IMR/PINRO

JOINT REPORT SERIES

4

2016

JOINT REPORT

Fish investigations in the Barents Sea winter 2016

Sigbjørn Mehl, Asgeir Aglen, Bjarte Bogstad,
Gjert Dingsør, Knut Korsbrekke, Erik Olsen, Arved Staby,
Thomas de Lange Wenneck and Rupert Wienerroither
Institute of Marine Research
P.O. Box 1870 Nordnes, N-5817 Bergen, Norway

Alexey V. Amelkin and Alexey A. Russkikh
PINRO
6 Knipovich Street, 183038 Murmansk. Russia

Institute of Marine Research - IMR

Polar Research Institute of Marine Fisheries and Oceanography - PINRO

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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 international landings statistics. The results from the demersal fish winter surveys in the Barents Sea are an important source of information for the annual stock assessment.

The development of the survey started in the early 1970s and focused on acoustic measurements of cod and haddock. Since 1981 it has been designed to produce both acoustic and swept area estimates of fish abundance. Some development has taken place since then, both in area coverage and in methodology. The development is described in detail by Jakobsen *et al*. (1997), Johannesen *et al*. (2009) and Appendix 2. At present the survey provides the main data input for a number of projects at the Institute of Marine Research, Bergen:
- monitoring abundance of the Barents Sea demersal fish 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 main results from the surveys in January-March 2016, but stomach data are only given until 2015. The surveys were performed with the Norwegian research vessels “Johan Hjort” and “Helmer Hanssen” and the Russian research vessel “Fridtjof Nansen”. Annual survey reports since 1981 are listed in Appendix 1, and names of scientific participants are given in Appendix 3.

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 the acoustic survey. 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 three vessels have participated from about 1 February to 15 March.

The purpose of the investigations is presently:

- Obtain acoustic abundance indices by length and age for cod and haddock
- Obtain swept area abundance indices by length (and age) for cod, haddock, redfish, Greenland halibut and blue whiting
- Map the geographical distribution of those fish stocks
- Estimate length, weight and maturity at age for cod and haddock
- Collect and analyse stomach samples from cod, for estimating predation by cod
- Map the distribution of maturing/prespawning capelin and of polar cod

Data and results from the survey are used both in the ICES stock assessments and by several research projects at IMR and PINRO.

From 1981 to 1992 the survey area was fixed (strata 1-12, main areas ABCD in Fig. 2.1). Due to warmer climate and increasing stock size in the early 1990s, the cod distribution area increased. Consequently, in 1993 the survey area was extended to the north and east (strata 13-23, main areas D'ES in Fig. 2.1) in order to obtain a more complete coverage of the younger age groups of cod, and since then the survey has aimed at covering the whole cod distribution area in open water. For the same reason the survey area was extended further northwards in the western part in 2014 (strata 24-26 in Fig. 2.1). In many years since 1997 Norwegian research vessels have had limited access to the Russian EEZ, and in 1997, 1998, 2007 and 2016 the vessels were not allowed to work in the Russian EEZ. In 1999 the coverage was partly limited by a rather unusually wide ice-extension. Since 2000, except in 2006 and 2007, Russian research vessels have participated in the survey and the coverage has been better, but for various reasons not complete in most years. In 2008-2015 Norwegian vessels had access to major parts of the Russian EEZ. The coverage was more complete in these years, especially in 2008, 2011 and 2014. In 2009, 2010, 2012, 2013 and 2015 the coverage in eastern areas was more limited due to strict rules regarding handling of the catch, bad weather or vessel problems. Table 3.6 summarizes degree of coverage and main reasons for incomplete coverage in the Barents Sea winter 1981-2016.

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 1990s Simrad EK500 echo sounder and Bergen Echo Integrator (BEI, Knudsen 1990) have been used. The Simrad ER60 echo sounder and the Large Scale Survey System (LSSS, Korneliussen *et al*. 2006) has replaced the EK500 and BEI; on R/V "Johan Hjort" since the 2005 survey and on R/V "Helmer Hanssen" since the 2008 survey. On the Russian vessels EK 500 was used from 2000 to 2004 and ER60 since 2005.

In the mid-1990s the echo sounder transducers were moved from the hull to a retractable centreboard, on R/V "Johan Hjort" since the 1994 survey and on R/V "Helmer Hanssen" since the 2008 survey. This latter change has largely reduced the signal loss due to air bubbles in the close to surface layer. None of the Russian vessels have retractable centreboards.

On the Norwegian vessels acoustic backscattering values (s_A) are stored at high resolution in LSSS. After scrutinizing and allocating the values to species or species groups, the values are stored with 10 m vertical resolution and 1 nautical mile (NM) 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
- inspection of target frequency responses

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 10 m above bottom) and the pelagic zone (more than 10 m above bottom). Each of those acoustic densities by rectangle are then converted to fish densities by the equation:

$$\bar{\rho}_A = \frac{\bar{s}_A}{\bar{\sigma}_A} \qquad (1)$$

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

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

$$\mathrm{TS} = 10 \cdot \log\left(\frac{\sigma}{4\pi}\right) = 20 \cdot \log(L) - 68 \qquad (2)$$

Indices for the period 1981-1992 have been recalculated (Aglen and Nakken 1997) 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 the indices for cod and haddock were revised and some errors in the time series were discovered and corrected (Bogstad *et al.* 1999).

Combining equations 1 and 2 gives

$$\overline{\rho}_A = 5.021 \cdot 10^5 \cdot \overline{s}_A \,/\, \overline{L^2} \qquad (3)$$

$\overline{L^2}$ 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. 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, while both pelagic and bottom trawl catches are applied to the pelagic zone. Length frequency distributions by 1 cm length groups form the basis for calculating mean squared length. The bottom trawl catches are normalised to 1 NM towing distance and adjusted for length dependant fishing efficiency (Aglen and Nakken 1997, see below). Length distributions from pelagic catches are applied unmodified. Since 2001 the post processing program BEAM has been used for working out the acoustic estimates. This program provides an automatic allocation of trawl samples to strata (rectangles). The automatic allocation is modified by the user when considered necessary.

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:

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

For each species the total density ($\overline{\rho}_A$) by rectangle and depth zone is now calculated by equation (3). This total density is then split on length groups according to the estimated length distribution. Next, these densities are converted to abundance by multiplying with the area of the rectangle. The abundance by rectangle is then summed for defined main areas (Figure 2.1). Estimates by length are converted to estimates by age using an age length key for each main area. The total biomass is estimated by multiplying the numbers at age by weight at age from the swept area estimates (see section 2.3).

In 2016 the Sea2Data software StoX was applied to estimate acoustic abundance indices for cod and haddock in the new extended area (strata 24-26). The main difference between BEAM and StoX acoustic abundance estimation is that in BEAM the survey area is divided into rectangles, and for each rectangle an average acoustic density (s_A) is calculated, while in StoX transects are defined within each stratum (Figure 2.1) and used to calculate acoustic density. StoX does also allow for uncertainty estimation by bootstrapping primary sampling units (PSUs) (http://www.imr.no/forskning/prosjekter/stox/nb-no).

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. Prior to 1994 a cod-end with 35-40 mm (stretched) mesh size and a cover net with 70 mm mesh size were mostly 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 trawl is now equipped with a rockhopper ground gear (Engås and Godø 1989). 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 length dependent fishing efficiency and/or sweep width (Godø and Sunnanå 1992, Aglen and Nakken 1997). The sweep wire length is 40 m, plus 12 m wire for connection to the doors.

In the Norwegian Barents Sea shrimp survey (Aschan and Sunnanå 1997) the Campelen trawl has been rigged with some extra floats (45 along the ground rope and 18 along the under belly and trunk, all with 20mm diameter) to reduce problems on very soft bottom. This rigging has been referred to as "Tromsø rigging". When the shrimp survey was terminated 2004 and later merged with the Barents Sea Ecosystem survey in 2005, improved shrimp data were also requested from the winter survey, and the “Tromsø rigging” was used in parts of the shrimp areas in 2004 (11 stations) and 2005 (9 stations). In 2006-2014 “Tromsø rigging” was used for nearly all bottom trawl stations taken by Norwegian vessels in the winter survey, while since 2015 “Tromsø rigging” has not been applied.

Vaco doors (6 m^2, 1500kg), were previously standard trawl doors on board the Norwegian research vessels. On the Russian vessels and hired vessels V-type doors (ca 7 m^2) have been used. In 2004, R/V “Johan Hjort” changed to a V-type door (Steinshamn W-9, 7.1m^2, 2050 kg), the same type as used on the Russian research vessels. In 2010 the V-doors were replaced by 125” Thyborøn trawl doors. R/V “Helmer Hanssen” has used Thyborøn trawl doors since the 2008 survey. In order to achieve constant sampling width of a trawl haul independent of e.g. depth and wire length, a 10-14 m rope “locks” the distance between the trawl wires 80-150 m in front of the trawl doors on the Norwegian vessels. This is called “strapping”. The distance between the trawl doors is then in most hauls restricted to the range 48-52 m regardless of depth (Engås and Ona 1993, Engås 1995). Strapping was first attempted in the 1993 survey on board one vessel, in 1994 it was used on every third haul and in 1995-1997 on every second haul on all vessels. Since 1998 it has been used on all hauls when weather conditions permitted. Strapping is not applied on the Russians vessels, but the normal distance between the doors is about 50 m (D. Prozorkevich, pers. comm.).

Standard tow duration is now 15 minutes (until 1985 the tow duration was 60 min. and from 1986 to 2010 30 min.). Trawl performance is constantly monitored by Scanmar trawl sensors, i.e., distance between the doors, vertical opening of the trawl and bottom contact control. In 2005-2008 sensors monitoring the roll and pitch angle of the doors were used due to problems with the Steinshamn W-9 doors. The data is logged on files, but have so far not been used for further evaluation of the quality of the trawl hauls.

At the start of the survey at least two of the trawls on the Norwegian vessels should go through a “sea test”. The purpose of the test is to check that the geometry of the trawl is within the specified limits and that the trawl performance is satisfactory, especially that the bottom contact is stable. It is further checked that the trawl sensors operate as they should.

The positions of the trawl stations are pre-defined. When the swept area investigations started in 1981 the survey area was divided into four main areas (A, B, C and D, Fig 2.1) and 35 strata.

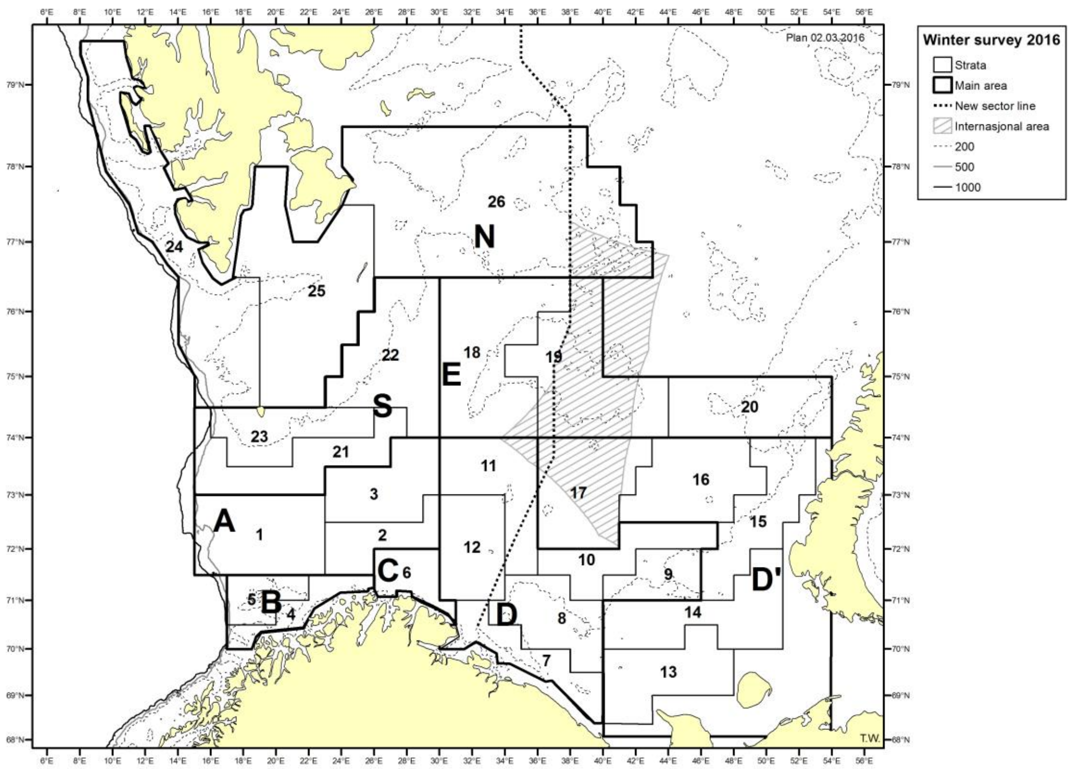

Figure 2.1. Strata (1-23) and main areas (A,B,C,D,D’,E and S) used for swept area estimations and acoustic estimations with StoX. The main areas are also used for acoustic estimations with BEAM. Additional strata (24-26, main area N) are covered since 2014, but not included in the full time series.

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 where high and variable fish densities were expected to occur. During the 1990s trawl stations have been spread out more evenly, yet the distance between stations in the most important cod strata is shorter (16 or 20 NM) compared to the less important strata (24, 30 or 32 NM). During the 1990s considerable amounts of young cod were 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. 2.1 and Table 3.5), 28 strata altogether. In the 1993-1995 survey reports, the Svalbard area was included in area A’ and the western (west of 30°E) part of area E. Since 1996 a revised strata system with 23 strata has been used (Figure 2.1). The main reason for reducing the number of strata was the need for a sufficient number of trawl stations in each stratum to get reliable estimates of density and variance. In later years a few pre-defined trawl stations have been performed north of the strata system due to increased abundance of cod in these areas, and in 2014 the investigated area was enlarged by three new strata in northwest, 24-26 (main area N, Fig. 2.1). However, the data are so far not included in the estimation of standard abundance indices used in the assessments.

Swept area fish density estimation

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

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

$\rho_{s,l}$ 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 (nm)

EW_l length dependent effective fishing width:

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

$$EW_l = EW_{l_{\min}} = \alpha \cdot l_{\min}^{\beta} \text{ for } l \le l_{\min}$$

$$EW_l = EW_{l_{\max}} = \alpha \cdot l_{\max}^{\beta} \text{ for } l \ge l_{\max}$$

The parameters are given in the text table below:

Species	α	β	$l_{\min}$	$l_{\max}$
Cod	5.91	0.43	15 cm	62 cm
Haddock	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.

For each station, s, observations of fish density by length ($\rho_{s,l}$) is summed in 5 cm length-groups. Stratified indices by length-group and stratum will then be:

$$L_{p,l} = \frac{A_p}{S_p} \cdot \sum_{s \text{ in stratum } p} \rho_{s,l}$$

$L_{p,l}$ 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 most northern and most eastern strata differs from year to year. The areas of these strata are therefore calculated according to the coverage each year (Table 3.5). Indices are estimated for each stratum within the main areas A, B, C, D, D', E, S and N. Total number of fish in each 5 cm length group in each main area is estimated by adding the indices of 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 the values for all main areas.

The Sea2Data software StoX was applied to estimate swept area indices for the new extended area (strata 24-26) for 2014-2016. StoX based estimates were also produced for the standard area (strata 1-23) for all species in 2012-2016 for comparisons with the SAS based Survey Program software used so far. The main difference between the Survey Program and StoX swept area estimation is in the use of the age-length data, see below.

2.3 Sampling of catch and age-length keys.

Sorting, weighing, measuring and sampling of the catch are done according to instructions given in Mjanger *et al*. (2016). Since 1999 all data except age are recorded electronically by Scantrol Fishmeter measuring board, connected to stabilized scales. The whole catch or a representative sub sample of most species was length measured on each station.

At each trawl station age (otoliths) and stomach were sampled from one cod per 5 cm length-group. In 2007-2009, all cod above 80 cm were sampled, and in 2010 all above 90 cm, limited to 10 per station. The stomach samples were frozen and analysed after the survey. Haddock otoliths were sampled from one specimen per 5 cm length-group. Regarding the redfish species *Sebastes norvegicus* and *S. mentella*, otoliths for age determination were sampled from two fish in every 5 cm length-group on every station. Greenland halibut were sorted by sex before length measurement. Table 3.4 gives an account of the sampled material.

An 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*

The Sea2Data software StoX does not use age-length keys (ALK) in the traditional sense with ALK estimated for large areas. Missing age information is imputed from known age-length data within station. If age information is still missing StoX searches within strata, or lastly within all strata (http://www.imr.no/forskning/prosjekter/stox/nb-no).

2.4 Estimation of variance.

The swept area survey indices of cod and haddock made with StoX are presented together with an estimate of uncertainty (coefficient of variation; CV). These estimates were made using StoX with a stratified bootstrap routine treating each trawl station as the primary sampling unit, and using 500 iterations. The estimated CV (variance · 100/mean) is strongly dependent on the choice of estimator (e.g. length or abundance) for the indices.

3 Survey operation and material

Table 3.1 presents the vessels participating in the survey in 2016 and IMR trawl station series numbers. Catch data and biological samples from the Russian vessels were converted to the IMR SPD-format. The acoustic data from the Russian vessels was reported to IMR as allocated values by species at 5 nm intervals, split on a bottom layer (<10m from bottom) and a pelagic layer (>10m above bottom).

Table 3.1. Norwegian and Russian vessel participation by time period and Norwegian trawl station series numbers by vessel for the winter survey in 2016.

	Period	**Series no.**
Johan Hjort	24.01-12.03	70001-70283
Helmer Hanssen	28.01-08.02	70301-70377
Fridtjof Nansen	05.02-26.02	70501-70601

Table 3.2 presents the number of swept area trawl stations, other bottom trawl stations and pelagic trawl stations taken in the different main areas. For the calculation of swept area indices, only the successful pre-defined bottom trawl stations within the strata system were used. The number of stations in the new strata 24-26 are also given. Table 3.3 gives an account of the sampled length- and age material from bottom hauls and pelagic hauls. Figure 3.1 shows survey tracks and trawl stations in 2016.

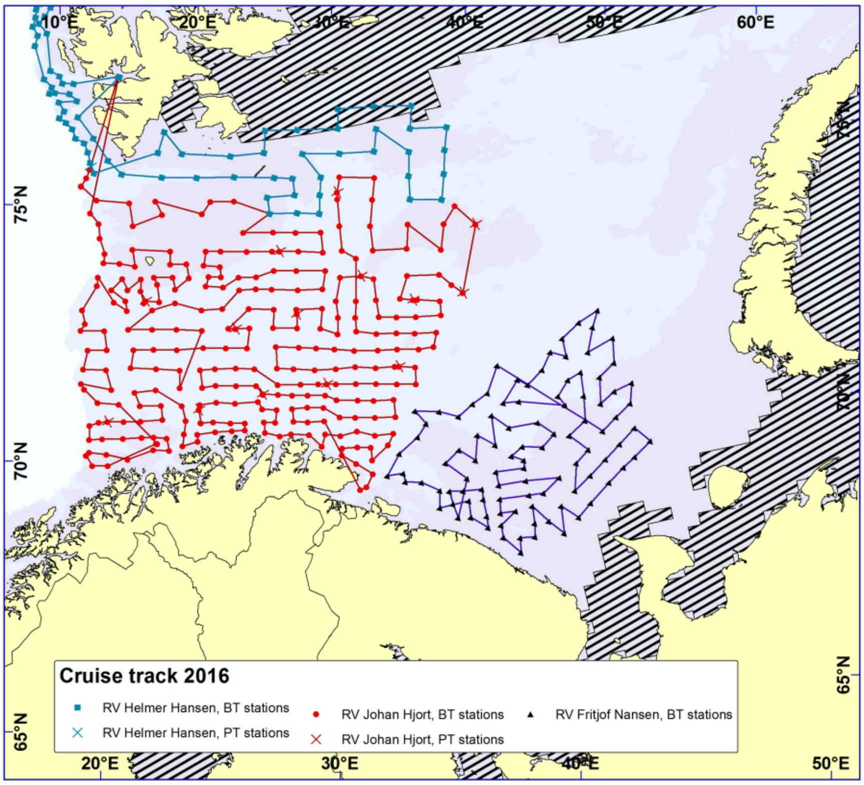

Figure 3.1. Survey tracks and all trawl stations in the winter survey 2016. Data source for the monthly ice cover: ftp://sidads.colorado.edu/DATASETS/NOAA/G02135/shapefiles/

Table 3.2. Number of trawl stations by main area in the Barents Sea winter 2016. B_1= swept area bottom trawl (quality=1 and condition<3), B_2=other bottom trawl, P=pelagic trawl, N=trawl stations in new strata.

Main area	Trawl type	
A	B_1 B_2 P	52 5 2
B	B_1 B_2 P	30 10 1
C	B_1 B_2 P	24 1
D	B_1 B_2 P	119 2 3
D'	B_1 B_2 P	31 1
E	B_1 B_2 P	22 1 3
S	B_1 B_2 P	65 1 3
Inside strata system	B_1 B_2 P	343 19 14
N	B_1 B_2 P	72 11 2
Total	B+B_1+B2 P	445 16

Table 3.3. Number of fish measured for length (L) and age (A) in the Barents Sea winter 2016.

