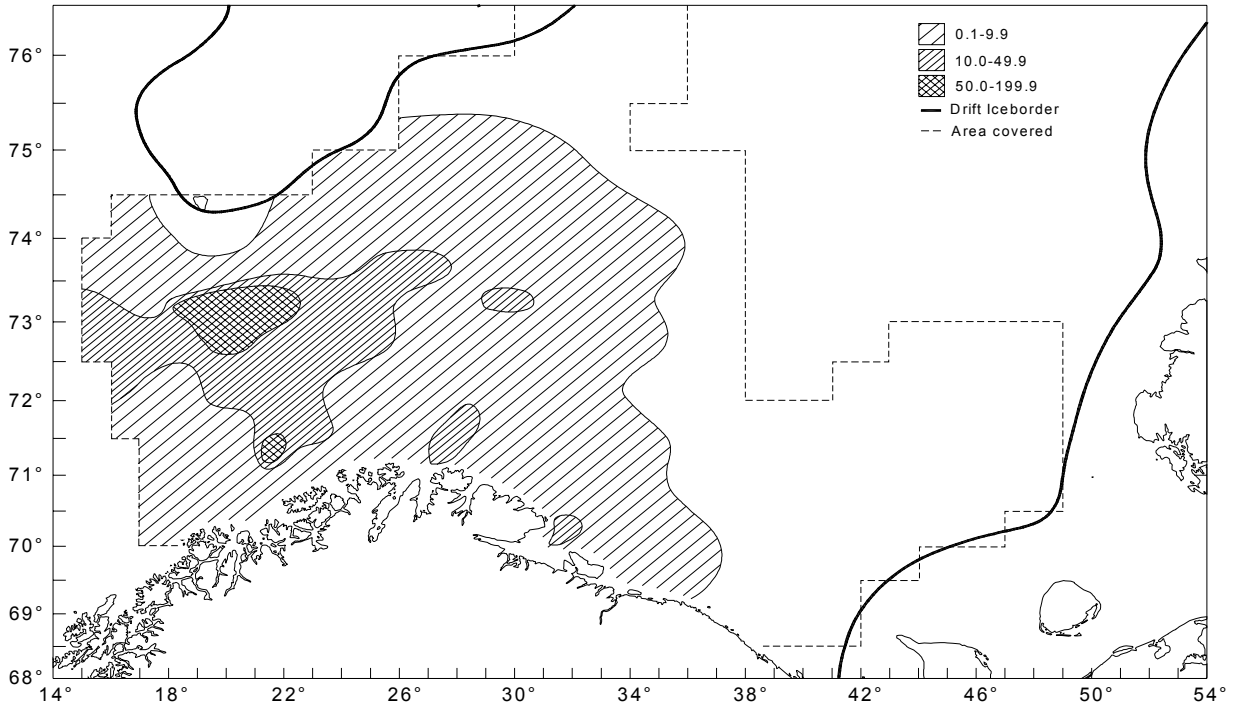

Figure 8.1. REDFISH. Distribution of total echo abundance winter 2001. Unit is area back scattering surface (s_A) per square nautical mile (m^2/n.mile^2).

Table 8.1 shows the acoustic indices for ***S. marinus*** by length-groups and main areas. 84% of the fish were recorded in area ABCD. In the time series (table 8.2), the indices for 1997 and 1998 are adjusted based on data from 1996 and 1999 to take account of the Russian EEZ. In recent years it has been observed few *S. marinus* in the eastern Barents Sea, and in 1996 and 1999 the Norwegian EEZ accounted for about 90% of the total *S. marinus* acoustic value. The adjustments of the indices for 1997 and 1998 are therefore more precise for *S. marinus* than for cod and haddock. The total index is low, only 52% of the 1993-1999 average, and there are no signs of improved recruitment.

Table 8.1. SEBASTES MARINUS. Acoustic abundance indices for main areas of the Barents Sea winter 2001 (numbers in millions).

Area	Length group (cm)								Total
	10-14	15-19	20-24	25-29	30-34	35-39	40-44	>45	
A	+	0.1	0.3	0.7	1.5	2.2	2.1	1.2	8.1
B	0.2	0.1	0.4	0.6	1.2	3.1	2.8	0.8	9.1
C	+	+	+	0.1	0.2	0.2	0.1	0.1	0.8
D	0.2	0.4	1.4	2.0	3.0	0.8	0.4	0.2	8.4
D'	-	-	-	-	-	-	-	-	-
E	+	+	0.1	+	+	+	-	+	0.2
S	0.1	+	0.5	2.2	1.3	0.3	0.1	0.4	4.9
ABCD	0.4	0.6	2.1	3.4	5.9	6.3	5.4	2.3	26.4
Total	0.4	0.6	2.7	5.6	7.3	6.5	5.6	2.8	31.5

Table 8.2. SEBASTES MARINUS. Abundance indices from acoustic surveys in the Barents Sea winter 1986-2001 (numbers in millions). 1986-1992 includes only the area covered in 1986.

Year	Length group (cm)								Total
	10-14	15-19	20-24	25-29	30-34	35-39	40-44	>45	
1986	4	7	7	8	5	1	+	6	38
1987	6	17	13	8	3	3	2	3	55
1988	1	1	5	4	2	1	1	+	15
1989	4	3	7	9	6	4	2	1	36
1990	2	2	6	9	9	6	5	4	43
1991	21	10	15	20	21	14	7	7	115
1992	2	4	9	11	13	11	5	3	58
1993	3	6	9	11	24	18	8	7	86
1994	5	11	5	5	7	5	2	1	41
1995	5	11	15	13	14	16	10	6	90
1996	1	4	9	13	15	22	10	4	77
1997[1]	0	2	9	11	12	12	6	3	56
1998[1]	8	3	9	11	11	9	6	4	61
1999	1	+	2	4	6	4	2	1	20
2000	2	3	4	5	10	6	3	2	35
2001	+	1	3	6	7	7	6	3	32

[1)] Indeksar oppjusterte til også å omfatta russisk sone.

The acoustic index for ***S. mentella*** by main area (table 8.3) show that main area A and S contributed most to the total value. Main area S represented 37% of the total estimate and the value is considerably higher compared to last year. In 1996 and 1999, 100 % and 96%, respectively, of the total index was registered in the Norwegian EEZ and at Svalbard (S). Accordingly, only minor adjustments were therefore necessary to take account of the lack of coverage in the Russian EEZ in 1997 and 1998 (table 8.4). For the length groups between 20 and 34 cm the acoustic index in 2001 is higher than in 2000. The indices for smaller fish are among the lowest observed.

Table 8.3. SEBASTES MENTELLA.[1] Acoustic abundance indices for main areas of the Barents Sea winter 2001 (numbers in millions).