Cod		**Haddock**		***S. norvegicus***		***S. mentella***		**Greenland halibut**	**Blue whiting**
L	**A**	**L**	**A**	**L**	**A**	**L**	**A**	**L**	**L**
16636	3368	25423	2067	614		8668		425	2396

Table 3.4 gives the area covered by the survey every year since 1981, while Table 3.5 summarizes the degree of coverage and main reasons for incomplete coverage in the whole period.

Table 3.4. Area (NM^2) covered in the bottom trawl surveys in the Barents Sea winter 1981-2016.

	Main Area								Sum		Added
Year	**A**	**B**	**C**	**D**	**D'**	**E**	**S**	**N**	**ABCD**	**Total**	**area**
1981-92	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[1]	27581	9701	5048	23592	2684	1954	16989		65922	87549	56200
1998[1]	27581	9701	5048	23592	5886	3819	23587		65922	99214	51100
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	
2002	26483	9701	5048	53932	21766	15611	24118		95165	156659	
2003	26483	9701	5048	52805	23506	6185	22849		94038	146578	
2004	27976	9845	5162	53567	42903	4782	20415		96549	164649	
2005	27581	9701	5048	53932	38716	19720	24194		96263	178893	
2006[2]	27581	9701	5048	53932	34980	13687	24194		96263	169123	18100
2007[1]	27581	9701	5048	23428	8420	20621	27416		65759	122216	56700
2008	27581	9701	5048	53932	23711	18557	25905		96263	164436	
2009	27581	9701	5048	53932	31691	15505	27416		96263	170874	
2010	27581	9701	5048	53932	17896	18330	27416		96263	159904	
2011	27581	9701	5048	53932	32937	16467	27416		96263	173082	
2012[2]	27581	9701	5048	53932	9831	16970	27416		96263	150480	16700
2013	27581	9701	5048	53932	57598	20818	27416		96263	202095	
2014[3]	27581	9701	5048	53932	54464	29692	27416	62000	96263	207835	
2015[3]	27581	9701	5048	53932	45180	26806	27416	52500	96263	195665	
2016[3]	27581	9701	5048	53932	28999	20134	27416	53528	96263	172812	

[1]REZ not covered, [2]REZ (Murman coast and Area D' in 2006 and Area D' in 2012) not completely covered

[3] Additional northern areas (N) covered, not included in total and standard survey index calculations.

Table 3.5. Degree of coverage and main reasons for incomplete coverage in the Barents Sea winter 1981-2016.

Year	Coverage	Comments
1981-1992	ABCD	
1993-1996	ABCDD'ES	
1997	Norwegian EEZ (NEZ), S	Not allowed access to Russian EEZ (REZ)
1998	NEZ, S, minor part of REZ	Not allowed access to most of REZ
1999	ABCDD'ES	Partly limited coverage due to westerly ice extension
2000	ABCDD'ES	
2001-2005	ABCDD'ES	Russian vessel covered where Norwegians had no access
2006	ABCDD'ES	Not access to Murman coast, no Russian vessel
2007	NEZ, S	Not allowed access to REZ, no Russian vessel
2008	ABCDD'ES	Russian vessel covered where Norwegians had no access
2009	ABCDD'ES	Reduced Norwegian coverage of REZ due to catch handling
2010	ABCDD'ES	Reduced Norwegian coverage of REZ due to bad weather
2011	ABCDD'ES	Russian vessel covered where Norwegians had no access
2012	ABCDD'ES	No Norwegian coverage of REZ due to vessel problems
2013	ABCDD'ES	No Norwegian coverage of REZ due to vessel shortage
2014	ABCDD'ESN	Strata 24-26 (N) covered for the first time
2015	ABCDD'ESN	Slightly Reduced/more open coverage due to bad weather
2016	ABCDD'ESN	No access to REZ, Russian vessel covered most of REZ

4 Total echo abundance of cod and haddock

Table 4.1 presents the time series of total echo abundance (echo density multiplied by area) of cod and haddock in the investigated areas.

Table 4.1. Cod and haddock. Total echo abundance and echo abundance in the 10 m layer above the bottom in the Barents Sea winter 1981-2016 (m^2 reflecting surface · 10^{-3}). 1981 - 1992 includes only mainly areas A, B, C and D. Observations outside main areas A-S not included.

	Total			Bottom			Bottom/total		
Year	**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
2002	1943	2329	4272	627	477	1104	0.32	0.20	0.26
2003	3699	3398	7097	1248	753	2001	0.34	0.22	0.28
2004	1162	1985	3147	576	626	1202	0.50	0.32	0.38
2005	1299	2873	4172	457	940	1397	0.35	0.33	0.33
2006	1195	2755	3950	462	697	1159	0.39	0.25	0.29
2007[1,2]	681	2515							
2008	3636	5981	9617	958	1306	2264	0.26	0.22	0.24
2009	2513	6326	8839	806	1280	2086	0.32	0.20	0.24
2010	3712	5905	9617	1014	1186	2200	0.27	0.20	0.23
2011	3044	3790	6834	823	864	1687	0.27	0.22	0.25
2012	3762	4157	7919	1028	810	1838	0.27	0.19	0.23
2013	5105	4078	9183	1364	1031	2395	0.27	0.25	0.26
2014	4722	3176	7898	926	529	1455	0.20	0.17	0.18
2015	4868	1862	6731	1358	352	1710	0.28	0.19	0.25
2016	2884	1701	4585	1078	417	1495	0.37	0.25	0.33

[1] not scaled for uncovered areas [2] not possible to split on bottom and total due to LSSS settings

Since 1993 the acoustic values have been split between the two species during the scrutinizing. The values for cod have showed an increasing trend since the late 2000s, with a peak in 2013. Total echo abundance was 40 % lower in 2016 compared to 2015. The values for haddock increased gradually from the end of the 1990s to 2009, and have since then decreased to less than one third of the 2009 value in 2016. The fraction of the total echo abundance recorded in the bottom layer has been somewhat lower in later years for cod compared to the mid-2000s, but increased in 2016 to mid-2000 levels. For haddock this fraction is lower than for cod and more stable over the time series. Figures 4.1 and 4.2 present the distribution of total echo abundance by estimation rectangles in 2016 for cod and haddock, respectively.

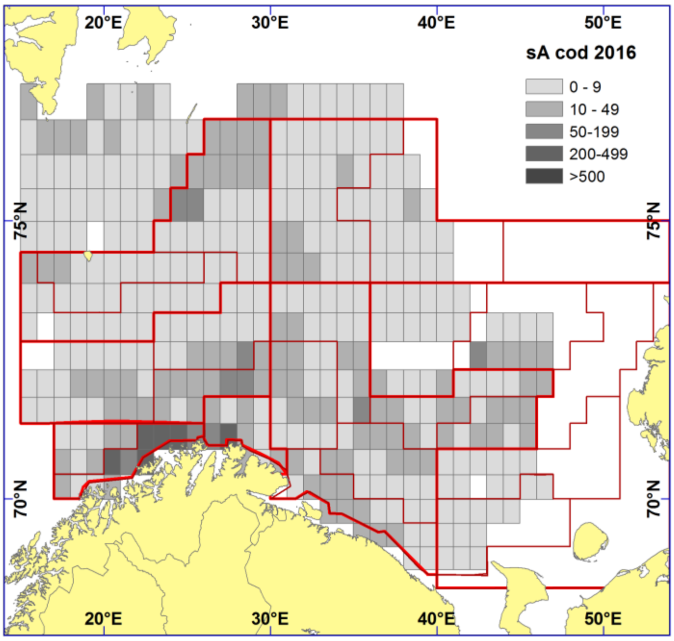

Figure 4.1. COD. Distribution of total echo abundance winter 2016. Unit is s_A per square nautical mile (m^2/n.mile^2). Swept area strata and main areas (thick line) in red.

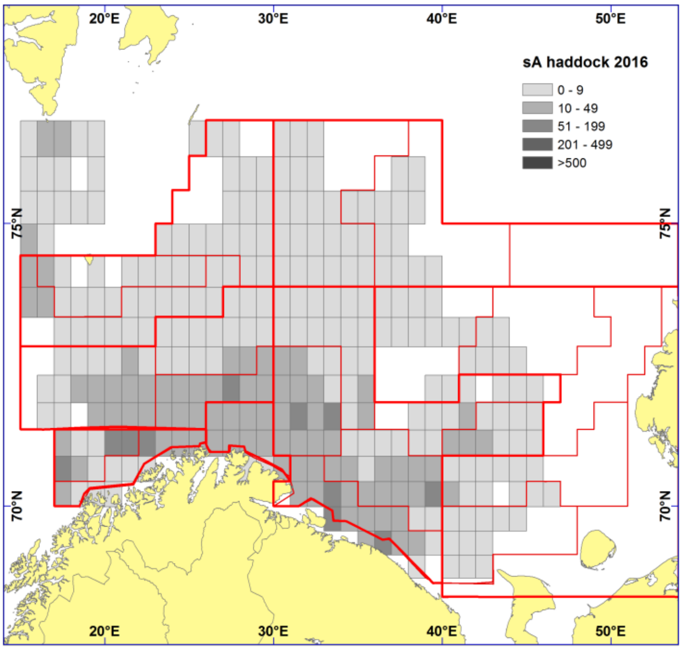

Figure 4.2. HADDOCK. Distribution of total echo abundance winter 2016. Unit is s_A per square nautical mile (m^2/n.mile^2). Swept area strata and main areas (thick line) in red.

5 Distribution and abundance of cod

5.1 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 their spawning migration southwards out of the investigated area, and are therefore to a lesser extent covered. There are indications that a higher proportion than normal spawned along Finnmark in some of the previous years, e.g. 2004-2006. Thereby a higher proportion of the spawners might have been covered by the survey these years.

Table 5.1 shows the acoustic indices for each age group by main areas in 2016. A rather high proportion of the 1 (43 %) and 2 (37 %) year olds was found in the extended area (N). The time series (1981-2016) is presented in Table 5.2. The estimates have been variable and increasing in later years, with a peak in biomass in 2013, and this may partly be explained by variable and not complete coverage of the distribution area towards north and east in several years. As cod grow older it gets a more south-westerly distribution during winter, it so to say "grows" into the incomplete survey. This is especially evident for the strong 2004 and 2005 year-classes, which as 6-10 year olds stand out as the strongest in the time series. Of more recent year-classes the 2011 seems to be strong. 2014 seemed strong at age 1, while at age 2 it appears rather moderate.

Table 5.1. COD. Acoustic abundance for the main areas of the Barents Sea winter 2016 (numbers in millions). Preliminary indices for new area N (strata 24-26) are estimated by StoX software

Area	Age group										Total	Biomass ('000 t)
	1	2	3	4	5	6	7	8	9	10+		
A	4.7	3.4	7.0	9.0	15.0	12.0	7.6	4.9	2.4	3.5	69.5	124.9
B	1.4	2.1	3.1	2.6	21.7	24.1	24.8	5.9	7.4	9.2	102.2	310.0
C	5.3	2.1	2.8	2.1	5.0	2.2	3.5	2.8	1.1	6.9	33.7	118.0
D	36.9	36.2	11.2	17.0	20.4	11.1	10.1	6.5	3.5	4.0	156.9	171.3
D'	12.4	22.3	2.4	9.1	7.9	5.7	1.9	1.0	0.3	0.1	63.0	34.8
E	41.8	37.5	6.4	6.1	8.6	3.3	0.9	0.2	0.2	0.1	105.0	23.6
S	40.6	17.1	8.2	12.4	18.2	4.9	2.4	0.6	0.2	0.3	104.9	44.1
ABCD	48.2	43.8	24.1	30.7	62.1	49.4	46.0	20.1	14.3	23.6	362.3	724.2
A-S	142.9	120.7	41.0	58.3	96.7	63.4	51.2	21.9	15.0	24.1	635.2	826.7
N	107.7	70.4	12.8	11.5	13.9	2.6	3.2	2.1	0.4	1.1	225.9	58.9
Total	250.6	191.1	53.8	69.8	110.6	66.0	54.4	24.0	15.4	25.2	861.1	885.6

Table 5.2. COD. Abundance indices from acoustic surveys in the Barents Sea winter 1981-2016 (numbers in millions). 1981-1992 includes only main areas A, B C and D. Observations outside main areas A-S not included.

	Age											Biomass
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**	**Total**	**(‘000 t)**
1981	8.0	82.0	40.0	63.0	106.0	103.0	16.0	3.0	1.0	1.0	423.0	595
1982	4.0	5.0	49.0	43.0	40.0	26.0	28.0	2.0	0.0	0.0	197.0	303
1983	60.5	2.8	5.3	14.3	17.4	11.1	5.6	3.0	0.5	0.1	120.5	111
1984	745.4	146.1	39.1	13.6	11.3	7.4	2.8	0.2	0.0	0.0	966.0	134
1985	69.1	446.3	153.0	141.6	19.7	7.6	3.3	0.2	0.1	0.0	840.9	392
1986	353.6	243.9	499.6	134.3	65.9	8.3	2.2	0.4	0.1	0.0	1308.2	503
1987	1.6	34.1	62.8	204.9	41.4	10.4	1.2	0.2	0.7	0.0	357.3	207
1988	2.0	26.3	50.4	35.5	56.2	6.5	1.4	0.2	0.0	0.0	178.4	99
1989	7.5	8.0	17.0	34.4	21.4	53.8	6.9	1.0	0.1	0.1	150.1	155
1990	81.1	24.9	14.8	20.6	26.1	24.3	39.8	2.4	0.1	0.0	234.1	246
1991	181.0	219.5	50.2	34.6	29.3	28.9	16.9	17.3	0.9	0.0	578.7	418
1992	241.4	562.1	176.5	65.8	18.8	13.2	7.6	4.5	2.8	0.2	1092.9	405
1993	1074.0	494.7	357.2	191.1	108.2	20.8	8.1	5.0	2.3	2.5	2264.0	753
1994	858.3	577.2	349.8	404.5	193.7	63.6	12.1	3.7	1.7	0.9	2465.4	950
1995	2619.2	292.9	166.2	159.8	210.1	68.8	16.7	2.1	0.7	1.0	3537.4	713
1996	2396.0	339.8	92.9	70.5	85.8	74.7	20.6	2.8	0.3	0.4	3083.8	450
1997[1]	1623.5	430.5	188.3	51.7	49.3	37.2	22.3	4.0	0.7	0.1	2407.5	322
1998[1]	3401.3	632.9	427.7	182.6	42.3	33.5	26.9	13.6	1.7	0.3	4762.8	506
1999	358.3	304.3	150.0	96.4	45.1	10.3	6.4	4.1	0.8	0.3	976.0	224
2000	154.1	221.4	245.2	158.9	142.1	45.4	9.6	4.7	3.0	1.1	985.4	481
2001	629.9	63.9	138.2	171.6	77.3	39.7	11.8	1.4	0.5	0.2	1134.7	408
2002	18.2	215.5	69.3	112.2	102.0	47.0	18.0	3.0	0.4	0.3	585.9	416
2003	1693.9	61.5	303.4	114.4	129.0	114.9	34.3	7.7	1.9	0.5	2461.5	731
2004	157.6	105.2	33.6	92.8	30.7	27.6	17.0	5.9	1.2	0.2	471.8	241
2005	465.3	119.6	123.9	33.7	62.8	16.9	14.5	4.2	1.0	0.4	842.4	249
2006[2]	544.6	216.6	79.8	59.1	15.5	25.6	8.8	4.5	1.4	0.5	956.5	222
2007[1]	125.0	61.7	80.3	37.1	30.4	9.1	14.1	5.0	2.1	0.7	365.6	198
2008	68.8	97.6	210.2	306.1	140.6	69.4	21.6	12.2	3.1	0.8	930.4	846
2009	321.5	30.6	182.6	178.3	137.1	35.0	12.5	5.2	3.7	0.9	907.3	541
2010	485.4	59.4	34.7	121.9	174.7	162.3	44.4	13.8	3.5	3.5	1103.6	932
2011	389.4	124.8	47.1	29.1	80.4	107.7	105.4	17.1	4.5	3.0	908.6	777
2012[2]	950.6	72.7	133.9	52.7	37.7	69.4	126.1	77.0	10.4	6.0	1536.4	1030
2013	470.6	110.8	64.1	85.0	70.8	51.7	86.0	123.8	70.1	12.4	1145.3	1536
2014	630.1	139.1	220.0	117.8	91.5	65.1	37.5	77.3	63.2	26.0	1467.7	1301
2015	1140.8	127.0	94.9	154.2	118.3	98.0	80.4	20.5	68.3	26.1	1928.5	1308
2016	142.9	120.7	41.0	58.3	96.7	63.4	51.2	21.9	15.0	24.1	635.2	827

[1] Indices raised to also represent the Russian EEZ. [2] Indices raised to also represent uncovered parts of the Russian EEZ’.

5.2 Swept area estimation

Figures 5.1 - 5.4 show the geographic distribution of bottom trawl catch rates (number of fish per NM^2, for cod size groups ≤ 19 cm, 20-34 cm, 35-49 cm and ≥ 50 cm. As in previous years, a high proportion of the smallest cod (less than 35 cm) were found in the eastern part of the survey area within the Russian EEZ and near the northern borders of the standard strata system (strata 1-23). In 2014 a higher proportion of cod ≤ 19 cm were found in the extended survey area (strata 24-26) than in the rest of the survey area, while in 2016 53 % of the number of cod ≤ 19 cm found in the standard survey area were found in the extended area. Mehl *et al*. (2013, 2014, 2015) found that since 2009 more of the largest cod had been found in the north-western part of the survey area (main area S), and this trend is confirmed by the 2016 estimates.

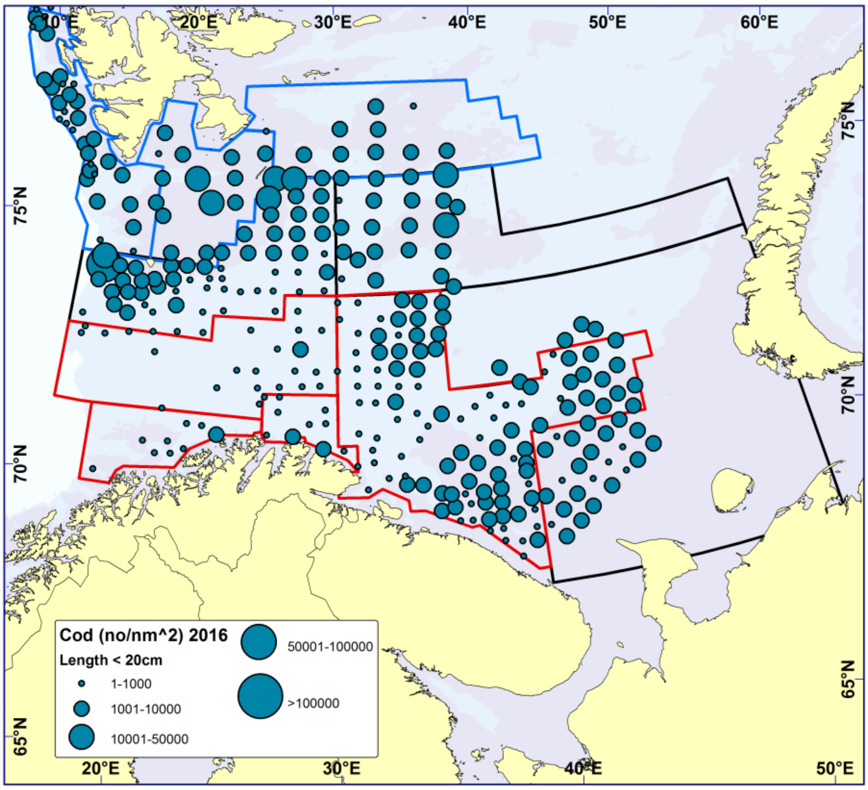

Figure 5.1. COD ≤ 19 cm. Distribution in valid bottom trawl catches winter 2016 (number per nm^2). Zero catches are indicated by black points.

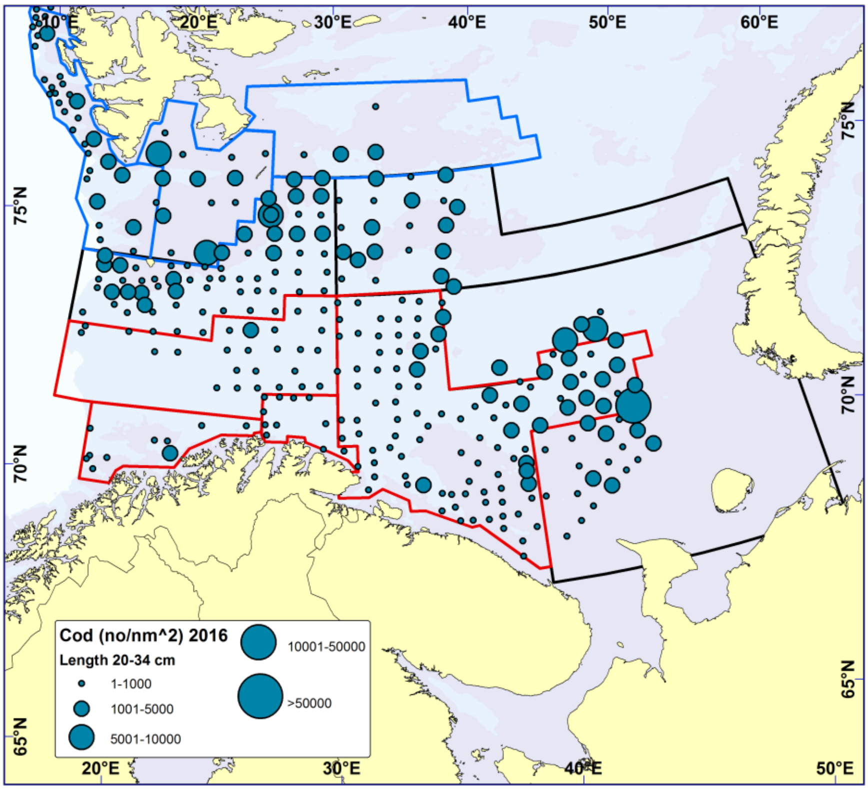

Figure 5.2. COD 20-34 cm. Distribution in valid bottom trawl catches winter 2016 (number per nm^2). Zero catches are indicated by black points.

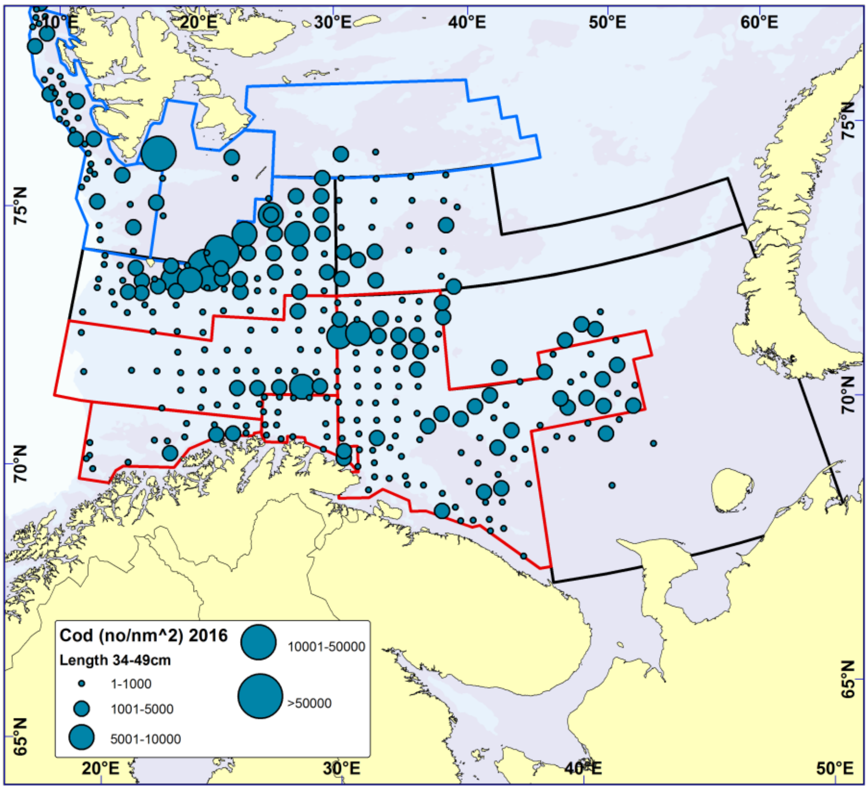

Figure 5.3. COD 35-49 cm. Distribution in valid bottom trawl catches winter 2016 (number per nm^2). Zero catches are indicated by black points.

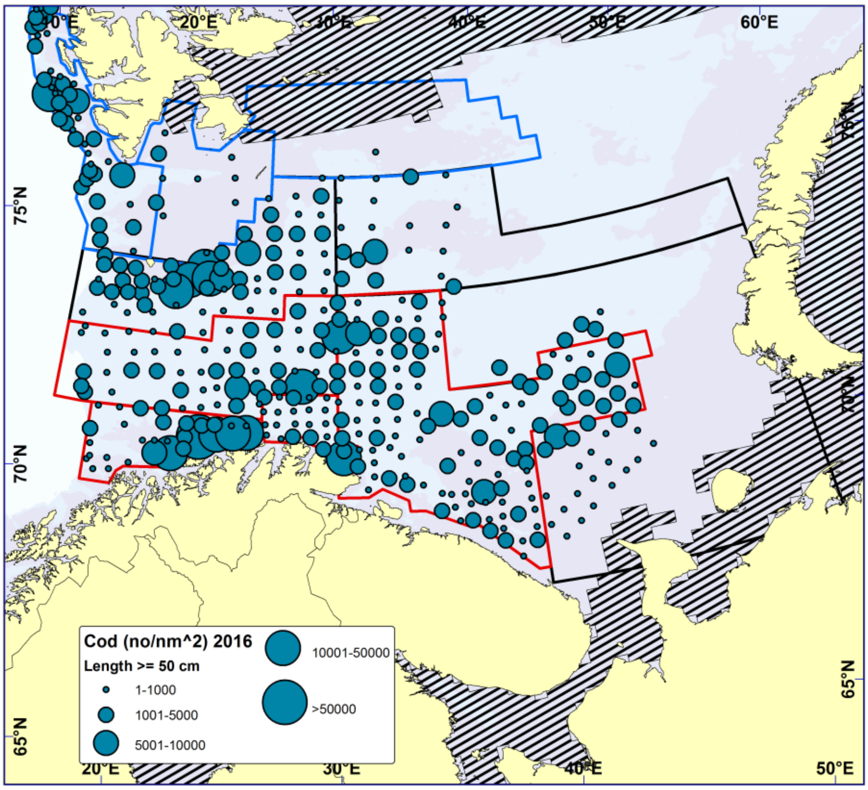

Figure 5.4. COD ≥ 50 cm. Distribution in valid bottom trawl catches winter 2016 (number per nm^2). Zero catches are indicated by black points.

Table 5.3 presents the distribution of the indices by main areas and age and the whole time series (1981-2016) is shown in Table 5.4. Also the bottom trawl indices have fluctuated somewhat due to the same reasons as for the acoustic indices, and the 2004 and 2005 year-classes stand out as the strongest in the time series. The 2009, 2011 and 2014 year-classes seemed to be strong as 1-year olds, but both the 2014 year-class was reduced to below average level at age 2. A considerable amount of cod was found in the extended survey area (Table 5.3), especially 1- and 3-year olds, and on average over all age groups about 29 % of the amount found in the standard survey area by numbers and about 11 % by biomass.

Table 5.3. COD. Abundance indices from bottom trawl hauls for main areas of the Barents Sea winter 2016 (numbers in millions.). Indices for new area N (strata 24-26) estimated by StoX software.

Area	Age group										Total	Biomass
	1	2	3	4	5	6	7	8	9	10+		('000 t)
A	2.8	4.4	4.5	6.3	13.6	9.4	6.3	4.4	2.2	3.2	56.8	102.9
B	0.7	0.8	1.4	2.5	19.1	19.8	16.4	8.0	4.4	7.9	81.0	248.7
C	1.5	0.7	0.9	0.9	1.8	0.9	0.9	0.9	0.7	2.6	11.7	41.2
D	55.0	65.1	19.3	29.1	36.2	21.3	16.6	9.3	4.3	4.9	261.0	254.3
D'	29.2	71.5	9.3	23.0	16.7	15.2	6.4	5.2	1.5	0.4	178.4	108.6
E	35.2	64.7	12.7	11.5	20.8	6.9	2.6	0.4	0.3	0.3	155.4	53.1
S	70.1	37.6	13.5	31.4	56.1	22.3	9.5	3.0	0.9	1.1	245.5	150.2
ABCD	60.0	70.9	26.1	38.8	70.6	51.4	40.2	22.5	11.6	18.5	410.5	647.2
Sum A-S	194.5	244.8	61.6	104.7	164.2	95.8	58.7	31.1	14.3	20.2	989.7	959.1
N	102.7	75.3	36.2	24.0	36.6	4.5	5.7	3.0	0.5	1.6	290.0	104.0
Total	297.2	320.1	97.8	128.7	200.8	100.3	64.4	34.1	14.8	21.8	1297.7	1063.1

Tables 5.5-5.7 present swept area abundance indices by age estimated with the new Sea2Data software StoX for new strata 24-26 in 2014-2016, standard strata 1-23 in 2012-2016 and all strata 1-26 in 2014-2016, respectively. The estimates made with the SAS based Survey Program software used so far and the new Sea2Data software StoX are quite similar for most age groups and years (Tables 5.4 and 5.6).

Table 5.8 presents estimated coefficients of variation (CV) for cod age groups 1-12 in 2012-2016. Estimates are based on a stratified bootstrap approach with 500 replicates (with trawl stations being primary sampling unit). A CV of 20 % or less could be viewed as acceptable in a traditional stock assessment approach if the indices are unbiased (conditional on a catchability model). Values above this indicate a highly uncertain index with little information regarding year class strength. Identification and possible correction of bias is limited by a high CV and much longer time series of consistent data will be needed. The high CVs for age groups 1 and 2 in 2012 may be explained by no coverage of REZ, where a large part of these age groups are found. In all years CVs for age groups older than 10 years are above what could be considered as acceptable.

Table 5.4. COD. Abundance indices from bottom trawl surveys in the Barents Sea winter 1981-2016 (numbers in millions). 1981-1992 includes only main areas A, B, C and D. Observations outside main areas A-S not included.

	Age											Biomass
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**	**Total**	**('000 t)**
1981	4.6	34.3	16.4	23.3	40.0	38.4	4.8	1.0	0.3	0	163	203
1982	0.8	2.9	28.3	27.7	23.6	15.5	16.0	1.4	0.2	0	116	174
1983	152.9	13.4	25.0	52.3	43.3	17.0	5.8	3.2	1.0	0.1	314	220
1984	2755.0	379.1	97.5	28.3	21.4	11.7	4.1	0.4	0.1	0.1	3298	310
1985	49.5	660.0	166.8	126.0	19.9	7.7	3.3	0.2	0.1	0.1	1034	421
1986	665.8	399.6	805.0	143.9	64.1	8.3	1.9	0.3	0	0	2089	639
1987	30.7	445.0	240.4	391.1	54.3	15.7	2.0	0.5	0	0	1180	398
1988	3.2	72.8	148.0	80.5	173.3	20.5	3.6	0.5	0	0	502	285
1989	8.2	15.6	46.4	75.9	37.8	90.2	9.8	0.9	0.1	0.1	285	271
1990	207.2	56.7	28.4	34.9	34.6	20.6	27.2	1.6	0.4	0	412	246
1991	460.5	220.1	45.9	33.7	25.7	21.5	12.2	12.7	0.6	0	833	352
1992	126.6	570.9	158.3	57.7	17.8	12.8	7.7	4.3	2.7	0.2	959	383
1993	534.5	420.4	273.9	140.1	72.5	15.8	6.2	3.9	2.2	2.4	1472	565
1994	1035.9	535.8	296.5	310.2	147.4	50.6	9.3	2.4	1.6	1.3	2391	761
1995	5253.1	541.5	274.6	241.4	255.9	76.7	18.5	2.4	0.8	1.1	6666	943
1996	5768.5	707.6	170.0	115.4	137.2	106.1	24.0	2.9	0.4	0.5	7033	701
1997[1]	4815.5	1045.1	238.0	64.0	70.4	52.7	28.3	5.7	0.9	0.5	6321	495
1998[1]	2418.5	643.7	396.0	181.3	36.5	25.9	17.8	8.6	1.0	0.5	3730	429
1999	484.6	340.1	211.8	173.2	58.1	13.4	6.5	5.1	1.2	0.4	1294	318
2000	128.8	248.3	235.2	132.1	108.3	26.9	4.3	2.0	1.2	0.4	888	356
2001	657.9	76.6	191.1	182.8	83.4	38.2	8.9	1.1	0.4	0.2	1241	428
2002	35.3	443.9	88.3	135.0	109.6	42.5	15.1	2.4	0.3	0.2	873	441
2003	2991.7	79.1	377.0	129.7	91.1	67.3	18.3	4.9	1.0	0.2	3760	546
2004	328.5	235.4	76.6	172.5	56.9	44.7	27.3	7.6	1.7	0.4	952	413
2005	824.3	224.6	246.9	62.1	98.1	24.7	15.5	4.5	1.1	0.4	1502	355
2006[2]	862.7	288.4	118.1	111.5	28.7	43.7	10.2	4.9	1.4	0.6	1470	335
2007[1]	485.9	393.9	367.7	85.0	62.9	14.8	17.9	4.8	1.8	0.7	1435	397
2008	70.4	92.1	190.2	333.6	91.0	47.2	13.0	8.8	2.0	0.4	849	684
2009	382.7	39.1	118.3	219.6	193.9	58.6	19.6	6.8	4.9	0.9	1044	738
2010	1020.2	104.4	36.0	106.9	160.8	140.7	40.0	11.9	3.5	2.2	1627	814
2011	618.6	223.0	88.1	54.1	122.1	139.9	95.6	16.8	3.9	2.4	1365	874
2012[2]	1364.0	329.9	98.0	68.4	44.8	87.3	124.1	53.1	7.9	4.8	2182	910
2013	399.5	164.1	73.8	110.0	65.3	35.4	61.3	79.3	27.2	4.6	1021	919
2014	499.1	152.4	174.2	83.7	66.8	48.3	27.7	44.2	33.1	11.1	1141	780
2015	1352.8	178.3	123.8	182.9	118.0	123.9	61.9	32.1	38.9	27.0	2240	1231
2016	194.5	244.8	61.6	104.7	164.2	95.8	58.7	31.1	14.3	20.2	990	959

[1] Indices raised to also represent the Russian EEZ.

[2] Indices raised to also represent uncovered parts of the Russian EEZ.

Table 5.5. COD. Abundance indices for new strata 24-26 winter 2014-2016 estimated by StoX software (numbers in millions).

	Age											Biomass
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**	**Total**	**('000 t)**
2014	743.1	35.7	47.6	10.1	20.1	9.7	1.5	5.9	3.7	0.2	877.4	116.0
2015	475.4	173.1	23.3	65.7	14.8	15.0	6.7	2.1	2.3	1.9	779.2	148.5
2016	102.7	75.3	36.2	24.0	36.6	4.5	5.7	3.0	0.5	1.6	290.0	104.0

Table 5.6. COD. Abundance indices for standard strata 1-23 winter 2012-2016 estimated by StoX software (numbers in millions).

	Age											Biomass
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**	**Total**	**('000 t)**
2012[1]	1366.9	320.9	98.1	68.3	40.6	91.7	124.2	55.0	8.2	4.4	2178	914
2013	438.8	146.7	69.5	118.6	62.5	41.2	64.0	78.1	31.3	5.3	1052	947
2014	491.5	151.5	179.7	84.4	65.7	48.9	30.6	44.3	33.5	11.5	1142	780
2015	1307.2	174.4	125.8	171.7	126.9	113.4	65.4	28.2	41.9	23.2	2179	1212
2016	210.3	232.4	52.4	110.8	159.4	99.7	64.8	28.4	13.3	20.7	992	969

[1]Indices raised to also represent uncovered parts of the Russian EEZ.

Table 5.7. COD. Abundance indices for strata 1-26 winter 2014-2016 estimated by StoX software (numbers in millions).

	Age											Biomass
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**	**Total**	**('000 t)**
2014	1234.6	187.2	227.3	94.5	85.8	58.6	32.1	50.2	37.2	11.7	2019	896
2015	1782.6	347.5	149.1	237.3	141.7	128.3	72.1	30.3	44.2	25.2	2958	1362
2016	313.0	307.7	88.6	134.8	196.0	104.2	70.5	31.4	13.8	22.3	1282	1073

Table 5.8. COD. Estimates of coefficients of variation (%) winter 2012-2016 estimated by StoX software. 2014-2016 includes strata 24-26.

	Age											
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
2012	46	58	27	12	18	21	18	12	20	20	24	32
2013	10	18	17	19	12	11	11	10	17	21	40	35
2014	10	8	11	10	9	11	13	10	11	19	25	35
2015	8	16	10	11	12	17	25	24	24	21	35	33
2016	9	10	9	11	11	17	20	14	18	22	22	39

5.3 Growth and survey mortalities

Tables 5.9 and 5.10 present the time series for mean length (1981-2015) and mean weight (1983-2016) at age for the entire standard area. Weights and lengths at age were fairly low in the period 1995-2000, but increased somewhat in 2001. Since then there has been moderate fluctuations, but with a slight decreasing trend for older fish (7+) in later year. The same pattern is reflected in the annual weight increments (Table 5.11).

Table 5.12 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 by natural and fishing mortality, age reading errors, and the catchability and availability (coverage) 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. Most later surveys show lower mortalities, but there are some fluctuations for the same reasons as mentioned for the acoustic and swept area indices. 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. Before 2001 the survey mortalities for age 4 and older were well above the mortalities 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 low survey mortalities in the most recent years, even with “impossible” negative values, could partly be caused by fish gradually “growing into” the covered area at increasing age. The observed mortality rates in the acoustic investigations have been more variable. This might be caused by changes in fish behaviour and how available the fish is for acoustic registration.

Table 5.9. COD. Length (cm) at age in the Barents Sea from the investigations winter 1981 - 2016. Observations outside main areas A-S not included.

	Age							
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
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
2002	12.2	19.9	30.1	43.6	52.2	61.7	71.6	79.1
2003	12.0	21.2	29.1	39.2	53.3	61.6	70.3	80.7
2004	11.0	18.9	32.0	40.9	52.0	61.8	69.0	79.0
2005	11.5	18.6	29.3	43.0	51.1	60.3	71.1	78.4
2006	12.2	19.9	31.3	42.1	53.5	60.8	68.9	77.7
2007	13.4	21.3	30.7	42.2	52.8	62.3	70.5	77.9
2008	12.5	22.3	32.5	43.7	52.4	63.6	71.6	80.8
2009	11.7	21.4	32.2	43.2	53.6	63.3	76.0	84.4
2010	11.4	19.1	31.2	42.3	52.0	61.3	70.5	80.6
2011	12.5	19.9	30.3	42.3	51.4	60.8	68.6	78.3
2012[1]	11.8	18.6	28.2	41.3	51.3	59.0	67.1	75.2
2013	11.4	20.1	31.6	41.2	52.0	62.2	69.9	76.7
2014	10.4	18.4	29.7	41.3	52.0	60.9	69.9	77.1
2015	10.8	17.7	29.8	40.0	51.5	61.3	69.6	76.3
2016	12.2	18.9	30.5	40.8	50.6	60.3	68.8	77.0

[1]Adjusted lengths

Table 5.10. COD. Weight (g) at age in the Barents Sea from the investigations winter 1983-2016. Observations outside main areas A-S not included.

Year \ Age	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1983	20	190	372	923	1597	2442	3821	4758				
1984	23	219	421	1155	1806	2793	3777	4566				
1985	20	171	576	1003	2019	3353	5015	6154				
1986	20	119	377	997	1623	2926	3838	7385				
1987[1]	21	65	230	490	1380	2300	3970	6000				
1988	24	114	241	492	892	1635	3040	4373				
1989	16	158	374	604	947	1535	2582	4906	10943	5226		
1990	26	217	580	1009	1435	1977	2829	4435	10772	11045	9615	
1991	18	196	805	1364	2067	2806	3557	4502	7404	13447		
1992	20	136	619	1118	1912	2792	3933	5127	6420	8103	17705	22060
1993	9	71	415	1179	1743	2742	3977	5758	7068	7515	7521	10744
1994	13	55	259	788	1468	2233	3355	4908	5931	8169	7990	15305
1995	16	54	248	654	1335	2221	3483	4713	6103	8727	7345	11258
1996	15	62	210	636	1063	1999	3344	5514	7954	8107	9334	13056
1997[2]	12	54	213	606	1112	1790	2851	4761	6786	6475	11176	
1998[2]	10	47	231	579	1145	1732	2589	3930	5773	11100	14431	
1999	13	55	219	604	1161	1865	2981	3991	6171	6459	18600	
2000	17	77	210	559	1189	1978	2989	3797	5338	6608	10332	16570
2001	14	103	338	664	1257	2188	3145	4463	5774	8249	8931	
2002	15	68	256	747	1234	2024	3190	4511	7274	7036	11904	
2003	15	82	228	569	1302	1980	2975	4666	6568	8257	12826	
2004	11	58	294	600	1167	1934	2657	4025	6517	7216	5831	17500
2005	13	57	230	705	1135	1817	2948	4081	5864	8495	12308	15082
2006	15	71	288	682	1366	1991	2959	4354	5751	9631	9958	
2007	19	78	253	691	1302	2128	3032	4327	6278	7837	10645	20239
2008	16	94	319	798	1393	2412	3413	5067	7070	8998	12917	12960
2009	13	83	291	724	1337	2180	3775	5267	6763	9198	8038	8100
2010	12	63	300	683	1246	2041	3076	4765	6703	8939	10386	8974
2011	15	64	255	683	1179	1933	2740	4048	5853	8043	10104	13076
2012[2]	13	53	214	635	1168	1706	2560	3667	5825	7489	12013	15174
2013	11	65	273	617	1211	2061	2838	3872	5018	8551	9135	14668
2014	9	53	237	629	1228	1914	2869	3944	4962	6467	8670	11397
2015	9	49	240	584	1243	2017	2879	3891	5119	5936	7190	11082
2016	13	55	259	608	1124	1868	2717	3872	5134	6421	7463	7895

1) Estimated weights
2) Adjusted weights

Table 5.11. COD. Yearly weight increment (g) from the investigations in the Barents Sea winter 1983 - 2016. Observations outside main areas A-S not included.