	Length group (cm)								
Area	10-14	15-19	20-24	25-29	30-34	35-39	40-44	>45	Total
A	7.7	4.5	60.7	74.9	65.3	7.1	0.5	0.2	221.7
B	0.1	0.1	3.3	3.5	2.2	0.3	0.1	-	9.6
C	1.4	0.6	2.8	10.5	4.4	1.0	+	-	20.7
D	5.9	1.6	5.4	3.8	1.4	0.3	-	-	18.2
D'	-	-	-	-	-	-	-	-	-
E	1.1	0.2	0.5	0.1	+	-	-	-	1.9
S	4.2	3.5	33.1	53.1	60.5	7.4	0.4	+	162.2
ABCD	15.1	6.8	72.2	92.7	73.3	8.7	0.6	0.2	271.2
Total	20.4	10.5	105.8	145.9	133.8	16.1	1.0	0.2	435.3

1) Includes unidentified Sebastes specimens, mostly less than 15 cm.

Table 8.4. SEBASTES MENTELLA.[1] Abundance indices from acoustic surveys in the Barents Sea winter 1988-2001 (numbers in millions).) 1986-1992 includes only the area covered in 1986.

	Length group (cm)								
(Year)	10-14	15-19	20-24	25-29	30-34	35-39	40-44	>45	Total
1986	83	54	11	22	19	9	2	1	201
1987	17	178	86	34	10	3	1	+	329
1988	13	46	75	15	13	8	1	+	171
1989	35	12	89	36	6	10	2	+	190
1990	77	12	33	73	23	40	3	1	262
1991	549	88	31	75	38	33	3	+	817
1992	386	207	24	23	23	8	1	+	672
1993	1560	599	188	48	47	18	4	+	2464
1994	687	299	111	18	13	4	1	+	1133
1995	80	565	414	108	78	34	3	1	1283
1996	147	183	283	128	44	15	4	+	723
1997[2]	167	41	229	165	44	25	2	0	672
1998[2]	133	79	98	213	68	50	5	1	646
1999	4	35	18	44	19	7	1	+	130
2000	18	31	72	110	87	28	7	1	355
2001	20	11	106	146	134	16	1	+	435

1) Includes unidentified Sebastes specimens, mostly less than 15 cm.
2) Indices raised to also represent the the Russian EEZ.

As in previous years, most of the ***S. viviparus*** are recorded in main areas A and B (table 8.5). The survey covers only the northern margin of this species' geographical distribution. Large variation in the indices from year to year is therefore likely due to variable area coverage in the south western part of the survey area and due to a very patchy distribution.

Table 8.5. SEBASTES VIVIPARUS. Acoustic abundance indices for main areas of the Barents Sea winter 2001(numbers in millions).

	Length group (cm)					
Area	10-14	15-19	20-24	25-29	>30	Total
A	0.7	5.2	7.1	0.6	+	13.7
B	2.2	14.0	15.0	2.6	0.2	34.1
C	+	0.1	+	+	-	0.2
D	0.3	0.2	+	+	-	0.5
D'	-	-	-	-	-	-
E	-	-	-	-	-	-
S	0.1	0.8	0.7	0.1	-	1.7
ABCD	3.2	19.5	22.2	3.3	0.3	48.5
Total	3.3	20.3	22.9	3.4	0.3	50.2

Table 8.6. SEBASTES VIVIPARUS. Abundance indices from acoustic surveys in the Barents Sea winter 1986-2001 (numbers in millions). 1986-1992 includes only the area covered in 1986.

	Length group (cm)					
Year	10-14	15-19	20-24	25-29	> 30	Total
1986	1	1	+	+	+	4
1987	+	+	+	+	+	2
1988	2	3	3	1	+	10
1989	3	5	5	1	0	14
1990	6	11	16	4	+	37
1991	17	29	23	4	+	73
1992	17	10	7	3	1	38
1993	45	15	11	4	0	75
1994	40	14	8	1	+	63
1995	304	64	30	2	+	400
1996	70	30	27	4	+	132
1997	19	21	16	4	-	61
1998	16	42	10	1	+	71
1999	4	8	2	1	+	15
2000	8	45	32	5	1	91
2001	3	20	23	3	+	50

8.2 Swept area estimation

The swept area time series for redfish (tables 8.9, 8.10 and 8.12) are based on catch data from trawls with bobbins gear until 1988 inclusive, and rockhopper gear since 1989. The time series has not been adjusted for this change.

Fig. 8.2 shows the horizontal distribution of ***S. marinus*** during the swept area investigation. The distribution is very similar to 2000. Table 8.7 presents indices with standard error for each main area in addition to the coefficient of variation for the total.

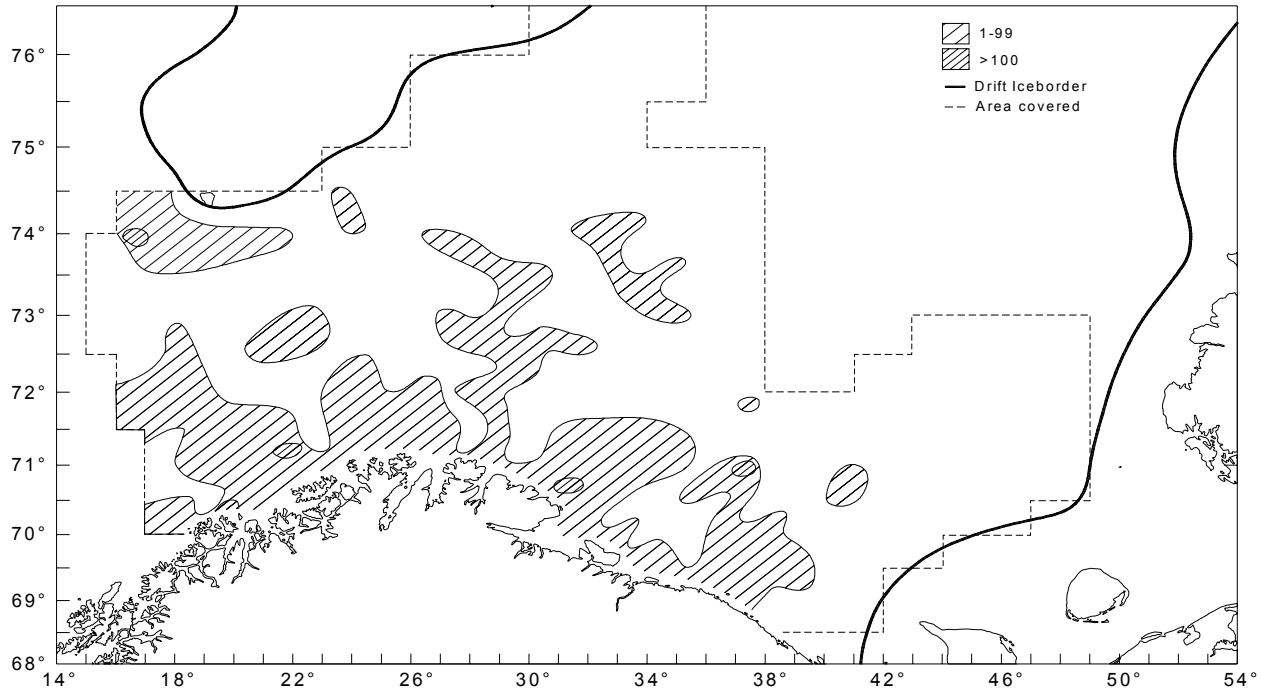

Figure 8.2. SEBASTES MARINUS. Distribution in the trawl catches winter 2001 (number per hour trawling).