Year\Age	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10
1983-84	199	231	783	883	1196	1335	745		
1984-85	148	357	582	864	1547	2222	2377		
1985-86	99	206	421	620	907	485	2370		
1986-87	45	111	113	383	677	1044			
1987-88	93	176	262	402	255	740	403		
1988-89	134	260	363	455	643	947	1866	6570	
1989-90	201	422	635	831	1030	1294	1853	5866	102
1990-91	170	588	784	1058	1371	1580	1673	2969	2675
1991-92	118	423	313	548	725	1127	1570	1918	699
1992-93	51	279	560	625	830	1185	1825	1941	1095
1993-94	46	188	373	289	490	613	931	173	1101
1994-95	41	193	395	547	753	1250	1358	1195	2796
1995-96	46	156	388	409	664	1123	2031	3241	2004
1996-97	39	151	396	476	727	852	1417	1272	-1479
1997-98	35	177	366	539	620	799	1079	1012	4314
1998-99	45	172	373	582	720	1249	1402	2241	686
1999-00	64	155	340	585	817	1124	816	1347	437
2000-01	86	261	454	698	999	1167	1474	1977	2911
2001-02	54	153	409	570	767	1002	1366	2811	1262
2002-03	67	160	313	555	746	951	1476	2057	983
2003-04	43	212	372	598	632	677	1050	1851	648
2004-05	46	172	411	535	650	1014	1424	1839	1978
2005-06	58	231	452	661	856	1142	1406	1670	3767
2006-07	63	182	403	620	762	1041	1368	1924	2086
2007-08	75	241	545	702	1110	1285	2035	2743	2720
2008-09	67	197	405	539	787	1363	1854	1696	2128
2009-10	50	217	392	522	704	896	990	1436	2176
2010-11	52	192	383	496	687	699	972	1088	1340
2011-12	38	150	380	485	527	627	927	1777	1636
2012-13	52	220	403	576	893	1132	1312	1351	2726
2013-14	42	172	356	611	703	808	1106	1090	1449
2014-15	40	187	347	614	789	965	1022	1175	974
2015-16	46	210	368	540	625	700	993	1243	1302

Table 5.12. Survey mortality observed for cod during the winter survey in the Barents Sea in 1993-2016.

	Age							
Year	**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
2001-02	1.07	-0.08	0.21	0.52	0.50	0.79	1.37	1.25
2002-03	-1.22	-0.34	-0.50	-0.14	-0.12	0.32	0.85	0.46
2003-04	2.78	0.60	1.18	1.32	1.54	1.91	1.76	1.86
2004-05	0.28	-0.16	0.00	0.39	0.60	0.64	1.40	1.77
2005-06	0.76	0.40	0.74	0.78	0.90	0.65	1.17	1.10
2006-07	2.18	0.99	0.76	0.67	0.53	0.60	0.57	0.76
2007-08	0.25	-1.23	-1.34	-1.33	-0.83	-0.86	0.14	0.48
2008-09	0.81	-0.63	0.16	0.80	1.39	1.71	1.42	1.19
2009-10	1.69	-0.13	0.40	0.02	-0.17	-0.24	-0.10	0.40
2010-11	1.36	0.23	0.18	0.42	0.48	0.43	0.95	1.12
2011-12	1.68	-0.07	-0.11	-0.26	0.15	-0.16	0.31	0.50
2012-13	2.15	0.13	0.45	-0.30	-0.32	-0.21	0.02	0.09
2013-14	1.22	-0.69	-0.61	-0.07	0.08	0.32	0.11	0.67
2014-15	1.60	0.38	0.36	0.00	-0.07	-0.21	0.60	0.12
2015-16	2.25	1.13	0.49	0.47	0.62	0.65	1.30	0.31
				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
2001-02	0.39	-0.14	0.35	0.51	0.67	0.93	1.31	1.30
2002-03	-0.81	0.16	-0.38	0.39	0.49	0.84	1.13	0.88
2003-04	2.54	0.03	0.78	0.82	0.71	0.90	0.89	1.06
2004-05	0.38	-0.05	0.21	0.56	0.83	1.06	1.80	1.93
2005-06	1.05	0.64	0.79	0.77	0.81	0.89	1.15	1.17
2006-07	0.78	-0.24	0.33	0.57	0.66	0.89	0.75	1.00
2007-08	1.66	0.73	0.10	-0.07	0.29	0.13	0.71	0.88
2008-09	0.59	-0.25	-0.14	0.54	0.44	0.88	0.65	0.59
2009-10	1.30	0.08	0.10	0.31	0.32	0.38	0.50	0.66
2010-11	1.52	0.17	-0.41	-0.13	0.14	0.39	0.87	1.12
2011-12	0.63	0.82	0.25	0.19	0.34	0.12	0.59	0.75
2012-13	2.12	1.50	-0.12	0.05	0.23	0.35	0.45	0.67
2013-14	0.96	-0.06	-0.13	0.50	0.30	0.25	0.33	0.87
2014-15	1.03	0.21	-0.05	-0.34	-0.62	-0.25	-0.15	0.13
2015-16	1.71	1.06	0.17	0.11	0.21	0.75	0.69	0.81

5.4 Stomach sampling

Since 1984, cod stomachs have been sampled regularly during the winter survey. The sampling strategy has generally been the same as that for sampling otoliths. Stomach have been frozen on board and analysed in the laboratory, except for the period 1994-2000, when some of the stomachs were analysed on board and only the main prey categories were identified. For details about the sampling methodology and the Norwegian-Russian cooperation on diet investigations in the Barents Sea, see Mehl and Yaragina (1992) and Dolgov *et al*. (2007).

The number of stations and stomachs sampled as well as the proportion of empty stomachs and the mean stomach fullness index (SFI, see below) for each of 4 size groups (≤ 19 cm, 20-34 cm, 35-49 cm, ≥ 50 cm) is given in Table 5.13. Table 5.14 - 5.17 show the mean diet composition by prey species/groups by year for each size group. Note that in the years 1994-2000, blue whiting, long rough dab and Norway pout were included in the category 'other fish' when stomachs were analysed on board.

The stomach fullness index is calculated as $SFI_i=100*\Sigma WS_i/W_i$, where WS_i is the weight (g) of the stomach of fish *i*, and W_i is the weight (g) of fish *i*. For 1987 SFI has not been calculated, because very few fish were weighed that year due to technical problems. The distribution on prey groups has been adjusted by distributing the unidentified component of the diet proportionally among the various components, taking into account the level of identification.

The proportion of empty stomachs is largest for the smallest fish (Table 5.13), a pattern seen for all years. Capelin is the dominating prey for cod ≥ 20cm (Tables 5.15-5.17), while krill dominates for the smallest cod (Table 5.14). However, in many years capelin is also an important prey for the smallest cod. The stomach fullness and diet composition in 2015 was similar to that in 2014.

Table 5.13. Number of stations and stomach sampled, % empty stomachs, and mean stomach fullness by length group in the Barents Sea winter 1984-2015.

		Stomachs				% empty				Stomach fullness			
Year	**Stations**	**<20cm**	**20-34cm**	**35-49cm**	**>=50cm**	**<20cm**	**20-34cm**	**35-49cm**	**>=50cm**	**<20cm**	**20-34cm**	**35-49cm**	**>=50cm**
1984	31	176	288	242	381	18.8	14.9	5.0	4.5	1.59	2.05	1.80	1.46
1985	49	106	494	582	612	44.3	34.0	19.8	20.6	1.55	3.58	4.46	3.43
1986	73	231	309	398	427	43.3	32.4	26.9	19.0	0.73	2.48	2.90	2.94
1987	52	133	415	501	409	32.3	48.9	45.3	48.9				
1988	79	29	418	844	704	34.5	40.2	31.6	29.7	1.01	1.29	0.91	0.84
1989	82	82	378	890	1132	40.2	21.2	16.3	20.6	1.45	2.28	2.12	1.47
1990	60	177	300	450	870	39.0	22.7	18.4	16.4	1.84	2.18	2.01	1.60
1991	70	271	463	450	1107	40.6	25.5	11.3	9.5	0.95	2.28	3.73	4.27
1992	100	229	382	471	922	65.9	45.8	31.4	38.2	1.79	3.15	3.05	1.92
1993	117	139	393	570	1073	76.3	38.4	21.2	26.7	1.86	3.34	2.99	3.05
1994	138	296	370	580	1163	64.9	34.9	25.0	24.3	0.76	2.04	2.00	1.63
1995	161	452	517	638	1482	52.2	36.4	32.0	30.8	1.16	1.39	0.93	0.80
1996	254	483	507	540	1338	55.7	39.1	28.0	27.4	0.92	1.32	1.38	1.02
1997	149	305	337	358	1105	57.0	34.1	20.7	29.5	0.98	1.60	1.81	1.48
1998	197	496	492	564	1042	64.7	48.2	29.3	28.6	2.20	1.93	1.67	1.22
1999	211	310	471	554	849	61.3	38.6	27.4	25.9	2.11	1.90	2.06	1.76
2000	243	413	645	669	1069	53.8	28.7	21.2	21.1	1.36	1.98	2.41	1.74
2001	361	644	728	884	1485	72.4	42.3	29.3	32.2	2.32	2.98	3.33	2.79
2002	345	393	704	799	1423	69.2	42.8	30.9	30.9	1.57	2.78	2.36	1.88
2003	285	325	499	637	1468	61.5	39.5	22.6	24.4	5.55	2.78	2.55	2.28
2004	329	508	525	663	1522	51.8	37.9	24.1	27.6	1.94	2.02	1.76	1.55
2005	335	509	651	648	1423	43.6	34.7	26.5	25.4	2.29	2.22	1.79	1.65
2006	259	402	464	534	1059	59.2	42.5	21.9	24.5	1.80	1.88	2.56	1.80
2007	273	386	483	592	1341	60.6	45.3	30.7	30.1	1.68	1.87	1.83	1.50
2008	326	260	733	933	1655	61.9	38.5	26.0	23.0	1.94	2.42	2.93	2.19
2009	319	385	547	798	1657	56.1	35.1	22.3	23.9	1.57	1.89	2.02	1.58
2010	360	594	552	748	2079	51.5	38.6	23.0	25.5	1.83	2.19	2.72	2.49
2011	359	515	628	506	1821	56.7	37.7	17.2	23.9	2.08	2.06	2.47	2.49
2012	297	373	408	431	1626	42.6	27.5	13.9	21.0	1.80	2.45	2.28	1.67
2013	279	209	352	425	1435	44.0	28.4	12.7	17.2	1.49	2.25	2.36	1.93
2014	434	570	686	686	2004	42.8	26.7	18.4	19.8	1.59	2.17	2.11	1.33
2015	356	664	562	670	1735	45.8	29.9	20.1	23.1	1.53	2.09	1.96	1.59

Table 5.14. Mean stomach content composition (% of total SFI) of cod ≤ 19 cm from the survey in the Barents Sea winter 1984-2015.

Year	Amphipods	Krill	Shrimp	Other invertebrates	Capelin	Herring	Polar cod	Blue whiting	Cod	Haddock	Redfish	Long rough dab	Norway pout	Other fish
1984	1.2	7.7	37.5	4.5	13.3						35.8			
1985	15.5	7.9	27.9	44.4										4.3
1986	14.3	3.8	34.0	14.4	15.2									18.3
1987	24.8	17.7	10.9	0.2	25.4		21.0							
1988	3.5	19.2		64.3							13.0			
1989	41.1	27.9		31.0										
1990	5.5	14.2	38.4	3.7	3.8						3.2			31.2
1991	12.2	18.7	6.9	8.4	53.8									
1992	3.7	3.8	6.9	54.3	17.7									13.6
1993	35.3	59.0		5.7										
1994	19.1	40.8	10.9	11.6										17.6
1995	12.9	6.7	33.9	3.5	7.4		27.8		6.2					1.6
1996	16.3	25.4	15.0	27.4	9.4									6.5
1997	23.3	35.9	26.5	0.3										14.0
1998	20.9	30.3	17.2	12.4	16.9							2.3		
1999	9.9	18.4	34.0	6.5		18.0	13.2							
2000	3.3	57.1	17.8	0.0	17.3									4.5
2001	7.0	31.2	10.1	10.7	26.8	8.6								5.6
2002	15.0	32.1	21.1	13.9	17.9									
2003	1.6	80.0	10.4	1.4	6.6									
2004	11.0	44.7	5.9	9.1	14.3	4.2	10.8							
2005	17.2	22.8	16.2	0.3	35.8									7.7
2006	9.7	49.9	7.8	20.5	12.1									
2007	6.0	74.6	6.1	0.5	11.6							1.2		
2008	7.3	47.6	31.3	8.7	0.7							0.3		4.1
2009	4.7	61.4	1.9	8.8	18.1									5.1
2010	3.5	41.7	1.4	1.6	48.2						0.7			2.9
2011	1.5	24.8	14.6	4.0	29.6						8.2			17.3
2012	4.7	20.2	8.5	4.0	53.0									9.6
2013	2.2	66.2		17.8										13.8
2014	8.9	42.6	12.7	8.9	26.8									0.1
2015	2.8	44.8	10.6	13.6	22.1									6.1

Table 5.15. Mean stomach content composition (% of total SFI) of cod 20-34 cm from the survey in the Barents Sea winter 1984-2015.

Year	Amphipods	Krill	Shrimp	Other invertebrates	Capelin	Herring	Polar cod	Blue whiting	Cod	Haddock	Redfish	Long rough dab	Norway pout	Other fish
1984	0.1	0.1	21.0	2.7	40.2		8.1				26.3	0.2		1.3
1985	0.2	0.1	17.0	2.0	69.2	9.3				1.1	0.2			0.9
1986	2.0	1.1	5.9	2.8	56.2	7.0				0.8	23.3			0.9
1987	0.5	1.9	25.2	0.3	53.7				6.6		11.4			0.4
1988	0.9	0.2	20.7	7.0	52.9						18.3			
1989	11.9	7.1	9.0	5.6	33.2		5.4		1.6		25.4	0.5		0.3
1990	0.6	0.5	18.5	0.7	66.7						8.4			4.6
1991	0.1	0.2	4.3	0.2	92.5						2.0			0.7
1992	0.4	0.8	6.4	1.2	88.1				0.4		2.5			0.2
1993	0.1	0.6	8.1	0.3	78.4	5.9	3.8		0.9	1.1	0.1			0.7
1994	1.2	10.2	8.3	1.7	54.9	14.2	4.8		1.7		1.2			1.8
1995	1.4	1.5	9.4	1.8	45.8		10.8	0.6	13.3	3.4	9.3			2.7
1996	1.9	0.5	13.6	1.3	48.9		5.3		24.9		1.8	0.3	0.8	0.7
1997	1.1	3.4	17.6	1.6	42.6		1.2	5.4	10.0					17.1
1998	2.2	2.6	23.5	1.6	47.8	3.4			10.3			5.6		3.0
1999	2.3	4.0	24.5	3.4	45.6	13.5	0.8		3.2	2.7				
2000	0.7	8.0	14.2	0.3	59.4	4.2	5.3		3.6	2.1		0.1		2.1
2001	0.9	2.8	8.5	2.8	69.4	4.7	5.6		4.0					1.3
2002	0.5	1.6	12.2	2.9	71.2	0.7	7.0			1.9				2.0
2003	0.5	2.4	7.3	0.7	71.9	14.4			2.1			0.1	0.5	0.1
2004	2.1	5.2	9.7	1.9	60.6	5.9	6.4		1.9	4.2				2.1
2005	0.6	2.3	12.0	0.9	61.2	3.6	7.7		5.7				4.9	1.1
2006	1.4	1.5	11.8	3.2	66.6	1.6	2.8	2.1		3.4			4.9	0.7
2007	2.3	4.8	15.0	7.3	58.8	0.1				7.7	3.7			0.3
2008	0.5	3.8	11.1	4.7	63.3		3.5			2.4	4.2	1.0		5.5
2009	0.5	6.6	8.8	5.6	71.2		2.4		1.5		0.2			3.2
2010	0.7	5.2	7.4	1.8	74.2	1.0			6.4		2.2			1.1
2011	0.9	3.3	8.3	3.7	74.3				1.1		6.0	0.1	1.1	1.2
2012	0.4	2.6	7.2	2.3	77.1	0.4			7.7					2.3
2013	0.3	7.2	10.4	3.4	68.0		2.1		4.3		0.3	0.1		3.9
2014	2.6	3.5	6.3	5.8	74.7	1.7			1.5	0.1				3.8
2015	0.9	2.4	9.8	3.4	75.9				3.7	1.6		0.3		2.0

Table 5.16. Mean stomach content composition (% of total SFI) of cod 35-49 cm from the survey in the Barents Sea winter 1984-2015.

Year	Amphipods	Krill	Shrimp	Other invertebrates	Capelin	Herring	Polar cod	Blue whiting	Cod	Haddock	Redfish	Long rough dab	Norway pout	Other fish
1984	0.5		18.2	1.3	41.5				0.7	2.6	34.5	0.1	0.6	
1985	0.5		4.7	0.2	88.7	4.2			0.5	0.2	0.9			0.1
1986	0.8	2.5	6.8	3.6	58.4	12.4					15.3			0.2
1987	0.5	0.2	22.9	1.7	47.9	9.2	1.8		4.4	2.0	5.5		3.8	0.1
1988	1.0	1.9	29.1	6.3	51.2			1.5			8.8			0.2
1989	4.1	1.8	11.3	3.3	50.2		7.9		0.2		18.6	0.8	0.2	1.6
1990	0.1	0.1	7.4	1.6	84.8	2.0				1.3	2.5		0.2	
1991	0.1	0.1	1.8	0.6	94.0					1.5	1.2	0.1		0.6
1992		0.1	3.3	3.7	79.7	9.1			0.3	0.3	1.2		1.7	0.6
1993	0.1	0.2	6.0	0.6	85.4	5.6	0.5		0.2	0.4		0.2	0.8	
1994	0.9	14.2	6.9	1.2	48.9	13.5	9.1		2.2	0.4	0.3			2.4
1995	0.9	0.6	12.8	2.2	44.7	6.2	1.2		17.9	8.6	4.7			0.2
1996	1.8	0.7	10.0	2.2	21.6	1.5	2.1	5.5	37.4	6.7	2.5		6.9	1.1
1997	0.9	0.3	14.8	4.3	40.3		5.2	3.6	17.1	3.7	0.5	0.1	1.2	8.0
1998	1.1	0.4	23.2	6.8	50.3	8.5	1.2	1.8	4.1	1.5	0.8			0.3
1999	0.3	0.4	28.0	1.8	44.9	12.0	2.4		1.9	5.7	0.5	0.1	0.4	1.6
2000	0.9	0.3	8.2	0.6	83.5	4.1	0.4		0.7	0.3				1.0
2001	0.4	0.2	6.3	3.3	73.6	5.2	7.3	1.4	1.1	0.5		0.3		0.4
2002	0.2	0.6	10.4	4.2	68.3	2.3	4.8	0.8	3.2	3.9		0.5	0.4	0.4
2003	0.3	1.1	8.2	1.6	68.4	11.1	1.2	0.2	2.7	4.9				0.3
2004	0.9	1.6	14.5	4.5	61.7	6.5	2.3	1.0	4.1	1.5			1.0	0.4
2005	0.7	0.7	13.7	2.1	58.3	3.1	3.6	1.9	0.2	13.2		0.3	1.4	0.8
2006	0.1	0.2	13.1	1.5	64.8	2.0	1.3	1.6	1.1	12.7		0.2	0.3	1.1
2007	3.5	0.8	18.7	2.4	47.6	7.8		0.2	1.1	13.1	0.4	0.4	3.3	0.7
2008	0.3	0.9	11.7	1.3	71.9	2.7	7.4			0.9	1.1	0.3	0.4	1.1
2009	0.8	1.7	6.9	6.9	75.9	1.8	2.4		1.7	0.4	0.6	0.1	0.8	
2010	1.0	1.2	6.3	1.3	81.2	0.4	0.3		2.2	3.6	1.4	0.1	0.6	0.4
2011	0.1	0.7	7.5	3.2	76.0	1.5		1.4	4.2	0.9	2.3	0.1	1.4	0.7
2012	0.5	0.9	7.7	4.3	71.2	0.5	0.8	0.3	4.2	4.4	0.8	0.3	2.6	1.5
2013	0.4	1.5	7.9	4.6	77.9		1.1		3.3	1.6	0.3	0.1	0.3	1.0
2014	0.3	0.6	10.5	3.9	74.4	1.8			1.6	4.3	0.6	0.1	0.9	1.0
2015	0.5	3.2	7.9	2.3	77.1	1.3	0.2	2.3	2.4	1.1	0.3	0.4		1.0

Table 5.17. Mean stomach content composition (% of total SFI) of cod ≥ 50 cm from the survey in the Barents Sea winter 1984-2015.