The time series for 1986-2001 (table 8.9), with adjusted indices for 1997 and 1998, shows historic low indices for most of the length-groups, and the lowest total index ever observed. There are no signs of improved recruitment.

Table 8.7. SEBASTES MARINUS. Abundance indices (I) at length with standard error of mean (S) from bottom trawl hauls for main areas of the Barents Sea winter 2001 (numbers in millions).

Length	Area																	
	A		B		C		D		D'		E		S		Total			
cm	I	S	I	S	I	S	I	S	I	S	I	S	I	S	I	S	CV (%)	
5-9			+	+	+	+	+	+							0.1	+	60.6	
10-14			0.1	0.1	+	+	0.2	0.1					+	+	0.4	0.1	33.0	
15-19	0.1	0.1	0.1	+	+	+	0.2	0.1	0.1	0.1			+	+	0.4	0.1	25.9	
20-24	0.2	0.1	0.5	0.3	+	+	1.3	0.5	+	+			0.4	0.3	2.4	0.7	27.2	
25-29	0.2	0.1	0.8	0.4	0.1	+	2.6	1.2			0.1	0.1	2.0	1.5	5.8	1.9	33.2	
30-34	0.4	0.1	1.0	0.4	0.1	+	2.6	1.2					1.4	1.2	5.5	1.7	31.5	
35-39	0.4	0.1	2.6	1.8	0.2	0.1	1.1	0.5					0.3	0.1	4.5	1.9	41.7	
40-44	0.3	0.1	2.3	1.7	0.2	0.1	0.4	0.2					0.1	+	3.2	1.7	53.7	
> 45	0.7	0.1	0.6	0.4	0.1	+	0.2	0.1					0.1	+	1.6	0.4	22.5	
Sum	2.2	0.3	7.9	2.6	0.6	0.1	8.5	1.8	0.1	0.1	0.1	0.1	4.3	1.9	23.7	3.7	15.6	

Table 8.8. SEBASTES MENTELLA.[1] Abundance indices (I) at length with standard error of mean (S) from bottom trawl hauls for main areas of the Barents Sea winter 2000 (numbers in millions).

Length	Area																	
	A		B		C		D		D'		E		S		Total			
cm	I	S	I	S	I	S	I	S	I	S	I	S	I	S	I	S	CV (%)	
5-9	3.5	0.7	0.2	0.2	2.4	0.9	3.1	1.0			0.1	0.1			9.3	1.5	16.0	
10-14	4.3	0.7	0.1	0.1	0.9	0.3	7.1	2.2	+	+	3.5	1.2	6.6	2.1	22.5	3.4	15.0	
15-19	2.0	0.5	+	+	0.4	0.2	1.8	0.8			0.4	0.2	2.3	0.5	7.0	1.1	15.7	
20-24	29.0	5.4	1.0	0.9	2.0	0.9	5.6	2.3			0.5	0.3	16.9	4.6	54.9	7.6	13.9	
25-29	45.2	7.9	0.8	0.8	7.6	3.5	3.7	1.2			0.1	0.1	20.0	6.0	77.4	10.6	13.8	
30-34	50.4	12.5	0.7	0.6	3.1	1.3	1.6	0.6					17.4	5.6	73.2	13.8	18.8	
35-39	5.1	1.2	0.3	0.1	0.7	0.3	0.3	0.2					3.0	0.8	9.4	1.5	15.8	
40-44	0.4	0.2	+	+	+	+	+	+					0.1	0.1	0.6	0.2	27.4	
> 45	0.1	0.1													0.1	0.1	71.5	
Sum	139.9	15.8	3.1	1.4	17.3	3.9	23.2	3.7	+	+	4.5	1.2	66.2	9.7	254.2	19.4	7.6	

[1] Includes unidentified Sebastes specimens, mostly less than 15 cm.

Table 8.9. SEBASTES MARINUS. Abundance indices from bottom trawl surveys in the Barents Sea winter 1986-2001 (numbers in millions). 1986-1992 includes only main areas A, B, C and D.

Year	Length group (cm)									Total
	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	> 45	
1986	3.0	11.7	26.4	34.3	17.7	21.0	12.8	4.4	2.6	134
1987	7.7	12.7	32.8	7.7	6.4	3.4	3.8	3.8	4.2	83
1988	1.0	5.6	5.5	14.2	12.6	7.3	5.2	4.1	3.7	59
1989	48.7	4.9	4.3	11.8	15.9	12.2	6.6	4.8	3.0	114
1990	9.2	5.3	6.5	9.4	15.5	14.0	8.0	4.0	3.4	75
1991	4.2	13.6	8.4	19.4	18.0	16.1	14.8	6.0	4.0	105
1992	1.8	3.9	7.7	20.6	19.7	13.7	10.5	6.6	5.8	92
1993	0.1	1.2	3.5	6.9	10.3	14.5	12.5	8.6	6.3	64
1994	0.7	6.5	9.3	11.7	11.5	19.4	9.1	4.4	2.8	75
1995	0.6	5.0	13.1	11.5	9.1	15.9	17.2	10.9	4.7	88
1996	+	0.7	3.5	6.4	9.4	11.7	16.6	7.9	3.9	60
1997[1]	-	0.5	1.5	3.2	6.6	21.4	28.0	8.4	3.3	73
1998[1]	0.2	6.0	2.5	10.5	49.5	25.2	13.1	6.9	2.3	116
1999	0.2	0.9	2.1	4.0	4.6	6.4	6.0	5.3	3.3	33
2000	0.5	1.1	1.5	4.2	4.7	5.0	3.5	1.8	1.2	24
2001	0.1	0.4	0.4	2.4	5.8	5.5	4.5	3.2	1.6	24

1) Indices raised to also represent the Russian EEZ.

The mapping of the distribution of ***S. mentella*** is not complete in the north western part of the surveyed area due to this species' extensive distribution further north in the Svalbard area, west and north of Spitsbergen. The 2001 coverage was nevertheless more complete than before (fig. 8.3).

Table 8.8 presents the swept area indices with corresponding standard errors for each main area in addition to the coefficient of variation of the total.

The time series for 1986-2001, with adjusted indices for 1997 and 1998, is presented in table 8.10. Similar to the acoustic abundance indices, the swept area indices for *S. mentella* in 2001 show for most size groups a decrease compared to last year. The indices for small fish are the lowest observed. The index for *S. mentella* smaller than 15 cm is only about 10% (!) of the 1993-1999 average. The future of the *S. mentella* stock is relying on the survival of the last good year classes born in 1989-1990 before the recruitment collapse in 1991. These year classes, at present about 30 cm, compose the bulk of the stock, and should be protected as much as possible if we want to improve the recruitment to maintain a fishery on this resource in the future.

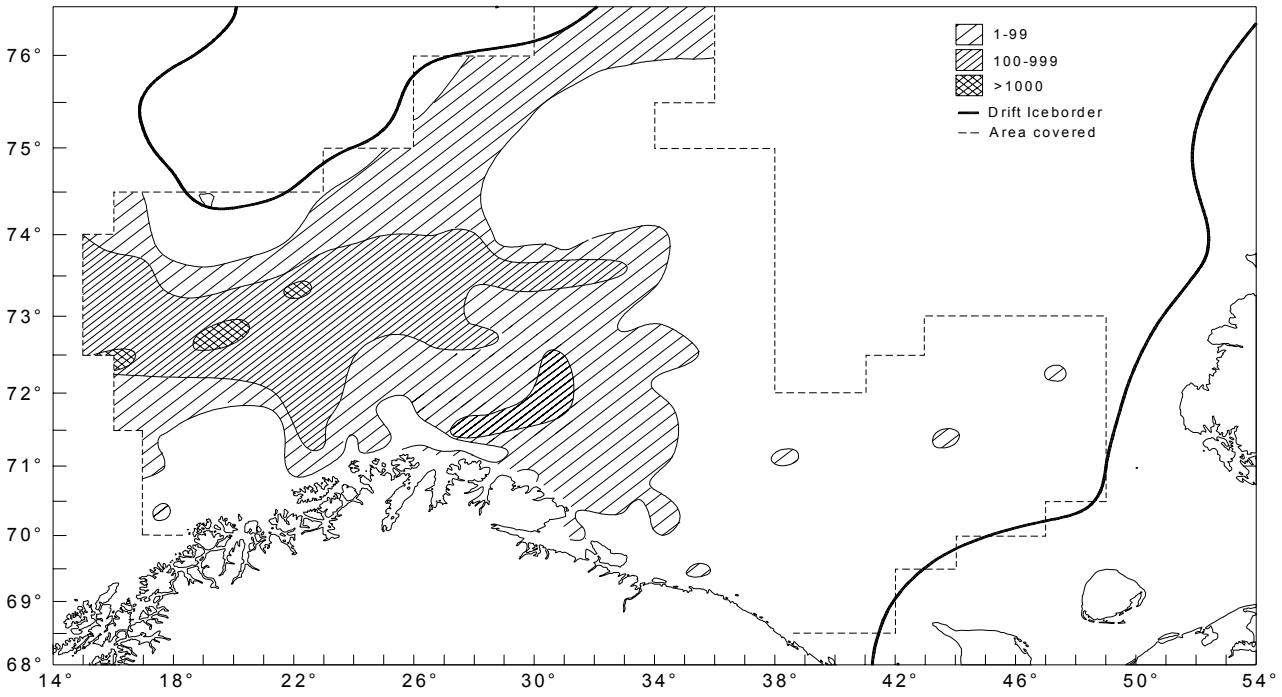

Figure 8.3. SEBASTES MENTELLA. Distribution in the trawl catches winter 2001 (number per hour trawling).

Table 8.10. SEBASTES MENTELLA.[1] Abundance indices from bottom trawl surveys in the Barents Sea winter 1986-2001 (numbers in millions). 1986-1992 includes only main areas A, B, C and D.

	Length group (cm)									
Year	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	> 45	Total
1986	81.3	151.9	205.4	87.7	169.2	129.8	87.5	23.6	13.8	951
1987	71.8	25.1	227.4	56.1	34.6	11.4	5.3	1.1	0.1	433
1988	587.0	25.2	132.6	182.1	39.6	50.1	47.9	3.6	0.1	1070
1989	622.9	55.0	28.4	177.1	58.0	9.4	8.0	1.9	0.3	962
1990	323.6	304.5	36.4	55.9	80.2	12.9	12.5	1.5	0.2	830
1991	395.2	448.8	86.2	38.9	95.6	34.8	24.3	2.5	0.2	1123
1992	139.0	366.5	227.1	34.6	55.2	34.4	7.5	1.8	0.5	867
1993	30.8	592.7	320.2	116.3	24.2	25.0	6.3	1.0	+	1117
1994	6.9	258.6	289.4	284.3	51.4	69.8	19.9	1.4	0.1	979
1995	263.7	71.4	637.8	505.8	90.8	68.8	31.3	3.9	0.5	1674
1996	213.1	100.2	191.2	337.6	134.3	41.9	16.6	1.4	0.3	1037
1997[2]	63.2	120.9	24.8	278.2	271.8	70.9	39.8	5.2	0.1	875
1998[2]	1.3	88.2	62.5	101.0	203.2	40.4	12.9	1.1	0.2	511
1999	2.2	6.8	68.2	36.8	167.4	71.3	21.0	3.1	0.1	374
2000	9.0	12.7	39.4	76.8	141.9	97.1	26.6	6.9	1.5	412
2001	9.3	22.5	7.0	54.9	77.4	73.2	9.4	0.6	0.1	254

1) Includes unidentified Sebastes specimens, mostly less than 15 cm.
2) Indices raised to also represent the Russian EEZ.

S. viviparus was mainly observed in main area B (table 8.11). The time series 1986-2001 of the swept area indices are shown in (table 8.12).

Table 8.11. SEBASTES VIVIPARUS. Abundance indices (I) at length with standard error of mean (S) from bottom trawl hauls for main areas of the Barents Sea winter 2001 (numbers in millions).