Year	Amphipods	Krill	Shrimp	Other invertebrates	Capelin	Herring	Polar cod	Blue whiting	Cod	Haddock	Redfish	Long rough dab	Norway pout	Other fish
1984	0.4	0.0	16.3	1.3	48.1	0.0	0.6	0.0	3.5	2.4	26.4	0.3	0.0	0.7
1985	0.2	0.0	5.2	0.4	85.8	3.0	0.0	0.3	2.1	0.6	1.2	1.1	0.1	0.0
1986	0.6	0.2	4.4	3.9	53.9	3.2	0.0	2.5	9.5	7.9	7.7	0.1	4.1	2.0
1987	1.9	0.1	7.4	6.5	2.2	3.6	3.1	3.3	15.6	0.0	35.3	0.3	18.9	1.8
1988	0.9	0.7	11.7	7.0	11.9	0.0	0.0	4.8	0.0	0.0	16.3	4.7	0.0	42.0
1989	0.8	1.0	10.1	7.2	50.9	0.0	1.1	0.0	0.0	0.5	25.1	1.2	0.8	1.3
1990	0.1	0.3	5.2	1.8	74.4	1.1	0.0	5.2	0.1	4.8	4.0	0.9	1.8	0.3
1991	0.0	0.0	1.2	0.5	94.1	0.4	0.0	0.0	0.6	0.9	1.0	0.1	0.4	0.8
1992	0.2	0.1	5.6	3.8	56.7	17.6	0.1	0.0	2.3	4.1	3.7	2.3	2.6	0.9
1993	0.0	0.3	2.2	11.4	54.9	16.0	0.3	0.6	5.2	4.3	0.9	0.0	3.8	0.1
1994	0.5	12.9	5.9	2.8	35.4	7.1	4.4	0.2	12.0	4.3	5.8	1.1	0.0	7.6
1995	0.5	0.3	5.0	2.2	8.4	8.0	0.7	0.0	18.3	20.4	18.8	2.2	0.2	15.0
1996	0.5	0.2	4.1	2.7	9.3	14.6	2.5	0.4	27.2	27.8	6.2	1.8	2.6	0.1
1997	0.2	0.2	10.1	0.8	45.8	5.0	1.1	3.4	5.3	8.2	4.3	0.8	0.6	14.2
1998	1.2	0.2	22.7	3.8	34.5	7.3	1.0	1.2	6.2	6.6	4.1	3.7	2.6	4.9
1999	0.2	0.1	25.8	6.3	26.5	9.8	2.5	0.7	10.3	5.0	0.4	1.4	0.5	10.5
2000	0.9	0.4	7.9	1.6	68.9	6.5	0.8	2.3	2.8	3.4	0.7	1.5	0.0	2.3
2001	0.7	0.2	4.4	4.6	71.7	4.4	1.6	2.5	3.3	2.6	0.3	1.9	0.4	1.4
2002	0.2	0.7	5.9	6.5	50.9	3.0	4.2	2.0	9.0	13.0	1.0	1.7	0.7	1.2
2003	0.1	0.2	5.5	4.9	59.1	10.6	1.5	1.1	4.3	9.1	0.5	1.4	0.4	1.3
2004	0.2	0.2	6.5	3.2	48.2	4.9	0.5	2.6	7.6	17.0	1.6	2.7	1.6	3.2
2005	0.3	0.3	5.8	4.2	33.2	2.9	0.8	5.6	7.9	31.2		1.5	2.5	3.8
2006	0.1	0.1	4.6	4.8	45.8	1.8	0.6	6.1	1.8	28.3	1.6	1.8	1.5	1.1
2007	0.5	0.2	8.3	5.0	29.2	18.4		1.9	7.8	20.8	2.0	2.3	2.7	0.9
2008	0.1	0.4	4.9	2.7	60.7	7.5	0.3	0.4	0.9	17.4	0.8	1.8	0.9	1.2
2009	0.2	0.3	5.5	4.2	53.0	8.6	0.8	0.4	4.1	12.9	1.5	2.9	3.9	1.7
2010	0.6	0.3	2.5	2.3	72.7	1.7	0.2	0.1	3.5	10.6	0.9	2.0	2.5	0.1
2011	0.1	0.3	3.1	2.9	82.0	0.4	0.6		2.6	5.2	0.9	0.5	1.1	0.3
2012	0.1	0.2	4.0	7.1	60.9		0.1	0.1	2.6	16.7	0.5	1.1	3.8	2.8
2013	0.3	0.7	4.1	7.6	67.9	0.2	0.4	0.6	5.1	8.3	0.9	1.4	1.8	0.7
2014	0.5	0.5	5.6	10.6	55.4	2.2		0.2	6.3	10.9	1.0	3.1	1.6	2.3
2015	0.2	0.1	4.1	6.7	69.9	1.1		1.1	2.9	6.8	2.1	1.3	2.4	1.3

6 Distribution and abundance of haddock

6.1 Acoustic estimation

Like for cod it is expected that the survey best covers the immature part of the stock. At this time of the year a large proportion of the mature haddock (age 6 and older) are on its spawning migration south-westwards out of the investigated area. In some earlier years, e.g. 2004 and 2005, concentrations of mature haddock have been observed pelagic rather far above bottom along the shelf edge. These concentrations are poorly covered by the bottom trawl sampling. 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. This occurred in the late 1990s and will have strongest effect on poor year-classes. In the later surveys small haddock has been widely distributed, and the strong year-classes have been found unusually far to the north. This might be caused by favourably hydrographic conditions and/or density-dependent mechanisms. However, it is difficult to separate the two factors. Favourable hydrographic conditions may lead to better distribution of larvae and thus better survival. On the other hand, high densities of juveniles may cause delayed settlement and more active movement in search of prey. Table 6.1 shows the acoustic abundance indices by age within the main areas. As in most of the previous years the highest abundance was observed in main area D. The time series (1981-2016) are presented in Table 6.2. The strong 2004-2006 year-classes can be followed through the time series and still have a strong contribution to the total abundance. In later years, the 2009, 2011, 2013 and 2014 year-classes seem to be fairly strong. The contribution from main area N is rather high for ages 9 and older, but low for younger ages.

Table 6.1. HADDOCK Acoustic abundance for the main areas of the Barents Sea winter 2016 (numbers in millions). Preliminary indices for new area N (strata 24-26) are estimated by StoX software.

	Age group										**Total**	**Biomass ('000 t)**
Area	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**		
A	357.1	16.6	7.5	1.4	11.8	3.0	3.1	3.3	2.4	3.6	410.0	55.0
B	80.2	20.0	2.5	0.1	12.2	2.0	9.1	0.5	2.1	6.6	135.2	58.8
C	148.6	2.5	2.2	0.6	4.9	1.1	1.0	0.3	0.7	0.8	162.6	17.5
D	546.3	75.0	54.2	7.3	28.3	6.1	9.7	3.4	6.6	4.4	741.4	130.4
D'	13.3	2.5	2.2	0.0	2.8	0.7	0.6	0.1	0.5	0.7	23.5	9.5
E	49.6	0.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	50.2	1.2
S	51.3	4.2	1.3	0.2	1.3	1.1	0.8	0.2	0.9	2.4	63.8	14.5
ABCD	1132.2	114.2	66.4	9.3	57.2	12.2	22.9	7.5	11.8	15.4	1449.2	261.7
A-S	1246.4	121.2	70.0	9.6	61.3	14.1	24.4	7.9	13.3	18.5	1586.7	286.9
N	222.8	2.8	5.0	0.4	9.6	1.5	2.3	2.0	7.4	7.7	262.3	61.8
Total	1469.2	124.0	75.0	10.0	70.9	15.6	26.7	9.9	20.7	26.2	1849.0	348.7

Table 6.2. HADDOCK. Abundance indices from acoustic surveys in the Barents Sea winter 1981-2016 (numbers in millions). 1981-1992 includes mainly areas A, B, C and D. Observations outside main areas A-S not included.

	Age											Biomass
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**	**Total**	**('000 t)**
1981	7	14	5	21	60	18	1	+	+	+	126	166
1982	9	2	3	4	4	10	6	+	+	+	38	50
1983	0	5	2	3	1	1	4	2	+	+	18	25
1984	1685	173	6	2	1	+	+	+	+	+	1867	101
1985	1530	776	215	5	+	+	+	+	+	+	2526	259
1986	556	266	452	189	+	+	+	+	+	+	1463	333
1987	85	17	49	171	50	+	+	+	0	+	372	157
1988	18	4	8	23	46	7	+	0	0	+	106	56
1989	52	5	6	11	20	21	2	0	0	0	117	49
1990	270	35	3	3	4	7	11	2	+	+	335	51
1991	1890	252	45	8	3	3	3	6	+	0	2210	166
1992	1135	868	134	23	2	+	+	1	2	+	2165	239
1993	947	626	563	130	13	+	+	+	+	3	2282	385
1994	562	193	255	631	111	12	+	+	+	+	1764	573
1995	1379	285	36	111	387	42	2	+	+	+	2242	466
1996	249	229	44	31	76	151	8	+	0	+	788	280
1997[1]	693	24	51	17	12	43	43	2	+	+	885	155
1998[1]	220	122	20	28	12	5	13	16	1	+	437	92
1999	855.8	45.5	57.3	13.1	13.9	3.6	1.4	1.9	1.6	0.03	994	81
2000	1024.4	508.9	32.2	64.9	18.5	10.5	1.6	0.5	1.8	0.4	1664	185
2001	976.5	315.6	209.6	23.1	21.6	1.3	0.9	0.1	0.04	0.5	1549	175
2002	2062.1	282.0	215.7	149.5	13.5	11.7	1.0	0.2	0.03	0.7	2736	264
2003	2394.5	278.6	145.2	197.6	168.8	17.2	5.0	0.2	0.1	1.1	3208	455
2004	751.8	474.3	126.7	75.9	76.0	65.9	6.6	2.0	0.1	0.3	1580	287
2005	3363.6	209.2	218.9	101.9	36.5	40.1	9.0	0.1	0.1	0.0	3979	302
2006[2]	2767.1	803.6	54.2	86.2	30.2	11.6	9.0	2.2	0.09	0.21	3764	282
2007[1]	3197.0	868.0	379.0	54.0	88.0	22.0	6.0	5.0	2.00	0.00	4621	462
2008	1266.6	1835.2	723.4	251.7	57.3	74.2	10.2	5.8	0.35	1.03	4226	841
2009	849.0	246.3	1021.7	773.0	402.1	31.3	14.9	1.6	0.13	0.53	3341	1006
2010	2035.8	81.8	138.0	593.0	557.4	191.4	10.3	2.9	0.68	0.72	3612	975
2011	786.5	408.0	47.6	68.1	313.0	262.6	52.4	1.6	0.45	0.63	1941	683
2012[2]	2222.2	176.0	224.3	30.0	58.4	294.3	134.9	31.6	0.83	0.42	3173	739
2013	525.5	605.0	52.9	132.4	29.5	39.0	243.8	104.3	14.20	0.29	1747	772
2014	1569.4	114.0	319.0	43.7	82.7	18.3	43.8	86.6	37.64	3.49	2318	556
2015	1163.6	169.2	17.0	146.4	36.5	30.8	11.5	18.5	17.61	5.29	1617	312
2016	1246.4	121.2	70.0	9.6	61.3	14.1	24.4	7.9	13.26	18.55	1587	287

[1] Indices raised to also represent the Russian EEZ.

[2] Indices raised to also represent uncovered parts of the Russian EEZ.

6.2 Swept area estimation

Figures 6.1 - 6.4 show the geographic distribution of bottom trawl catch rates (number of fish per NM^2) for haddock size groups ≤ 19 cm, 20-34 cm, 35-49 cm and ≥ 50 cm. Like in previous years (Mehl *et al*. 2013, 2014, 2015), the distribution extends further to the north and to the east than what was usual in the 1990s. To a certain degree, one can follow the high densities through the size groups, especially the northern and eastern distributions. This indicates that the distribution is more cohort-dependent than age-dependent, and it may be more appropriate to use cohort as scaling covariate rather than age, when indices are adjusted for poor coverage.

Table 6.3 presents the indices for each age group by main areas. The time series (1981-2016) are shown in Table 6.4. As with the acoustic indices, the strong 2004-2006 year-classes dominates bottom trawl indices. Overall, this survey tracks both strong and poor year-classes fairly well. In later years, the 2009, 2011, 2013, 2014 and 2015 year-classes are stronger than the 2007, 2008, 2010 and 2012 year-classes. The 2009 year-class index was unexpectedly low this year. Compared to cod a lower proportion of haddock was found in the extended survey area (Table 6.3). This difference is most pronounced for the young ages. The extended area represents about 2 % of the total numbers and about 8 % total biomass.

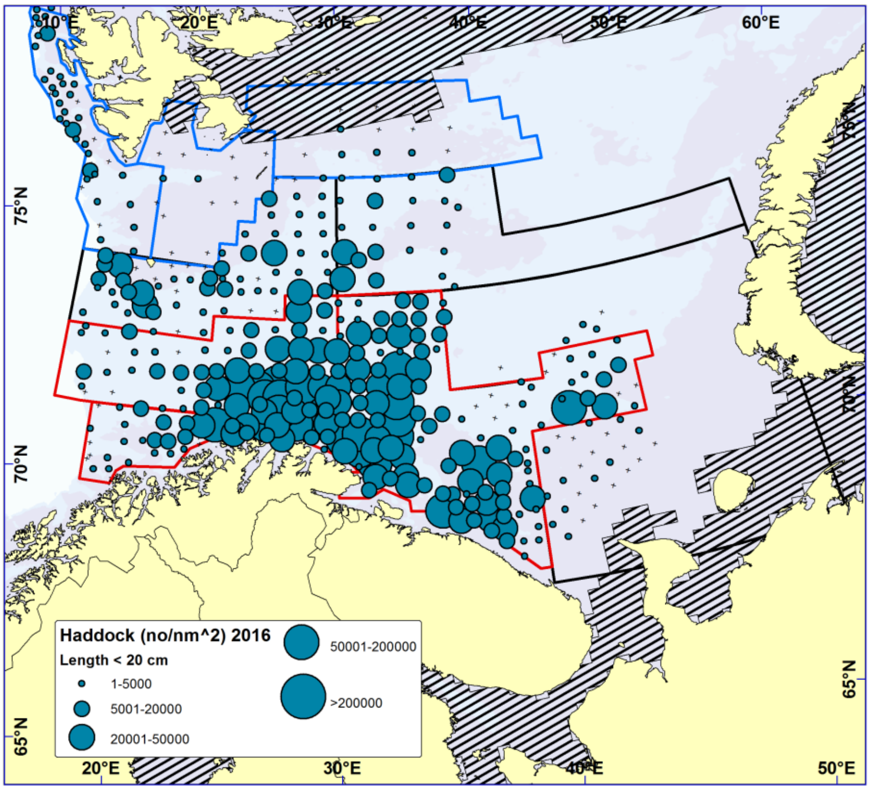

Figure 6.1. HADDOCK ≤ 19 cm. Distribution in valid bottom trawl catches winter 2016 (number per nm^2). Zero catches are indicated by black points.

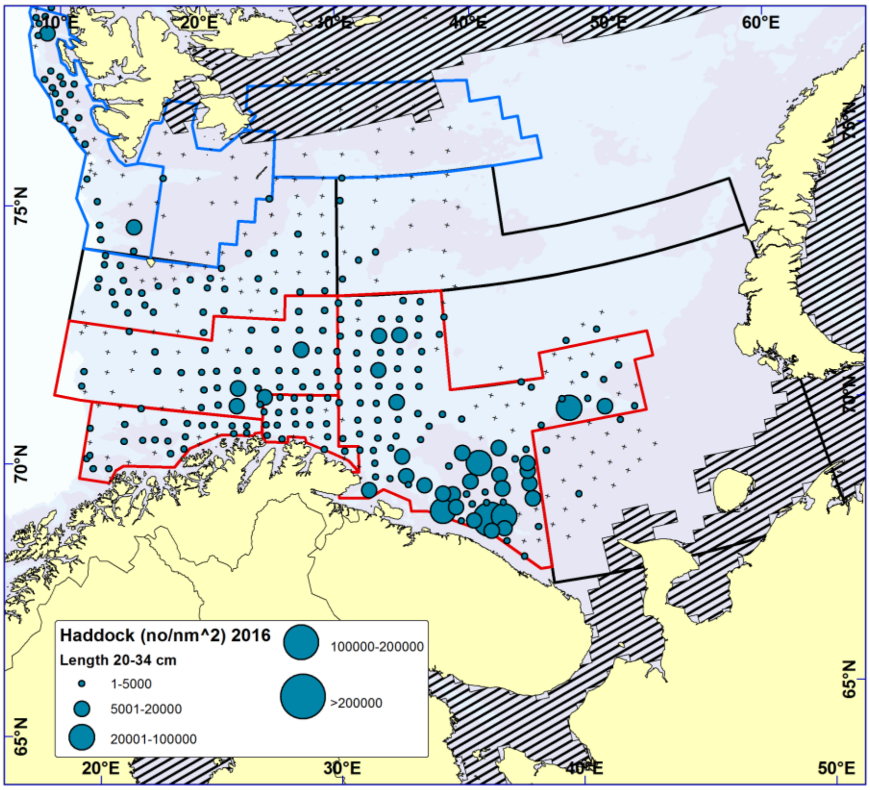

Figure 6.2. HADDOCK 20-34 cm. Distribution in valid bottom trawl catches winter 2016 (number per nm^2). Zero catches are indicated by black points.

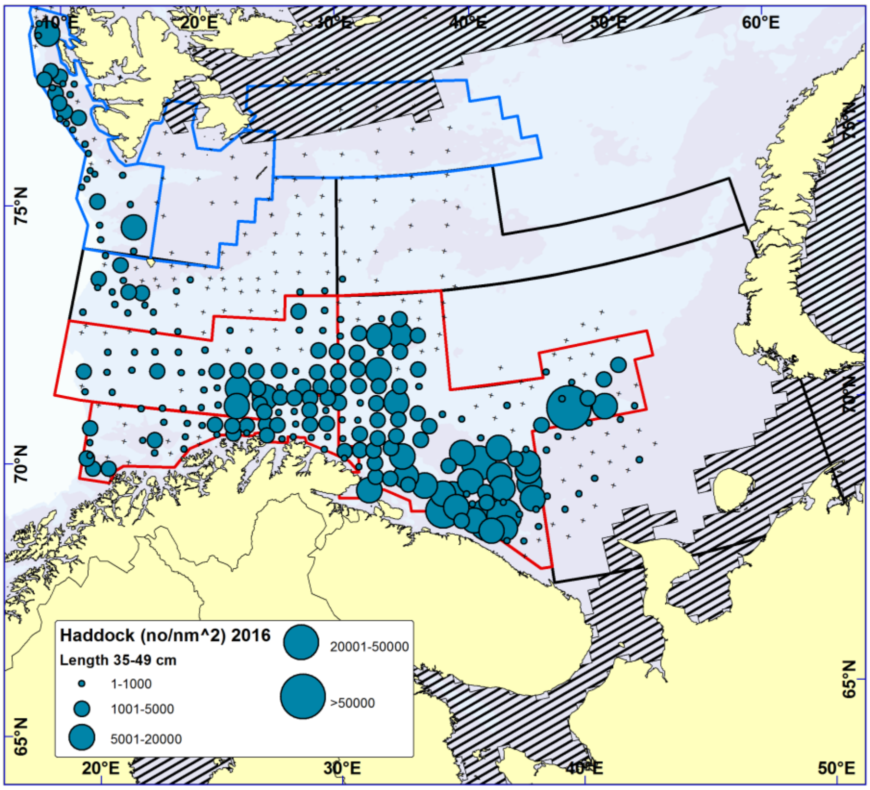

Figure 6.3. HADDOCK 35-49 cm. Distribution in valid bottom trawl catches winter 2016 (number per nm^2). Zero catches are indicated by black points.

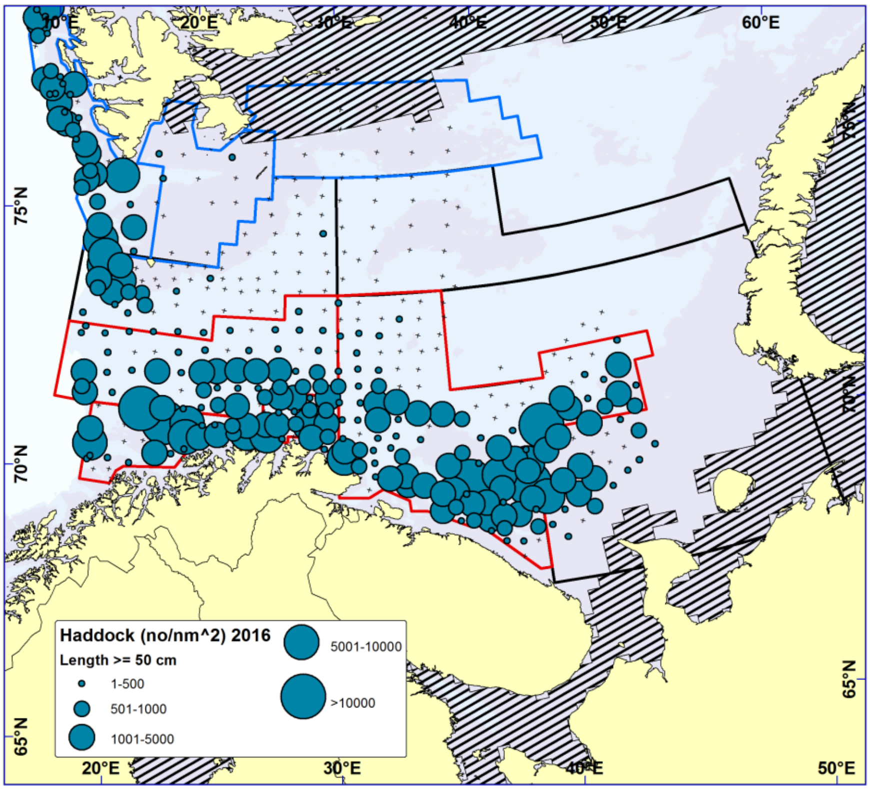

Figure 6.4. HADDOCK ≥ 50 cm. Distribution in valid bottom trawl catches winter 2016 (number per nm^2). Zero catches are indicated by black points.