Length	Area												
	A		B		C		D		S		Total		
cm	I	S	I	S	I	S	I	S	I	S	I	S	CV (%)
5-9	-	-	0.2	0.1	-	-	0.1	0.1	-	-	0.3	0.1	40.2
10-14	0.1	0.0	1.9	0.6	-	-	0.2	0.1	0.1	0.1	2.2	0.6	26.8
15-19	1.6	0.7	26.7	9.9	0.0	0.0	0.2	0.1	1.0	1.0	29.5	10.0	33.7
20-24	4.7	2.5	28.2	10.8	0.0	0.0	-	-	0.8	0.8	33.7	11.1	32.8
25-29	0.5	0.3	3.0	1.4	0.0	0.0	0.0	0.0	0.2	0.2	3.7	1.4	38.7
30-34	0.0	0.0	0.1	0.1	-	-	-	-	-	-	0.1	0.11	77.7
Sum	7.0	2.6	60.1	14.7	0.1	0.0	0.4	0.0	2.0	1.3	69.6	15.0	21.6

Table 8.12. SEBASTES VIVIPARUS. Abundance indices from bottom trawl surveys in the Barents Sea winter 1996-2001 (numbers in millions). 1986-1992 includes only the area covered in 1986.

	Length group (cm)						
Area	5-9	10-14	15-19	20-24	25-29	> 30	Total
1986	1.0	2.3	4.8	6.4	1.3	+	16
1987	+	0.5	4.4	8.0	1.9	0.2	15
1988	6.9	6.2	6.4	10.0	3.6	0.3	33
1989	3.7	7.8	6.3	4.3	0.9	0.0	23
1990	0.3	12.7	11.7	9.9	3.3	0.2	38
1991	3.7	13.6	16.1	16.8	4.2	0.4	55
1992	15.1	32.1	27.4	16.9	5.1	0.3	97
1993	18.6	23.7	7.7	3.5	1.0	+	55
1994	48.0	64.0	15.0	12.3	1.2	0.2	141
1995	7.6	53.2	21.9	7.9	2.4	0.3	93
1996	0.5	45.0	42.5	35.4	5.5	0.1	129
1997	0.9	23.8	28.5	18.5	4.3	-	76
1998	0.7	9.3	41.7	20.6	2.9	0.1	75
1999	1.6	10.0	11.5	2.9	0.7	+	27
2000	0.9	4.8	36.5	21.7	2.1	0.1	66
2001	0.3	2.2	29.5	33.7	3.7	0.1	70

9. DISTRIBUTION AND ABUNDANCE OF OTHER SPECIES

9.1 Greenland halibut

Fig. 9.1 shows the horizontal distribution of Greenland halibut in the swept area investigations. Important parts of this species' distribution, e.g., northern part of Svalbard and the continental slope, are not covered by the survey. The observed distribution pattern was similar to those observed in previous years' surveys, i.e., mainly in the Bear Island channel towards the Hopen Deep.

Table 9.1 presents the swept area indices with corresponding standard errors for each main area in addition to the coefficient of variation of the total. Most of the Greenland halibut was found in the northern main areas (D, E and S). For most length groups the coefficient of variation is higher than for cod and haddock. For each of the length groups between 45 and 64 cm the CVs are below 23%.

The time series for 1990-2001, with indices adjusted for 1997 and 1998, is presented in table 9.2. Compared to last year the indices for fish less than 40 cm are lower, while those in the size range 40 to 59 cm are higher.

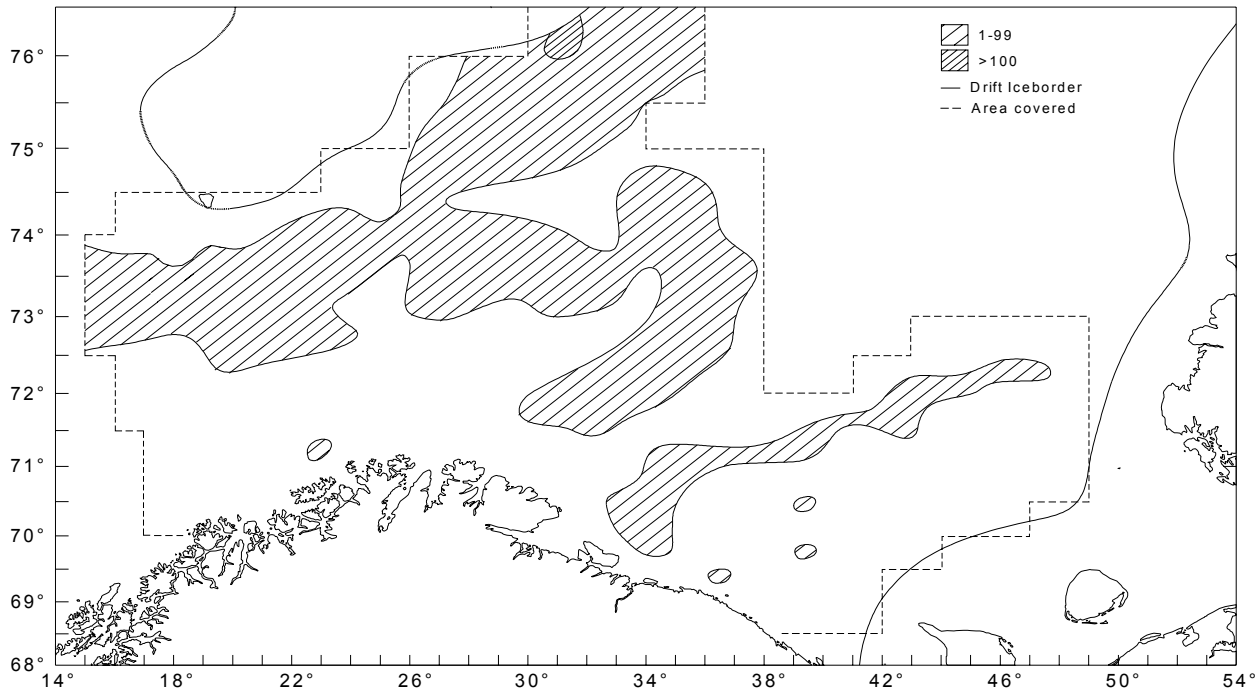

Figure 9.1. GREENLAND HALIBUT. Distribution in the trawl catches winter 2001 (number per hour trawling).

Table 9.1. GREENLAND HALIBUT. Abundance indices (I) at length with standard error of mean (S) from bottom trawl hauls for main areas of the Barents Sea winter 2001 (numbers in thousands).

Length	Area																	
	A		B		C		D		D'		E		S		ABCD	Total		
cm	I	S	I	S	I	S	I	S	I	S	I	S	I	S	I	I	S	CV(%)
5-9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10-14	19	19	-	-	-	-	-	-	-	-	49	49	-	-	68	68	52	77
15-19	-	-	-	-	-	-	-	-	-	-	49	49	-	-	49	49	49	100
20-24	-	-	-	-	-	-	17	17	-	-	112	112	-	-	17	129	114	88
25-29	19	19	-	-	-	-	17	17	37	37	105	71	-	-	36	178	84	47
30-34	-	-	-	-	-	-	230	84	184	184	266	149	-	-	230	680	251	37
35-39	42	30	-	-	-	-	437	237	-	-	970	721	55	40	479	1504	761	51
40-44	80	46	-	-	-	-	394	106	37	37	2759	1621	438	140	474	3708	1632	44
45-49	124	62	-	-	-	-	113	46	-	-	2257	1480	764	250	237	3258	1503	46
50-54	210	91	-	-	-	-	196	62	-	-	781	730	1076	409	406	2263	844	37
55-59	319	162	11	11	-	-	445	112	90	90	352	94	773	255	775	1990	348	18
60-64	204	88	11	11	-	-	390	111	-	-	195	150	280	91	605	1081	226	21
65-69	64	36	-	-	-	-	122	45	-	-	205	160	131	60	186	522	180	35
70-74	41	29	-	-	-	-	40	28	-	-	49	49	74	45	81	204	77	38
75-79	-	-	-	-	10	10	-	-	-	-	-	-	38	27	10	48	29	60
> 80	-	-	-	-	-	-	-	-	-	-	-	-	40	28	-	40	28	70
Sum	1123	278	22	16	10	10	2399	329	348	212	8149	2445	3668	576	3554	15720	2552	16

Table 9.2. GREENLAND HALIBUT. Abundance indices from the bottom trawl surveys in the Barents Sea winter 1990-2001 (numbers in thousands). 1990-1992 includes only main areas A, B, C and D. Indices for 1997 and 1998 are raised to also represent the Russian EEZ.

	Length group (cm)															
Year	<14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	> 80	Total
1990	21	199	777	785	1205	1657	1829	2043	1349	479	159	160	40	40	0	10800
1991	0	42	262	618	655	868	954	1320	1875	1577	847	165	34	34	0	9270
1992	14	35	64	149	509	843	1096	1072	1029	827	633	108	31	31	26	6500
1993	0	0	17	67	265	959	2310	4004	3374	1911	1247	482	139	139	34	14840
1994	0	0	16	99	142	1191	2625	3866	2885	1796	753	440	25	25	0	13838
1995	42	0	0	0	83	149	3228	9240	7438	2811	2336	909	468	468	0	26761
1996	3149	0	0	0	61	124	1163	3969	4425	1824	1041	593	346	73	12	16781
1997	0	65	0	0	173	227	858	4344	5500	2725	1545	632	282	66	22	16439
1998	80	217	1006	444	532	403	1064	3888	6331	2977	1725	633	337	76	43	19765
1999	41	82	261	427	576	264	757	1706	3069	1640	1077	483	109	74	28	10594
2000	122	184	322	859	1753	3841	2190	1599	2143	1715	1163	564	242	75	0	16769
2001	68	49	129	178	680	1504	3708	3258	2263	1990	1081	522	204	48	40	15720

9.2 Blue whiting

Blue whiting had a wider distribution than usual, and the echo recordings also indicated unusual high abundance in the Barents sea. Figure 9.2 shows the geographical distribution of the bottom trawl catch rates of blue whiting. Since the fish was mainly found pelagic the bottom trawl do not reflect the real density distribution, but gives some indication of the distribution limits. Acoustic observations would better reflect the relative density distribution. The catches of blue whiting was dominated by small fish (15-20 cm), mainly the 2000 year class.

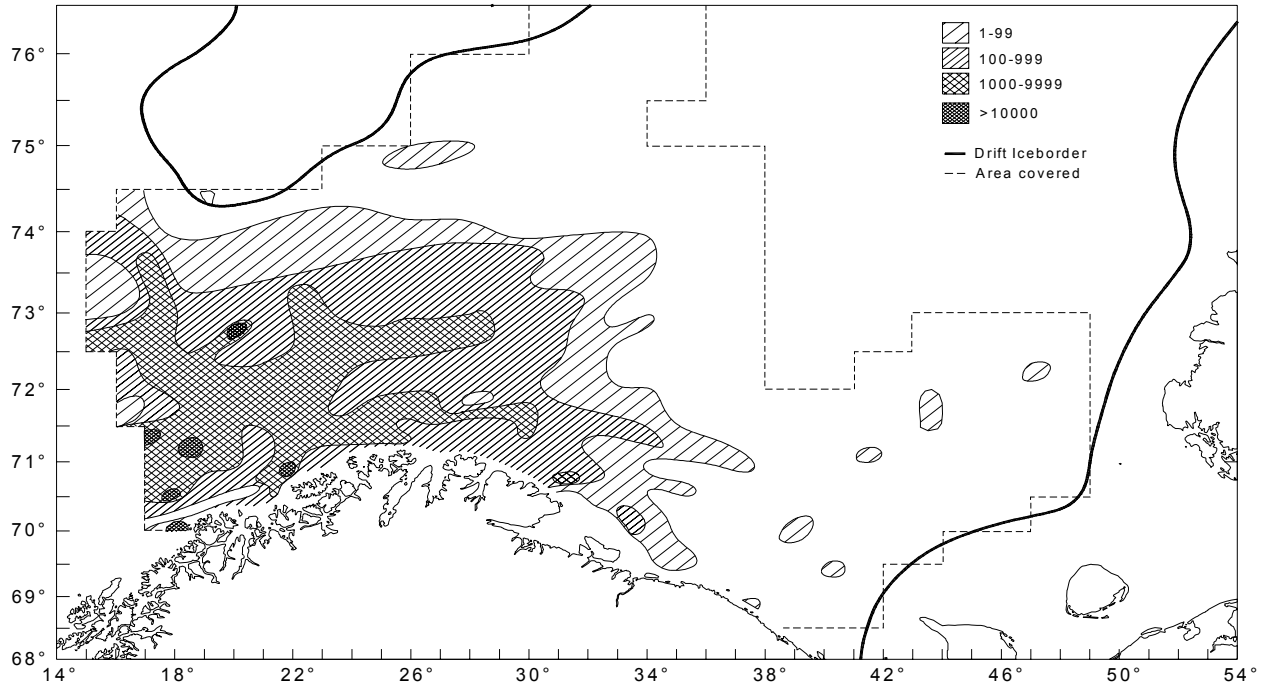

Figure 9.2. BLUE WHITING. Distribution in the trawl catches winter 2001 (number per hour trawling).

10. COMPARISONS BETWEEN RESEARCH VESSELS

The vessels “Persey4” and “Johan Hjort” made 6 parallel bottom trawl hauls for comparison in main area D. Catches by length groups for each haul and each vessel are shown for cod in table 10.1 and for haddock in table 10.2. At the comparative haul number 3 “Johan Hjort” had considerably lower catch than “Persey4”. Presumably this low catch by “Johan Hjort” was caused by large amounts of clay in the trawl. Figure 10.1 is a scatter plot of the pairs of observations, and comparative haul number 3 is shown by a separate symbol.

Table 10.1 Cod. Catch in numbers by length group in parallel tows for R/V ”Johan Hjort” and R/V “Persey4”.