Table 6.3. HADDOCK. Abundance indices from bottom trawl hauls for main areas of the Barents Sea winter 2013-2016 (numbers in millions). Indices for new area N (strata 24-26) estimated by StoX software.

Area	Age 1	2	3	4	5	6	7	8	9	10+	Total	Biomass ('000 t)
A	800.9	163.9	15.9	3.8	17.9	4.5	4.4	3.1	3.7	3.7	1021.7	90.9
B	55.8	13.1	2.1	0.2	10.8	1.7	8.4	0.5	2.3	7.2	102.0	54.9
C	202.7	10.9	4.0	1.3	8.5	1.8	2.1	0.5	1.6	1.1	234.4	31.4
D	840.7	337.1	142.6	19.7	56.6	8.4	14.6	8.8	16.2	12.9	1457.4	287.5
D'	65.7	5.1	1.7	0.1	8.8	3.7	2.5	0.6	2.8	3.7	94.7	38.0
E	151.5	0.9	0.7	0.1	-	-	-	-	-	-	153.2	3.9
S	133.1	10.2	3.6	0.6	3.9	0.4	0.9	1.0	1.3	1.6	156.5	20.9
ABCD	1900.1	525.0	164.6	24.9	93.7	16.3	29.5	12.8	23.8	24.8	2815.5	464.6
Sum A-S	2250.4	541.1	170.5	25.7	106.5	20.3	33.0	14.3	28.0	30.1	3219.9	527.3
N	41.0	4.5	10.1	0.4	10.1	2.0	1.5	2.8	4.2	3.7	80.1	45.4
Total	2291.4	545.6	180.6	26.1	116.6	22.3	34.5	17.1	32.2	33.8	3300.0	572.7

Table 6.4. HADDOCK. Abundance indices from bottom trawl surveys in the Barents Sea winter 1981-2016 (numbers in millions). 1981-1992 includes only main areas A, B, C and D. Observations outside Main Areas A-S not included.

	Age											Biomass
Year	1	2	3	4	5	6	7	8	9	10+	Total	('000 t)
1981	3.1	7.3	2.3	7.8	1.8	5.3	0.5	0.2	0.0	0.0	28	26
1982	3.9	1.5	1.7	1.8	1.9	4.8	2.4	0.2	0.0	0.0	18	23
1983	2919.3	4.8	3.1	2.4	0.9	1.9	2.5	0.7	0.0	0.0	2936	170
1984	3832.6	514.6	18.9	1.5	0.8	0.2	0.1	0.4	0.1	0.0	4369	249
1985	1901.1	1593.8	475.9	14.7	0.5	0.5	0.1	0.1	0.4	0.3	3987	507
1986	665.0	370.3	384.6	110.8	0.6	0.2	0.1	0.1	0.1	0.1	1532	271
1987	163.8	79.9	154.4	290.2	52.9	0.0	0.0	0.0	0.0	0.3	742	261
1988	35.4	15.3	25.3	68.9	116.4	13.8	0.1	0.0	0.0	0.0	275	142
1989	81.2	9.5	14.1	21.6	34.0	32.7	3.4	0.1	0.0	0.0	197	82
1990	644.1	54.6	4.5	3.4	5.0	9.2	11.8	1.8	0.0	0.0	734	72
1991	2006.0	300.3	33.4	5.1	4.2	2.7	1.7	4.2	0.0	0.0	2358	165
1992	1659.4	1375.5	150.5	24.4	2.1	0.6	0.7	1.6	2.3	0.0	3217	337
1993	727.9	599.0	507.7	105.6	10.5	0.6	0.4	0.3	0.4	1.1	1954	336
1994	603.2	228.0	339.5	436.6	49.7	3.4	0.2	0.1	0.2	0.6	1662	417
1995	1463.6	179.3	53.6	171.1	339.5	34.5	2.8	0.0	0.1	0.0	2245	444
1996	309.5	263.6	52.5	48.1	148.6	252.8	11.6	0.9	0.0	0.1	1088	461
1997[1]	1268.0	67.9	86.1	28.0	19.4	46.7	62.2	3.5	0.1	0.0	1582	226
1998[1]	212.9	137.9	22.7	33.2	13.2	3.4	8.0	8.1	0.7	0.1	440	78
1999	1244.9	57.6	59.8	12.2	10.2	2.8	1.0	1.7	1.1	0.0	1391	86
2000	847.2	452.2	27.2	35.4	8.4	4.0	0.8	0.3	0.7	0.2	1376	126
2001	1220.5	460.3	296.0	29.3	25.1	1.7	0.9	0.1	0.1	0.3	2034	232
2002	1680.3	534.7	314.7	185.3	17.6	8.2	0.8	0.3	+	0.3	2742	316
2003	3332.1	513.1	317.4	182.0	73.6	5.5	2.3	0.2	0.1	0.2	4427	429
2004	715.9	711.2	188.1	102.7	80.4	46.2	5.9	1.1	0.2	0.1	1852	311
2005	4630.2	420.4	346.5	133.3	66.8	52.2	12.3	0.6	0.2	0.0	5663	440
2006[2]	5141.3	1313.1	77.4	140.5	48.2	19.6	15.2	3.1	0.1	0.3	6759	462
2007[1]	3874.0	1594.0	508.0	66.0	86.0	23.0	7.5	3.7	1.4	0.2	6164	591
2008	860.2	2129.4	1522.4	600.9	86.8	48.9	6.3	2.5	0.8	0.1	5258	1115
2009	564.7	328.0	1270.4	773.2	365.4	38.5	10.6	1.4	0.1	0.3	3353	999
2010	1619.5	111.2	102.8	508.6	479.6	131.2	7.0	1.0	0.6	0.6	2962	772
2011	685.4	343.5	64.9	95.1	468.3	338.1	62.1	1.6	0.4	0.2	2060	850
2012[2]	1921.5	108.4	315.3	46.1	83.2	289.6	145.7	21.9	2.4	0.4	2934	761
2013	291.1	494.9	72.9	146.1	21.5	38.4	154.1	95.2	12.1	0.1	1326	609
2014	1204.7	117.0	373.4	44.4	100.1	24.7	42.7	91.5	51.4	5.3	2055	620
2015	1093.2	347.0	25.6	183.2	35.3	35.1	11.6	23.6	23.1	11.8	1790	377
2016	2250.4	541.4	170.5	25.7	106.5	20.3	32.9	14.3	28.0	30.1	3220	527

[1] Indices raised to also represent the Russian EEZ

[2] Indices raised to also represent uncovered parts of the Russian EEZ.

Tables 6.5-6.7 present swept area abundance indices by age estimated with the new Sea2Data software StoX for new strata 24-26 in 2014-2016, standard strata 1-23 in 2012-2016 and all strata 1-26 in 2014-2016, respectively. As for cod, the estimates made with the SAS based Survey Program software used so far and the new Sea2Data software StoX are quite similar for most age groups and years (Tables 6.4 and 6.6).

Table 6.5. HADDOCK. Abundance indices for new strata 24-26 winter 2014-2016 estimated by StoX software (numbers in millions).

	Age											Biomass
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**	**Total**	**('000 t)**
2014	124.5	1.2	12.4	0.6	2.0	0.2	2.9	1.5	0.9	0.1	146.3	21
2015	52.9	17.7	0.3	13.1	0.4	4.3	1.0	0.7	3.2	2.4	96.0	35
2016	41.0	4.5	10.1	0.4	10.1	2.0	1.5	2.8	4.2	3.7	80.1	45

Table 6.6. HADDOCK. Abundance indices for standard strata 1-23 winter 2012-2016 estimated by StoX software (numbers in millions).

	Age											Biomass
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**	**Total**	**('000 t)**
2012[1]	1628.4	102.9	330.4	33.5	81.8	321.9	188.0	29.8	3.2	0.4	2720.3	848
2013	332.2	472.9	55.7	153.4	19.0	35.3	180.0	72.3	8.0	0.1	1329.0	599
2014	1145.3	92.0	365.2	31.9	101.6	21.2	45.5	93.8	40.7	2.1	1939.2	627
2015	1060.9	315.1	26.2	190.1	29.8	34.8	14.0	19.4	27.0	8.4	1725.7	372
2016	2181.8	506.0	159.2	24.2	105.4	20.8	36.1	10.5	27.7	29.4	3101.4	512

[1]Indices raised to also represent uncovered parts of the Russian EEZ.

Table 6.7. HADDOCK. Abundance indices for strata 1-26 winter 2014-2016 estimated by StoX software (numbers in millions).

	Age											Biomass
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**	**Total**	**('000 t)**
2014	1269.8	93.2	377.5	32.4	103.7	21.4	48.4	95.3	41.6	2.2	2085.6	647
2015	1113.8	332.8	26.5	203.3	30.2	39.1	15.0	20.1	30.2	10.7	1821.7	407
2016	2222.8	510.5	169.3	24.6	115.5	22.8	37.6	13.3	31.9	33.1	3181.5	557

Table 6.8 presents estimated coefficients of variation (CV) for cod age groups 1-12 in 2012-2016. Estimates are based on a stratified bootstrap approach with 500 replicates (with trawl stations being primary sampling unit). A CV of 20 % or less could be viewed as acceptable in a traditional stock assessment approach if the indices are unbiased (conditional on a catchability model). Values above this indicate a highly uncertain index with little information regarding year class strength. Identification and possible correction of bias is limited by a high CV and much longer time series of consistent data will be needed. In most years CVs for age groups older than 8 years are above what could be considered as acceptable.

Table 6.8. HADDOCK. Estimates of coefficients of variation (%) 2012-2016 estimated by StoX software. 2014-2016 includes strata 24-26.

	Age											
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
2012	20	19	15	22	13	11	13	25	80	44	84	76
2013	12	11	16	16	31	26	20	22	38	53	-	-
2014	8	17	12	22	19	22	18	17	21	33	55	-
2015	8	12	22	11	25	15	30	17	16	26	59	85
2016	22	22	18	21	10	15	18	17	15	18	24	51

6.3 Growth and survey mortalities

Tables 6.9 and 6.10 present the time series for mean length (1983-2016) and mean weight (1983-2016) at age for the entire standard area. Length estimates have been variable with no specific trends in the latest years. However, the variation is less than what it has been in earlier periods. Weight estimates also show less variation in later years, but there is a slight trend of decreasing weights of 4 years and older haddock for the last decade. However, in 2016 weights of 5 years and older haddock increased compared to previous years. Annual weight increments are shown in Table 6.11, these are highly variable and show no trends.

Survey mortalities based on the acoustic indices (Table 6.12) have varied between years, and for most age groups there are no obvious trends. However, there are signs of co-variability within years.

Table 6.9. HADDOCK. Length (cm) at age in the Barents Sea from the investigations winter 1983 – 2016. Observations outside main areas A-S not included.

Year	Age							
	1	2	3	4	5	6	7	8
1983	16.8	25.2	34.9	44.7	52.5	58.0	62.4	65.1
1984	16.6	27.5	32.7	-	56.6	62.4	61.8	66.2
1985	15.7	23.9	35.6	41.9	58.5	61.9	63.9	67.6
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	57.6
1990	15.7	24.7	32.7	43.4	46.1	50.1	52.4	55.7
1991	16.8	24.0	35.7	44.4	52.4	54.8	55.6	55.9
1992	15.1	23.9	33.9	45.5	53.1	59.2	60.6	60.5
1993	14.5	21.4	31.8	42.4	50.6	56.1	59.4	64.2
1994	14.7	21.0	29.7	38.5	47.8	54.2	56.9	63.6
1995	15.4	20.1	28.7	34.2	42.8	51.2	55.8	60.0
1996	15.4	21.6	28.6	37.8	42.0	46.7	55.3	60.2
1997[1]	16.1	21.2	27.7	35.4	39.7	47.5	50.1	55.3
1998[1]	14.4	22.9	29.2	35.8	41.3	48.4	50.9	55.3
1999	14.7	20.8	32.3	39.4	45.5	52.3	54.6	52.6
2000	15.8	22.5	30.3	41.6	47.7	50.8	51.1	56.5
2001	14.6	22.2	32.2	37.8	47.2	51.2	58.7	53.9
2002	15.5	21.1	29.6	40.2	44.2	50.9	58.4	59.4
2003	16.5	24.1	28.0	37.2	46.5	49.6	54.7	59.4
2004	14.2	22.3	30.6	36.3	43.4	49.8	51.4	58.0
2005	15.1	20.8	30.0	36.6	41.5	47.9	51.9	56.9
2006	14.7	22.6	31.3	37.8	43.2	48.0	50.8	57.0
2007	15.7	23.2	28.7	37.4	45.5	48.5	53.5	55.5
2008	15.9	23.8	30.1	38.1	39.7	48.6	53.4	54.3
2009	14.5	22.5	29.6	36.0	41.9	46.9	51.7	55.5
2010	14.7	20.2	30.4	37.1	41.2	45.9	50.0	58.4
2011	13.9	23.4	27.7	37.2	42.8	46.1	48.6	61.4
2012[1]	15.8	21.1	31.3	34.2	43.7	47.5	50.4	52.1
2013	14.4	23.3	29.4	40.9	44.0	49.5	51.9	-
2014	15.7	19.8	31.9	36.8	46.0	50.0	53.1	-
2015	14.4	21.3	27.2	39.8	45.6	51.6	52.7	56.8
2016	14.9	20.0	31.2	39.1	47.8	52.4	56.7	59.7

[1]Adjusted lengths

Table 6.10. HADDOCK. Weight (g) at age in the Barents Sea from the investigations winter 1983 – 2016. Observations outside main areas A-S not included.

Year\Age	1	2	3	4	5	6	7	8	9	10
1983	52	133	480	1043	1641	2081	2592	na	na	na
1984	36	196	289	964	1810	2506	2240	na	na	na
1985	35	138	432	731	1970	2517	na	na	na	na
1986	47	100	310	734	na	na	na	na	na	na
1987[1]	24	91	273	542	934	na	na	na	na	na
1988	23	139	232	442	743	1193	1569	na	na	na
1989	43	125	309	484	731	1012	1399	na	na	na
1990	34	148	346	854	986	1295	1526	na	na	na
1991	41	138	457	880	1539	1726	1808	na	na	na
1992	32	136	392	949	1467	2060	2274	na	na	na
1993	26	93	317	766	1318	1805	2166	na	na	na
1994	25	86	250	545	1041	1569	1784	na	na	na
1995	30	71	224	386	765	1286	1644	na	na	na
1996	30	93	220	551	741	1016	1782	na	na	na
1997	35	88	200	429	625	1063	1286	na	na	na
1998[2]	25	112	241	470	746	1169	1341	na	na	na
1999[2]	27	85	333	614	947	1494	1616	na	na	na
2000	32	108	269	720	1068	1341	1430	1910	2247	2654
2001	28	106	337	556	1100	1429	2085	1746	2854	3147
2002	30	84	144	623	848	1341	1938	2032	2511	2569
2003	38	127	202	493	981	1189	1613	1925	1940	2880
2004	23	98	266	459	780	1167	1328	1894	2280	3609
2005	29	84	253	469	699	1054	1378	1919	1998	2730
2006	26	107	303	540	821	1111	1332	1846	2119	4321
2007	32	112	237	539	970	1195	1608	1759	1802	2980
2008	33	115	250	538	692	1259	1609	1649	1983	1577
2009	25	98	230	440	718	1029	1402	1627	2372	2580
2010	28	76	273	473	656	945	1249	1799	1935	2463
2011	21	114	198	491	737	932	1152	2211	1636	2262
2012[2]	34	86	283	384	809	1036	1270	1379	1236	2678
2013	24	112	241	645	815	1186	1354	1480	1797	3198
2014	31	70	307	513	945	1253	1461	1589	1794	1967
2015	23	86	203	603	919	1347	1475	1861	1851	1937
2016	27	74	284	602	1054	1448	1785	2107	2244	2216

[1] Estimated weights
[2] Adjusted weights

Table 6.11. HADDOCK. Yearly weight increment (g) from the investigations in the Barents Sea winter 1983-2016. Observations outside main areas A-S not included.

Year\Age	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10
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	1	181	374	369	338	106			
1993-94	60	157	228	275	251	-21			
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	317	544	278			
1998-99	60	221	373	477	748	447			
1999-00	81	184	387	454	394	-64			
2000-01	74	229	287	380	361	744	316	944	900
2001-02	56	38	286	292	241	509	-53	765	-285
2002-03	97	118	349	358	341	272	-13	-92	369
2003-04	60	139	257	287	186	139	281	355	1669
2004-05	61	155	203	240	274	211	591	104	450
2005-06	78	219	287	352	412	278	468	200	2323
2006-07	86	130	236	430	374	497	427	-44	861
2007-08	83	138	301	153	289	414	41	224	-225
2008-09	65	115	190	180	337	143	18	723	597
2009-10	51	175	243	216	227	220	809	9	-110
2010-11	86	122	218	264	276	207	962	-163	327
2011-12	65	169	186	318	299	338	227	-975	1042
2012-13	78	155	362	431	377	318	210	418	1962
2013-14	46	195	272	300	438	275	235	314	170
2014-15	55	133	296	406	402	222	400	262	143
2015-16	51	198	399	451	529	438	632	383	365

Table 6.12. Survey mortality observed for haddock during the winter survey in the Barents Sea for the period 1993-2016.

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	1.56	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	1.10	2.68	2.50	2.96
2001-02	1.24	0.38	0.34	0.54	0.61	0.24	1.57
2002-03	2.00	0.66	0.09	-0.12	-0.24	0.85	1.63
2003-04	1.62	0.79	0.65	0.96	0.94	0.96	0.92
2004-05	1.28	0.77	0.22	0.73	0.64	1.99	4.19
2005-06	1.43	1.35	0.93	1.22	1.15	1.49	1.41
2006-07	1.16	0.75	0.00	-0.02	0.32	0.66	0.59
2007-08	0.56	0.18	0.41	-0.06	0.17	0.77	0.03
2008-09	1.64	0.59	-0.07	-0.47	0.60	1.61	1.85
2009-10	2.34	0.58	0.54	0.33	0.74	1.11	1.64
2010-11	1.61	0.54	0.71	0.64	0.75	1.30	1.86
2011-12	1.50	0.60	0.46	0.15	0.06	0.67	0.51
2012-13	1.30	1.20	0.53	0.02	0.40	0.19	0.26
2013-14	1.53	0.64	0.19	0.47	0.48	-0.12	1.04
2014-15	2.23	1.90	0.78	0.18	0.99	0.46	0.86
2015-16	2.26	0.88	0.58	0.87	0.95	0.23	0.38
	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	-0.07	0.34	1.60	1.49	2.08
2001-02	0.83	0.38	0.47	0.51	1.12	0.75	1.10
2002-03	1.19	0.52	0.55	0.92	1.16	1.27	1.39
2003-04	1.54	1.00	1.13	0.82	0.47	-0.07	0.74
2004-05	0.53	0.72	0.34	0.43	0.43	1.32	2.29
2005-06	1.26	1.69	0.90	1.02	1.23	1.23	1.38
2006-07	1.17	0.95	0.16	0.49	0.74	0.96	1.41
2007-08	0.60	0.05	-0.17	-0.27	0.56	1.29	1.10
2008-09	0.96	0.52	0.68	0.50	0.81	1.53	1.50
2009-10	1.62	1.16	0.92	0.48	1.02	1.70	2.36
2010-11	1.55	0.54	0.08	0.08	0.35	0.75	1.48
2011-12	1.84	0.09	0.34	0.13	0.48	0.84	1.04
2012-13	1.36	0.40	0.77	0.76	0.77	0.63	0.43
2013-14	0.94	0.28	0.43	0.38	-0.14	-0.11	0.52
2014-15	1.24	1.49	0.71	0.30	1.05	0.76	0.59
2015-16	0.70	0.71	0.00	0.54	0.55	0.06	-0.21

7 Distribution and abundance of redfish

Earlier reports from this survey has presented distribution maps and abundance indices based on acoustic observations of redfish. In recent years blue whiting has dominated the acoustic records in some of the main redfish areas. Due to incomplete pelagic trawl sampling the splitting of acoustic records between blue whiting and redfish has been very uncertain. The uncertainty relates mainly to the redfish, since it only makes up a minor proportion of the total value. This has been the case since the 2003 survey, and the acoustic results for redfish are therefore not included in the report.