		Length group									
Station	Vessel	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	> 50
1	J.Hjort	45	174	6	14	44	111	101	35	9	10
1	Persey4	9	109	4	10	26	106	169	68	20	2
2	J.Hjort	33	202	3	6	21	34	28	15	3	0
2	Persey4	0	199	8	8	23	28	38	11	2	1
*3	J.Hjort	2	303	1	3	6	22	15	8	2	3
3	Persey4	8	402	15	13	26	45	53	18	9	2
4	J.Hjort	3	18	2	8	15	57	73	39	24	4
4	Persey4	0	50	1	3	6	28	49	44	15	7
5	J.Hjort	5	40	6	5	19	100	156	89	23	16
5	Persey4	0	24	3	3	22	131	195	132	59	37
6	J.Hjort	2	18	0	0	6	49	112	129	53	25
6	Persey4	1	13	0	1	11	40	139	130	70	30

Table 10.2 Haddock. Catch in numbers by length group in parallel tows for R/V ”Johan Hjort” and R/V “Persey4”.

		Length group						
Station	Vessel	10-14	15-19	20-24	25-29	30-34	35-39	>40
1	J.Hjort	239	150	133	76	16	16	0
1	Persey4	124	150	177	115	42	46	6
2	J.Hjort	236	74	113	102	14	13	3
2	Persey4	109	146	83	67	25	14	1
*3	J.Hjort	129	58	16	8	3	5	0
3	Persey4	95	286	140	106	46	28	4
4	J.Hjort	43	32	36	104	43	74	13
4	Persey4	31	33	32	82	47	61	16
5	J.Hjort	23	27	49	76	47	123	36
5	Persey4	10	14	25	70	52	84	37
6	J.Hjort	27	7	12	15	9	17	6
6	Persey4	15	16	21	45	23	22	9

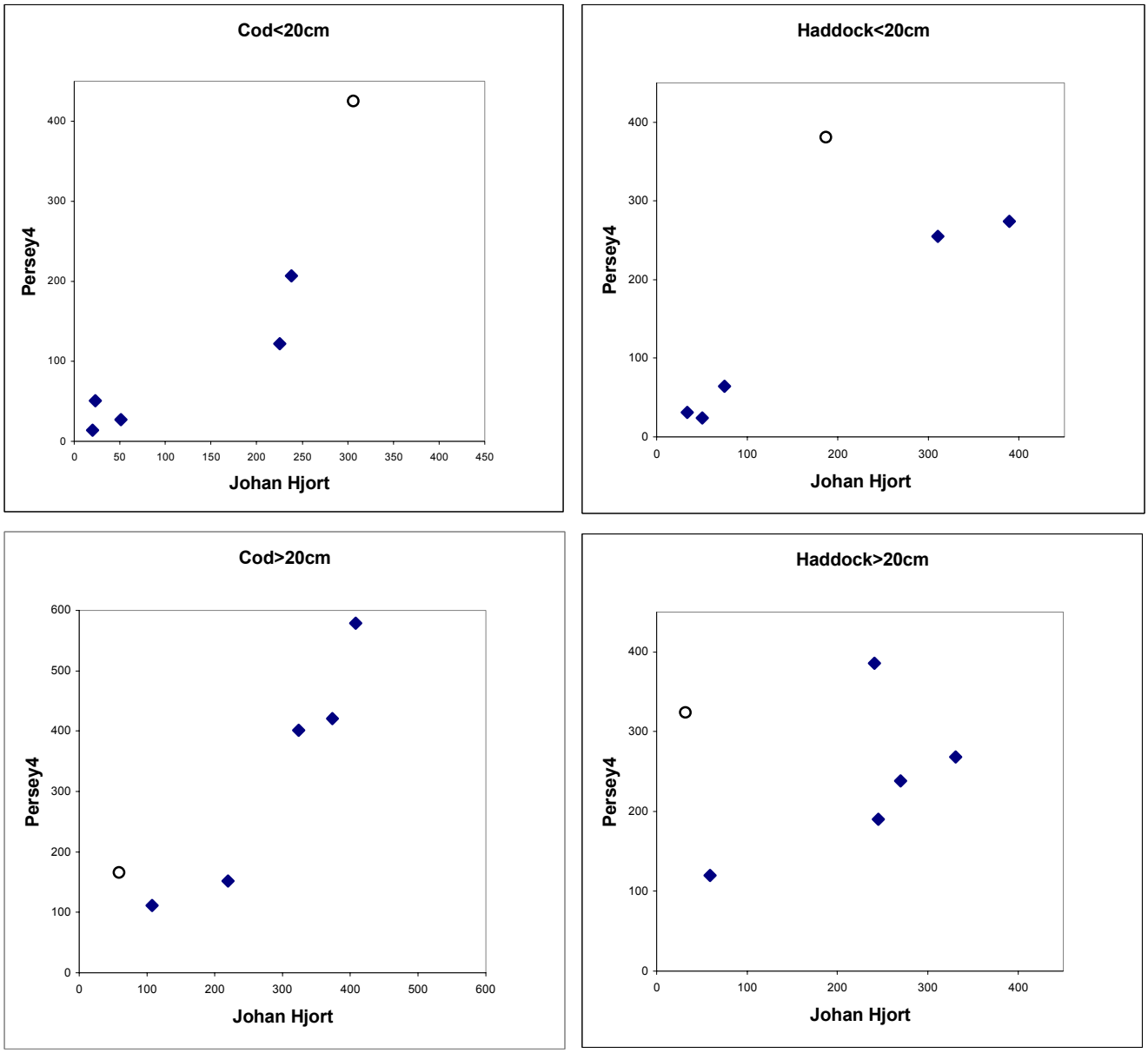

Figure 10.1. Pairs of observed catch in numbers of cod and haddock in comparative hauls for R/V "Johan Hjort" and R/V "Persey4". The upper panels represent fish less than 20 cm, the lower panels represent fish greater or equal to 20 cm. Pair number 3 is indicated by an open circle.

Figure 10.2 shows the sum of the five hauls (excluding number 3) for cod, and figure 10.3 shows the sum for haddock. For cod above 35 cm "Persey4" gave the highest summed catch, while for cod below 15 cm "Johan Hjort" gave the highest. For haddock the ratio between the vessels varied between neighbouring length groups. Given the low number of hauls, these observations do not give evidence for any significant differences between the vessels.

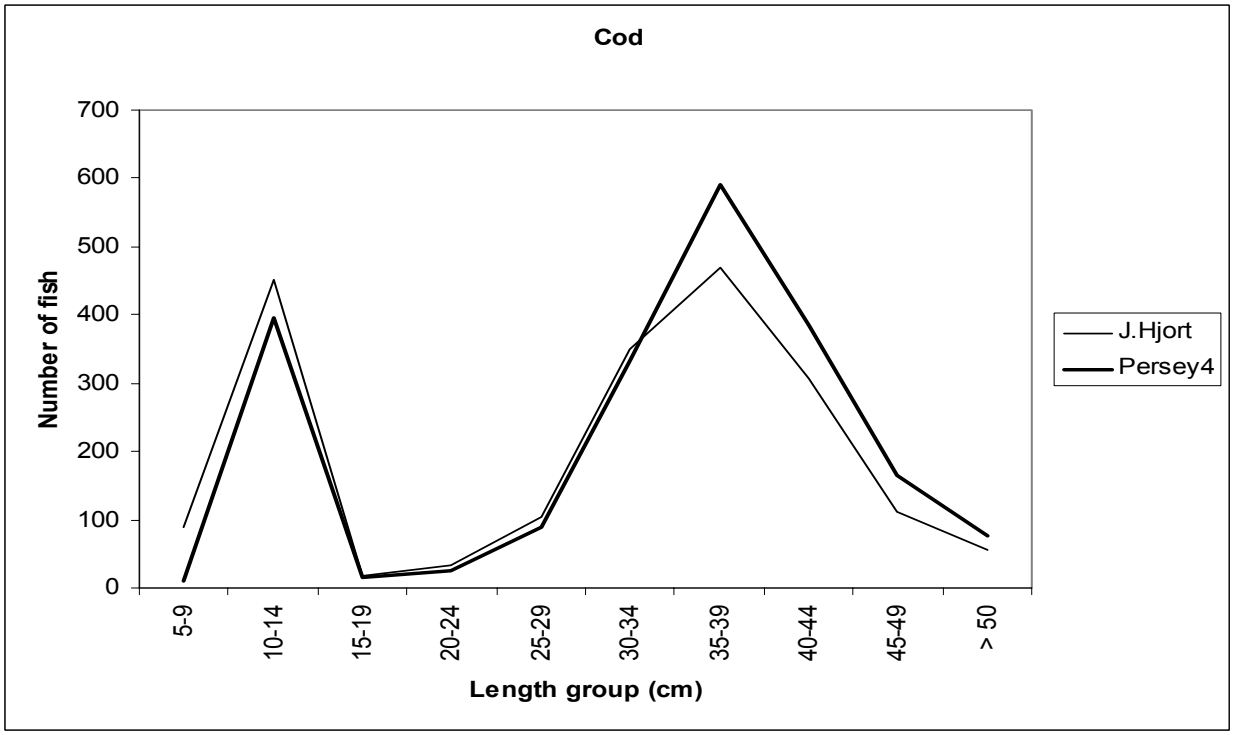

Figure 10.2. Cod. Summed catch in numbers over 5 parallel hauls by R/V ”Johan Hjort” and R/V ”Persey4”.

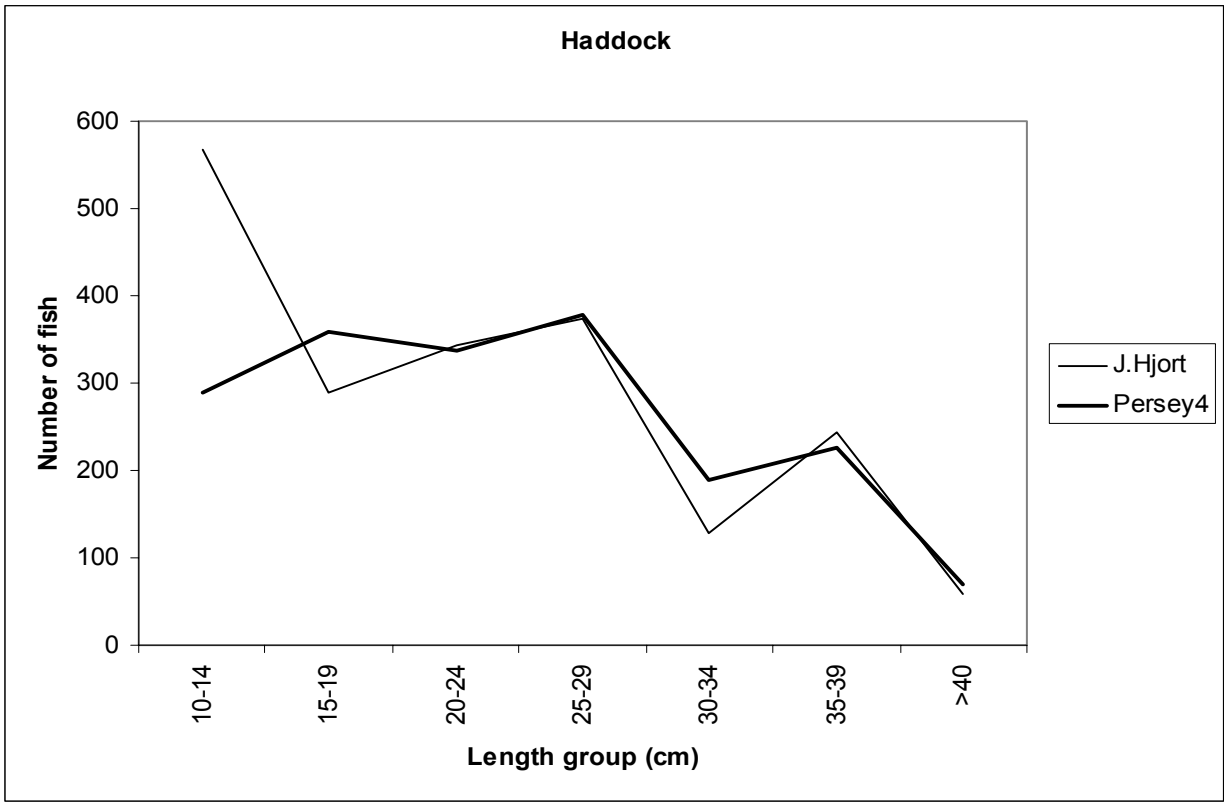

Figure 10.3. Haddock. Summed catch in numbers over 5 parallel hauls by R/V ”Johan Hjort” and R/V ”Persey4”.

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12. LIST OF PARTICIPANTS (Norwegian vesels)

VESSEL:	**F/F "G. O. Sars"**	**F/F "Johan Hjort"**
DEPARTURE:	Tromsø 27.01.2001	Vadsø 29.01.2001
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ARRIVAL:	Hammerfest 07.03.2001	Tromsø 01.03.2001

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IMR/PINRO Joint Report Series

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No. 2

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No. 3

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No. 8

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2002

No.1

Anon. 2002. Report of joint Russian/Norwegian aerial surveys in the Barents sea in September 2001. IMR/PINRO Joint Report Series,No. 1/2002. ISSN 1502-8828. 11pp.

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REPORT