The swept area time series for redfish 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.

Figure 7.1 shows the geographical distribution of ***Sebastes norvegicus*** (Golden redfish) based on the catch rates in bottom trawl. In most years the distribution is completely covered except towards northwest. *S. norvegicus* was also found in the extended survey area in 2014-2016, mainly west of Spitsbergen (strata 24). On average over all size groups about 13 % of the amount found in the standard survey area by numbers was found in the extended area in 2016 (Tables 7.2-7.4). Table 7.1 presents the time series (1986-2016) of swept area indices by 5 cm length groups. The indices have remained low since 1999 for all length groups. This indicates that about the twenty last year classes are very weak. However, in 2016 there was an increase in the indices of fish above 25 cm and the total index is the highest since 1998.

Also the coverage of ***S. mentella*** (Beaked redfish) (Figure 7.2) was not complete west and north of Spitsbergen. However, compared to *S. norvegicus* a smaller proportion was found in the extended survey area in 2016, about 4 % of the amount found in the standard survey area by numbers (Tables 7.7-7.9). Table 7.6 presents the time series (1986-2016) of swept area indices for *S. mentella* by 5 cm length groups. A few good year classes were born in 1988-1990 before the recruitment collapse in 1991 and the stock decreased to low levels for about fifteen years. However, these few year classes got enough protection to survive to maturity and since 2007-2008 both recruitment and the number of larger *S. mentella* has been at a fairly high level. In 2015 the estimated indices for 20-39 cm *S. mentella* were considerable higher than what was found in the most recent years, and in 2016 the same was found for 20-34 cm long fish.

Figure 7.3 shows the geographical distribution of ***S. viviparus*** (Norway redfish) and Table 7.11 presents the time series (1986-2016) of swept area indices by 5 cm length groups. Almost all *S. viviparus* are found in areas ABCD, mainly in main area B, and almost nothing in the extended survey area (Tables 7.12-7.14). The indices are often driven by a few large catches. There was a large and unexplained increase in the indices of most length groups from 2013 to 2014 and the 2015 to the highest levels in the time series. The 2016 indices were somewhat lower but well above the average of the time series for most length groups.

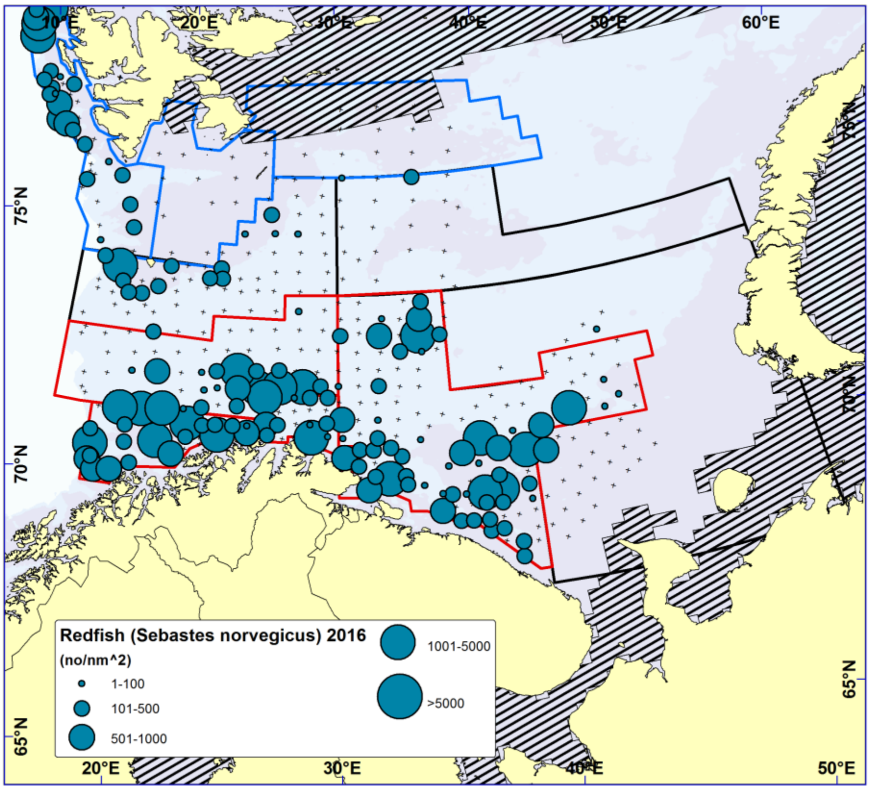

Figure 7.1. *Sebastes norvegicus*. Distribution in the trawl catches winter 2016 (number per nm^2). Zero catches are indicated by black points.

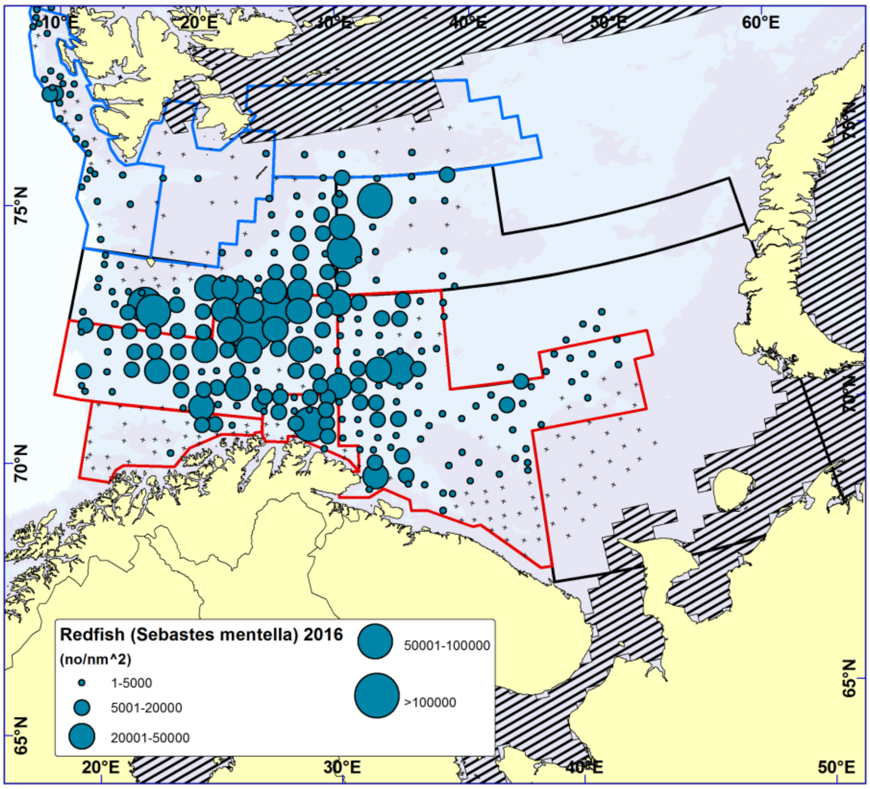

Figure 7.2. *Sebastes mentella*. Distribution in the trawl catches winter 2016 (number per nm^2). Zero catches are indicated by black points.

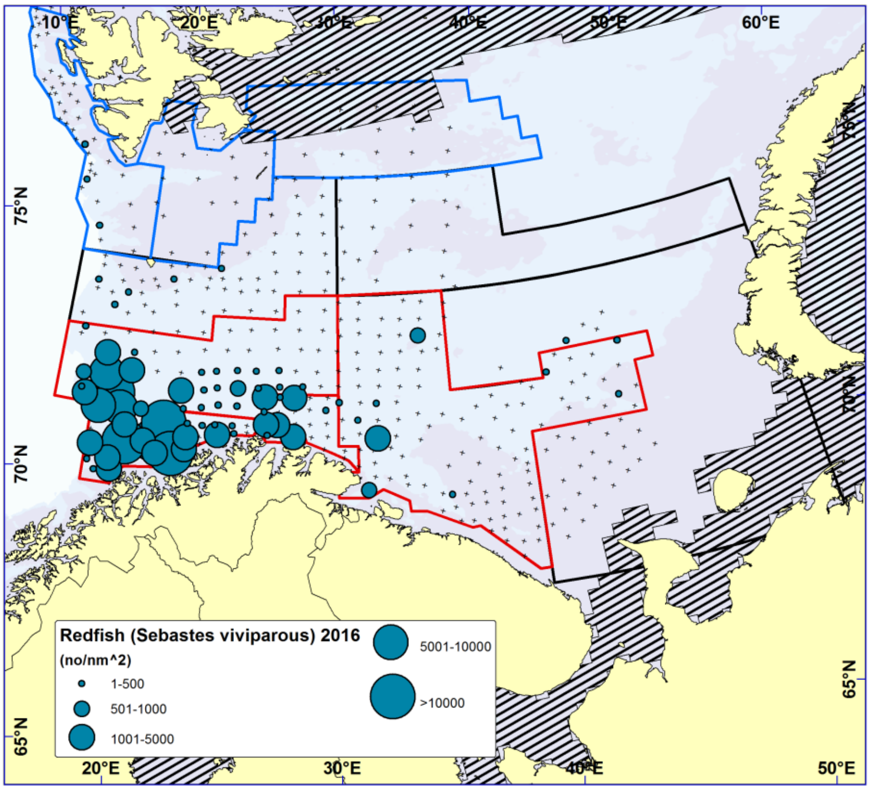

Figure 7.3. *Sebastes viviparus*. Distribution in the trawl catches winter 2016 (number per nm^2). Zero catches are indicated by black points.

Tables 7.2-7.4, 7.7-7.9 and 7.12-7.14 present swept area abundance indices by length groups for the three redfish species estimated with the new Sea2Data software StoX for new strata 24-26 in 2014-2016, standard strata 1-23 in 2012-2016 and all strata 1-26 in 2014-2016, respectively. As for cod and haddock, the estimates made with the SAS based Survey Program software used so far and the new Sea2Data software StoX are quite similar for most length groups and years.

Tables 7.5, 7.10 and 7.15 present estimated coefficients of variation (CV) for the redfish species by length groups in 2012-2016. Estimates are based on a stratified bootstrap approach with 500 replicates (with trawl stations being primary sampling unit). A CV of 20 % or less could be viewed as acceptable in a traditional stock assessment approach if the indices are unbiased (conditional on a catchability model). Values above this indicate a highly uncertain index. In most years only CVs for *S. mentella* less than 30 cm are within what could be considered as acceptable.

Table 7.1. *Sebastes norvegicus*. Abundance indices from bottom trawl surveys in the Barents Sea winter 1986-2016 (numbers in millions). 1986-1992 includes only main areas A, B, C and D. Observations outside main areas A-S not included. Species identification uncertain for fish < 10cm.

	Length group (cm)										Biomass
Year	**5-9**	**10-14**	**15-19**	**20-24**	**25-29**	**30-34**	**35-39**	**40-44**	**≥ 45**	**Total**	**(tons)**
1986	3.0	11.7	26.4	34.3	17.7	21.0	12.8	4.4	2.6	134	42811
1987	7.7	12.7	32.8	7.7	6.4	3.4	3.8	3.8	4.2	83	21627
1988	1.0	5.6	5.5	14.2	12.6	7.3	5.2	4.1	3.7	59	24793
1989	48.7	4.9	4.3	11.8	15.9	12.2	6.6	4.8	3.0	114	28792
1990	9.2	5.3	6.5	9.4	15.5	14.0	8.0	4.0	3.4	75	29920
1991	4.2	13.6	8.4	19.4	18.0	16.1	14.8	6.0	4.0	105	42146
1992	1.8	3.9	7.7	20.6	19.7	13.7	10.5	6.6	5.8	92	41492
1993	0.1	1.2	3.5	6.9	10.3	14.5	12.5	8.6	6.3	64	40909
1994	0.7	6.5	9.3	11.7	11.5	19.4	9.1	4.4	2.8	75	32348
1995	0.6	5.0	13.1	11.5	9.1	15.9	17.2	10.9	4.7	88	46558
1996	+	0.7	3.5	6.4	9.4	11.7	16.6	7.9	3.9	60	37756
1997[1]	-	0.5	1.5	3.2	6.6	21.4	28.0	8.4	3.3	73	49454
1998[1]	0.2	6.0	2.5	10.5	49.5	25.2	13.1	6.9	2.3	116	51114
1999	0.2	0.9	2.1	4.0	4.6	6.4	6.0	5.3	3.3	33	18281
2000	0.5	1.1	1.5	4.2	4.7	5.0	3.5	1.8	1.2	23.6	10316
2001	0.1	0.4	0.4	2.4	5.7	5.5	4.5	3.2	1.6	23.8	12970
2002	0.1	1.0	2.0	1.8	3.8	4.1	3.3	3.6	2.5	22.2	13280
2003	-	0.5	1.2	1.5	4.3	3.8	2.7	3.3	2.9	20.2	13997
2004	0.7	0.2	0.4	1.0	2.9	4.4	5.5	4.0	3.2	22.3	16366
2005	-	0.1	0.2	0.4	1.1	2.0	3.8	4.6	4.4	16.6	16593
2006[2]	-	-	-	0.2	2.5	5.4	6.1	4.1	4.2	22.5	18323
2007[2]	-	0.1	0.5	0.1	0.6	3.6	4.8	4.7	4.1	18.5	17067
2008	1.8	2.6	0.2	0.2	0.4	0.7	1.9	2.5	4.4	14.7	12243
2009	-	-	0.1	-	0.1	0.4	1.7	3.7	6.6	12.7	17495
2010	0.4	2.0	1.2	0.6	0.1	0.1	0.8	1.1	3.9	10.3	9564
2011	0.3	3.1	2.1	0.3	0.4	0.1	0.3	2.3	5.2	14.1	13124
2012[2]	0.8	4.4	4.0	1.9	0.6	0.3	0.9	3.6	6.2	22.7	16011
2013	0.1	7.5	5.5	4.0	1.7	0.4	0.9	0.8	3.6	24.4	11112
2014	0.1	1.1	1.5	3.0	3.4	1.0	0.5	1.4	4.1	16.0	11647
2015	0.1	0.9	1.5	3.0	2.7	2.0	0.5	0.7	3.4	15.0	10396
2016	0.8	1.3	1.5	2.4	4.2	3.6	3.4	1.7	5.9	24.7	20182

[1] Indices raised to also represent the Russian EEZ
[2] Indices not scaled for uncovered areas.

Table 7.2. S*ebastes norvegicus*. Abundance indices for new strata 24-26 winter 2014-2016 estimated by StoX software (numbers in millions).

Year	Length group (cm) 5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	>45	Total	Biomass (tons)
2014	0.04	0.3	0.4	1.4	2.6	1.3	0.2	0.5	0.4	7.1	2948
2015	-	0.2	0.2	0.1	0.8	0.8	0.4	-	0.2	2.6	1262
2016	-	-	0.1	0.3	0.5	1.2	0.8	0.1	0.1	3.1	1418

Table 7.3. S*ebastes norvegicus*. Abundance indices for standard strata 1-23 winter 2012-2016 estimated by StoX software (numbers in millions).

Year	Length group (cm) 5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	>45	Total	Biomass (tons)
2012[1]	0.8	4.3	3.9	1.8	0.5	0.3	0.9	3.6	6.2	22.4	15858
2013	0.1	7.3	4.8	3.9	1.5	0.4	0.9	0.8	3.7	23.4	11352
2014	0.1	1.0	1.4	3.0	3.3	1.0	0.5	1.4	4.1	15.9	11973
2015	0.1	0.9	1.4	3.0	2.6	2.0	0.5	0.7	3.4	14.5	10006
2016	0.7	1.3	1.5	2.4	4.3	3.6	3.4	1.6	5.7	24.5	18042

[1]Indices not scaled for uncovered areas.

Table 7.4. S*ebastes norvegicus*. Abundance indices for strata 1-26 winter 2014-2016 estimated by StoX software (numbers in millions).

Year	Length group (cm) 5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	>45	Total	Biomass (tons)
2014	0.2	1.4	1.8	4.4	5.9	2.3	0.7	1.9	4.5	23.0	14921
2015	0.1	1.1	1.6	3.1	3.4	2.8	0.8	0.7	3.5	17.1	11268
2016	0.7	1.3	1.6	2.7	4.8	4.8	4.2	1.7	5.8	27.6	19460

Table 7.5. S*ebastes norvegicus*. Estimates of coefficients of variation (%) winter 2012-2016 estimated by StoX software. 2014-2016 includes strata 24-26.

Year	Length group (cm) 5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49
2012	38	41	21	21	35	40	28	40	45
2013	55	40	27	17	22	45	38	39	38
2014	52	31	27	18	21	38	36	35	28
2015	64	37	31	28	21	18	23	36	27
2016	50	28	21	22	24	20	18	23	28

Table 7.6. *Sebastes mentella*[1]. Abundance indices from bottom trawl surveys in the Barents Sea winter 1986-2016 (numbers in millions). 1986-1992 includes only main areas A. B. C and D. Observations outside main areas A-S not included.

	Length group (cm)										**Biomass**
Year	**5-9**	**10-14**	**15-19**	**20-24**	**25-29**	**30-34**	**35-39**	**40-44**	**≥ 45**	**Total**	**(tons)**
1986	81.3	151.9	205.4	87.7	169.2	129.8	87.5	23.6	13.8	951	215946
1987	71.8	25.1	227.4	56.1	34.6	11.4	5.3	1.1	0.1	433	40365
1988	587.0	25.2	132.6	182.1	39.6	50.1	47.9	3.6	0.1	1070	99517
1989	622.9	55.0	28.4	177.1	58.0	9.4	8.0	1.9	0.3	962	55059
1990	323.6	304.5	36.4	55.9	80.2	12.9	12.5	1.5	0.2	830	52713
1991	395.2	448.8	86.2	38.9	95.6	34.8	24.3	2.5	0.2	1123	78144
1992	139.0	366.5	227.1	34.6	55.2	34.4	7.5	1.8	0.5	867	62528
1993	30.8	592.7	320.2	116.3	24.2	25.0	6.3	1.0	+	1117	70561
1994	6.9	258.6	289.4	284.3	51.4	69.8	19.9	1.4	0.1	979	117111
1995	263.7	71.4	637.8	505.8	90.8	68.8	31.3	3.9	0.5	1674	184972
1996	213.1	100.2	191.2	337.6	134.3	41.9	16.6	1.4	0.3	1037	122860
1997[2]	63.2	120.9	24.8	278.2	271.8	70.9	39.8	5.2	0.1	875	166996
1998[2]	1.3	88.2	62.5	101.0	203.2	40.4	12.9	1.1	0.2	511	95024
1999	2.2	6.8	68.2	36.8	167.4	71.3	21.0	3.1	0.1	374	96757
2000	9.0	12.7	39.4	76.8	141.9	97.1	26.6	6.9	1.5	412	113417
2001	9.3	22.5	7.0	54.9	77.4	73.2	9.4	0.6	0.1	254	63286
2002	16.1	7.2	19.1	41.7	103.9	113.7	22.9	1.4	0.03	326	91453
2003	3.9	3.9	10.0	12.4	70.8	199.8	46.9	6.0	0.3	354	137169
2004	2.2	3.0	6.9	18.5	32.9	86.7	31.8	2.0	0.1	184	70049
2005	-	6.2	7.3	10.7	28.4	153.4	86.6	3.9	0.2	297	129777
2006[2]	98.8	1.9	9.8	14.6	22.7	102.8	81.9	2.7	0.7	336	103311
2007[2]	372.0	116.0	2.5	6.5	12.0	118.0	118.0	6.5	0.1	752	136545
2008	846.5	353.8	26.2	5.3	11.9	114.0	179.9	4.9	0.1	1543	160657
2009	94.2	321.7	134.2	5.4	8.7	66.1	160.1	5.7	0.4	797	149846
2010	646.8	273.1	213.2	63.8	7.1	73.4	190.4	5.9	0.4	1474	192570
2011	495.5	227.6	210.9	148.2	14.0	46.4	156.5	4.9	0.2	1304	168586
2012[3]	127.1	274.8	84.3	122.9	46.1	14.1	150.8	17.3	0.2	838	159784
2013	247.9	224.0	243.1	158.2	143,1	35.1	192.0	27.0	0.3	1271	240791
2014	89.2	172.9	249.0	112.8	123.1	50.9	117.4	13.8	0.2	929	165355
2015	175.2	110.5	217.5	303.3	290.7	214.1	171.7	18.1	0.2	1501	336755
2016	612.1	104.6	146.4	326.2	208.7	159.2	120.4	13.8	0.6	1692	260433

[1] Includes unidentified *Sebastes* specimens, mostly less than 10cm
[2] Indices raised to also represent the Russian EEZ
[3] Indices not scaled for uncovered areas.

Table 7.7. *Sebastes mentella*[1]. Abundance indices for new strata 24-26 winter 2014-2016 estimated by StoX software (numbers in millions).

	Length group (cm)										Biomass
Year	**5-9**	**10-14**	**15-19**	**20-24**	**25-29**	**30-34**	**35-39**	**40-44**	**>45**	**Total**	**(tons)**
2014	19.1	9.0	11.4	6.8	5.4	1.7	2.2	0.4	-	55.9	5503
2015	14.4	7.2	9.8	11.9	11.4	5.2	3.4	0.1	0.03	63.5	9305
2016	53.9	3.1	2.1	4.5	4.8	4.1	1.4	0.3	-	74.3	4441

[1] Includes unidentified *Sebastes* specimens, mostly less than 10cm

Table 7.8. *Sebastes mentella*[1]. Abundance indices for standard strata 1-23 winter 2012-2016 estimated by StoX software (numbers in millions).

	Length group (cm)										Biomass
Year	**5-9**	**10-14**	**15-19**	**20-24**	**25-29**	**30-34**	**35-39**	**40-44**	**>45**	**Total**	**(tons)**
2012	128.1	277.6	85.9	124.9	47.2	14.3	153.5	17.7	0.2	849.4	168001
2013	247.6	224.5	243.2	158.4	143.2	35.1	192.5	27.0	0.3	1271.9	240334
2014	89.9	173.8	248.1	112.9	124.0	50.5	115.3	13.7	0.2	928.5	170230
2015	173.4	109.7	214.5	300.5	289.6	214.5	170.6	18.0	0.1	1491.0	340105
2016	610.2	104.4	147.5	329.2	212.6	162.5	123.6	14.1	0.6	1704.6	262331

[1] Includes unidentified *Sebastes* specimens, mostly less than 10cm

Table 7.9. *Sebastes mentella*[1]. Abundance indices for strata 1-26 winter 2014-2016 estimated by StoX software (numbers in millions).

	Length group (cm)										Biomass
Year	**5-9**	**10-14**	**15-19**	**20-24**	**25-29**	**30-34**	**35-39**	**40-44**	**>45**	**Total**	**(tons)**
2014	109.0	182.8	259.5	119.7	129.4	52.2	117.5	14.1	0.2	984.4	175733
2015	187.8	116.9	224.3	312.4	301.0	219.7	174.0	18.1	0.2	1554.5	349410
2016	664.1	107.5	149.6	333.7	217.4	166.6	125.0	14.4	0.6	1778.9	266772

[1] Includes unidentified *Sebastes* specimens, mostly less than 10cm

Table 7.10. *Sebastes mentella*. Estimates of coefficients of variation (%) winter 2012-2016 estimated by StoX software. 2014-2016 includes strata 24-26.

	Length group (cm)								
Year	**5-9**	**10-14**	**15-19**	**20-24**	**25-29**	**30-34**	**35-39**	**40-44**	**45-49**
2012	16	12	13	11	21	32	37	54	44
2013	15	15	35	23	32	29	39	41	49
2014	8	12	11	15	20	21	30	27	48
2015	13	12	14	18	25	22	19	28	47
2016	9	11	13	20	15	15	18	17	58

Table 7.11. *Sebastes viviparus*. Abundance indices from bottom trawl surveys in the Barents Sea winter 1986-2016(numbers in millions). 1986-1992 includes only the area covered in 1986. Species identification uncertain for fish < 10cm.

Year	Length group (cm)							Biomass (tons)
	5-9	10-14	15-19	20-24	25-29	≥ 30	Total	
1986	1.0	2.3	4.8	6.4	1.3	0.0	16	1989
1987	0.0	0.5	4.4	8.0	1.9	0.2	15	2469
1988	6.9	6.2	6.4	10.0	3.6	0.3	33	3785
1989	3.7	7.8	6.3	4.3	0.9	0.0	23	1802
1990	0.3	12.7	11.7	9.9	3.3	0.2	38	4204
1991	3.7	13.6	16.1	16.8	4.2	0.4	55	6199
1992	15.1	32.1	27.4	16.9	5.1	0.3	97	7996
1993	18.6	23.7	7.7	3.5	1.0	0.0	55	2378
1994	48.0	64.0	15.0	12.3	1.2	0.2	141	6057
1995	7.6	53.2	21.9	7.9	2.4	0.3	93	5709
1996	0.5	45.0	42.5	35.4	5.5	0.1	129	12751
1997[1]	0.9	23.8	28.5	18.5	4.3	0.0	76	7420
1998[1]	0.7	9.3	41.7	20.6	2.9	0.1	75	7894
1999	1.6	10.0	11.5	2.9	0.7	0.0	27	1990
2000	0.9	4.8	36.5	21.7	2.1	0.1	66	7887
2001	0.3	2.2	29.5	33.7	3.7	0.1	70	9190
2002	0.3	3.1	17.0	14.5	1.2	0.1	36	4660
2003	0.2	4.0	21.4	30.1	4.2	0.2	60	8527
2004	0.1	1.8	24.5	32.9	3.3	0.3	63	8967
2005	0.2	1.6	16.2	36.9	6.1	0.4	61	9691
2006[1]	0.8	4.4	3.6	10.2	2.2	0.2	21	3002
2007[1]	0.7	5.2	15.6	36.5	3.4	0.1	62	8897
2008	0.0	1.8	5.8	20.8	4.5	0.0	33	5518
2009	0.5	0.5	3.1	10.9	3.4	0.4	19	3473
2010	1.7	0.5	10.0	52.5	7.5	0.0	72	12389
2011	0.5	1.2	2.1	7.5	2.1	0.1	14	2395
2012[1]	0.6	3.9	4.0	28.9	6.2	0.1	44	7126
2013	1.2	9.4	3.3	23.3	8.5	0.1	46	6489
2014	9.8	16.7	20.2	61.3	14.6	2.0	125	18055
2015	7.5	27.6	31.2	67.0	9.1	0.1	143	15963
2016	2.8	27.3	18.3	29.4	11.3	1.0	90	10879

[1] Indices not scaled for uncovered areas, *Sebastes viviparus* is mainly found in NEZ

Table 7.12. *Sebastes viviparus*. Abundance indices for new strata 24-26 winter 2014-2016 estimated by StoX software (numbers in millions).

Year	Length group (cm) 5-9	10-14	15-19	20-24	25-29	>30	Total	Biomass (tons)
2014	-	0.1	0.04	-	-	-	0.1	
2015	-	-	0.04	-	-	-	0.04	
2016	-	-	0.1	-	-	-	0.1	

Table 7.13. *Sebastes viviparus*. Abundance indices for standard strata 1-23 winter 2012-2016 estimated by StoX software (numbers in millions).

Year	Length group (cm) 5-9	10-14	15-19	20-24	25-29	>30	Total	Biomass (tons)
2012	0.6	3.9	4.0	28.9	6.2	0.1	43.7	
2013	1.2	9.4	3.3	23.3	8.5	0.1	45.7	
2014	11.2	17.5	20.8	63.2	14.9	2.0	129.6	
2015	7.3	27.0	30.4	64.9	8.9	0.1	138.6	
2016	2.8	26.4	18.2	28.9	11.2	0.9	88.4	

Table 7.14. *Sebastes viviparus*. Abundance indices for strata 1-26 winter 2014-2016 estimated by StoX software (numbers in millions).

Year	Length group (cm) 5-9	10-14	15-19	20-24	25-29	>30	Total	Biomass (tons)
2014	10.2	17.6	20.8	63.2	14.9	2.0	129.8	
2015	7.3	27.0	30.4	64.9	8.9	0.1	138.6	
2016	2.8	26.4	18.3	28.9	11.2	0.9	88.5	

Table 7.15. *Sebastes viviparus*. Estimates of coefficients of variation (%) winter 2012-2016 estimated by StoX software. 2014-2016 includes strata 24-26.

Year	Length group (cm) 5-9	10-14	15-19	20-24	25-29	30-34
2012	45	30	48	45	43	100
2013	58	32	25	41	51	98
2014	43	35	40	40	41	79
2015	38	32	34	43	53	100
2016	37	28	29	23	46	95

8 Distribution and abundance of Greenland halibut

Figure 8.1 shows the distribution of bottom trawl catch rates of Greenland halibut. The most important distribution areas for the adult fish (depths between 500 and 1000 m along the western slope), are not covered by the survey. The observed distribution pattern in 2016 was similar to those observed in previous years' surveys. Greenland halibut was found in the extended survey area in 2014-2016 (Tables 8.2-8.4). In 2016 a higher number of fish less than 25 cm was found in the extended area (mainly strata 26) than in the standard area (strata 1-23). On average over all size groups about 19 % of the amount found in the standard survey area by numbers was found in the extended area. The estimates made with the SAS based Survey Program software used so far and the new Sea2Data software StoX are quite similar for most length groups and years (Tables 8.1 and 8.3).

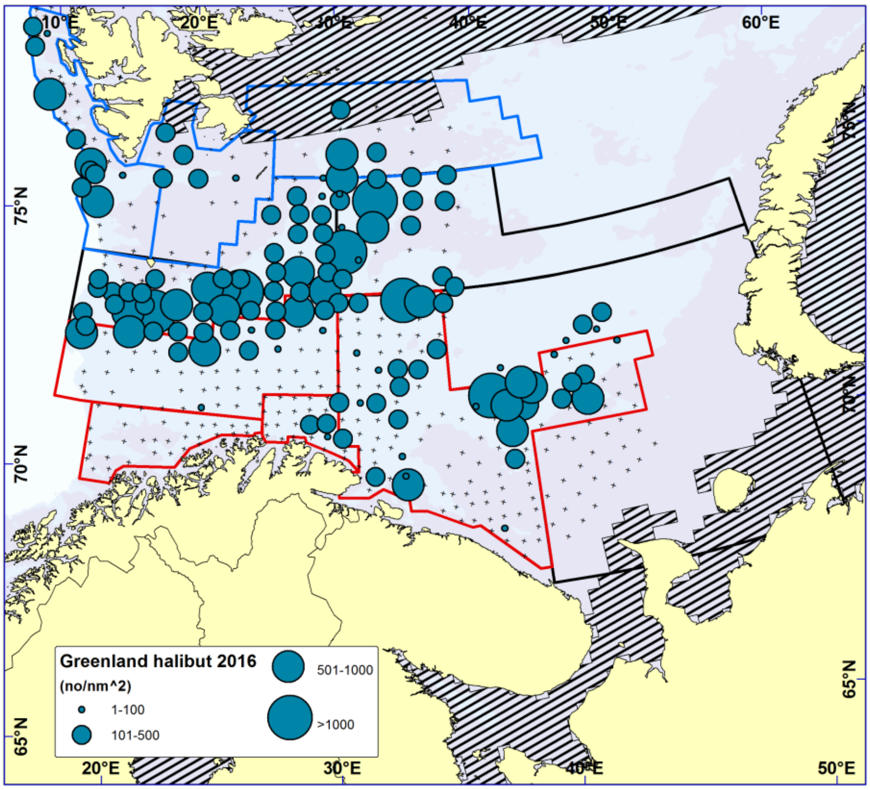

Figure 8.1 GREENLAND HALIBUT. Distribution in the trawl catches winter 2016 (number per nm^2). Zero catches are indicated by black points.

The time series of swept area indices by 5 cm length groups for 1990-2016 is presented in Table 8.1. Abundance indices have been low in the whole period, with few signs of improved recruitment in the covered area. However, recruitment from more northern areas has led to an increase in abundance indices of length groups above 30 cm since about 2005. There was a large increase in the indices of most length groups between 30 and 79 cm from 2014 to 2015, and the total index was the highest in the time series back to 1990. In 2016 the indices of length groups between 25 and 44 cm showed an increase, while the indices of fish between 45 and 69 cm were lower than in 2015. Table 8.5 presents estimated coefficients of variation by length groups in 2012-2016, which only are acceptable (<20) for fish between 40 and 60 cm.

Table 8.1. GREENLAND HALIBUT. Abundance indices from the bottom trawl surveys in the Barents Sea winter 1990-2016 (numbers in thousands). 1990-1992 includes only main areas A, B, C and D. Observations outside main areas A-S not included.

Year	Length group (cm)																Biomass (tons)
	≤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	8443
1991	0	42	262	618	655	868	954	1320	1875	1577	847	165	34	34	0	9270	10584
1992	14	35	64	149	509	843	1096	1072	1029	827	633	108	31	31	26	6500	7319
1993	0	0	17	67	265	959	2310	4004	3374	1911	1247	482	139	139	34	14840	19299
1994	0	0	16	99	142	1191	2625	3866	2885	1796	753	440	25	25	0	13838	16337
1995	42	0	0	0	83	149	3228	9240	7438	2811	2336	909	468	468	0	26761	37576
1996	3149	0	0	0	61	124	1163	3969	4425	1824	1041	593	346	73	12	16781	19454
1997[1]	0	65	0	0	173	227	858	4344	5500	2725	1545	632	282	66	22	16439	23665
1998[1]	80	217	1006	444	532	403	1064	3888	6331	2977	1725	633	337	76	43	19765	26045
1999	41	82	261	427	576	264	757	1706	3069	1640	1077	483	109	74	28	10594	14649
2000	122	184	322	859	1753	3841	2190	1599	2143	1715	1163	564	242	75	0	16769	17024
2001	68	49	129	178	663	1470	3674	3258	2263	1990	1081	522	204	48	40	15636	18133
2002	268	0	71	33	408	996	1927	3702	3188	2210	1110	975	230	157	96	15371	21004
2003	50	0	71	17	295	674	1793	2916	4647	2186	708	609	231	125	0	14322	19490
2004	67	103	15	0	316	1238	1224	1714	2278	1227	791	298	146	95	26	9537	11795
2005	259	69	157	1125	2194	2695	4173	3687	3817	1992	935	583	330	116	0	22132	21922
2006[2]	0	72	93	408	1949	5096	4565	5696	4250	2103	880	442	252	34	18	25859	25935
2007[2]	0	18	139	1715	1337	2885	4806	4890	3946	1945	678	547	351	78	89	23424	23957
2008	0	0	0	240	1689	6570	4762	6033	5163	3361	814	635	173	79	48	29567	29971
2009	55	0	0	25	1033	4256	8005	4476	4000	2221	978	613	430	249	149	26489	28663
2010	0	0	0	98	671	3607	5675	6498	4853	2449	1053	550	226	126	42	25850	29164
2011	50	0	0	0	214	4369	5812	5451	5189	3651	686	928	324	251	93	27020	31773
2012[2]	77	0	0	0	51	1124	4435	5275	4368	2744	1122	193	74	0	46	19507	22310
2013	0	0	0	0	0	502	3427	4734	5187	3580	1927	925	345	308	153	21087	30132
2014	0	0	45	91	151	368	2182	5425	5711	3485	2244	1325	138	243	79	21487	30715
2015	346	0	64	0	279	1608	3190	6527	7399	6835	3220	1953	583	340	0	32344	45899
2016	51	0	113	481	921	1909	3379	4423	5249	5253	1885	1863	631	97	78	26333	34608

[1] Indices raised to also represent the Russian EEZ

[2] not scaled for uncovered areas.

Table 8.2. GREENLAND HALIBUT. Abundance indices for new strata 24-26 winter 2014-2016 estimated by StoX software (numbers in thousands).

	Length group (cm)																Biomass
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**	**(tons)**
2014	-	130	137	-	134	447	1338	1427	1333	288	794	39	116	-	-	6182	7274
2015	-	-	-	389	30	322	658	1082	699	703	669	66	106	38	-	4761	6046
2016	666	908	589	426	330	425	330	723	338	252	67	33	139	-	33	5261	2838

Table 8.3. GREENLAND HALIBUT. Abundance indices for strata 1-23 winter 2014-2016 estimated by StoX software (numbers in thousands).

	Length group (cm)																Biomass
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**	**(tons)**
2012	76	-	-	-	51	1145	4494	5329	4487	2755	1135	193	74	-	49	19787	22488
2013	-	-	-	-	-	504	5332	4838	5328	3647	1929	928	346	309	154	23314	31460
2014	-	-	45	91	154	365	2256	5551	5861	3532	2238	1356	153	258	79	21939	30903
2015	362	-	61	-	281	1598	3166	6425	7219	6693	3310	1914	580	331	-	31941	46428
2016	204	-	123	506	943	1942	3464	4530	5462	5599	1988	1963	642	97	78	27539	35369

Table 8.4. GREENLAND HALIBUT. Abundance indices for standard strata 1-26 winter 2014-2016 estimated by StoX software (numbers in thousands).

	Length group (cm)																Biomass
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**	**(tons)**
2014	-	130	182	91	288	812	3594	6978	7194	3820	3032	1395	269	258	79	28121	38177
2015	362	-	61	389	311	1920	3824	7507	7918	7396	3979	1980	686	369	-	36702	52474
2016	870	908	712	932	1273	2367	3794	5253	5800	5851	2055	1996	781	97	111	32800	38207

Table 8.5. GREENLAND HALIBUT. Estimates of coefficients of variation (%) winter 2012-2016 estimated by StoX software. 2014-2016 includes strata 24-26

	Length group (cm)														
Year	**10-14**	**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**	**80-84**
2012	93	-	-	-	100	23	13	14	14	11	24	70	72	-	-
2013	-	-	-	-	-	44	39	12	16	20	19	33	50	50	-
2014	-	93	78	68	57	26	23	16	20	17	27	23	61	51	72
2015	83	-	99	66	46	25	22	17	15	17	29	36	34	43	-
2016	72	63	48	42	38	25	19	29	25	30	16	19	31	70	72

9 Distribution and abundance of capelin, polar cod and blue whiting

9.1 Capelin

Although capelin is primarily a pelagic species, small amounts of capelin are normally caught in the bottom trawl throughout most of the investigated area. In Figure 9.1 catch rates of capelin smaller and larger than 14 cm are shown for each of the winter survey in 2015. Capelin smaller than 14 cm during this period will mainly comprise the immature stock component, while the larger capelin constitutes the prespawning capelin stock. Some few trawl hauls show large capelin catches (numbers exceeding 100 000 individuals) and these can probably not be considered representative for the density in the area, because such hauls will either result from hitting a capelin school at the bottom or up in the water column. For this reason, we chose not to present swept-area based indices for capelin in this report.

At this time of the year, mature capelin has started their approach to the spawning areas along the coast of Troms, Finnmark and the Kola peninsula, while immature capelin will normally be found further north and east, in the wintering areas. This is reflected on the maps of capelin distribution, even though some large capelin is always found north of 75°N, and smaller capelin are found sporadically in near-coastal areas in a couple of years. The geographical coverage of the total capelin stock is incomplete, but the maturing component is probably completely covered.

It has been noted during several surveys that when sampling capelin from demersal and pelagic trawls, the individuals from demersal trawls are normally larger (and older) than those sampled pelagically. This has led to formation of a hypothesis saying that larger individuals tend to stay deeper than smaller individuals and some even to take up a demersal life. This hypothesis has not been tested, and during the winter surveys there are probably too few pelagic hauls to study the vertical distribution of capelin in a systematic way.

9.2 Polar cod

Polar cod are not well represented in the trawl hauls conducted during the winter surveys (Figure 9.2). This reflects the more northern and eastern distribution area of this endemic arctic species. During this time of the year, the polar cod is known to be spawning under the ice-covered areas of the Pechora Sea and close to Novaya Semlya. It is not clear whether the concentrations found in open water these years are mature fish either on their way to spawning or from the spawning areas, or this is immature fish.

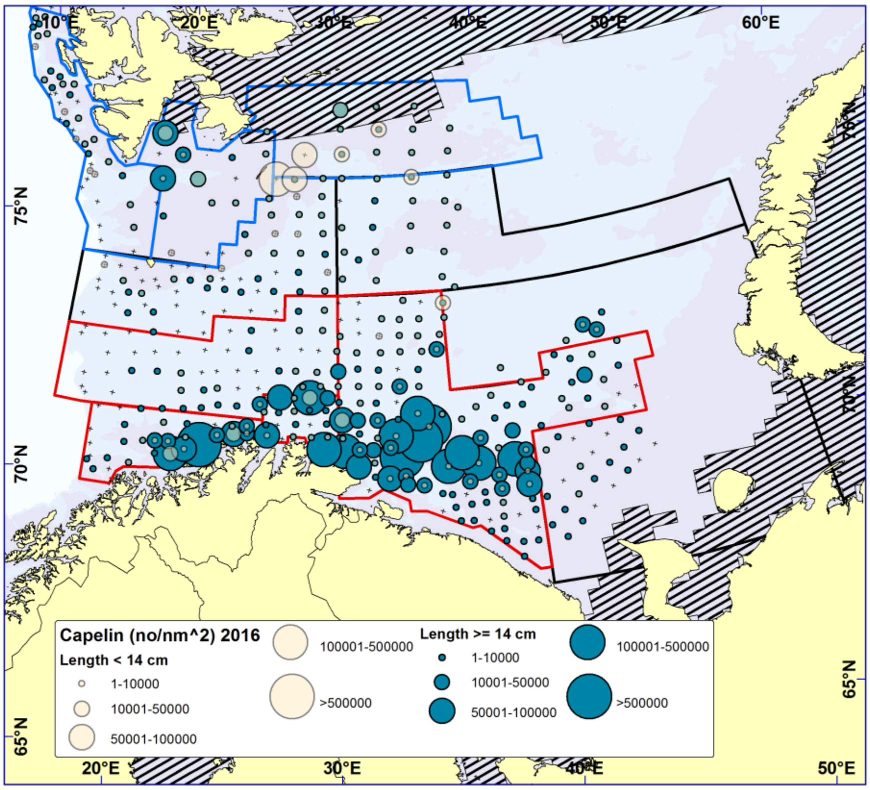

Figure 9.1. CAPELIN. Distribution in the trawl catches winter 2016 (number per nm^2). Zero catches are indicated by black points.

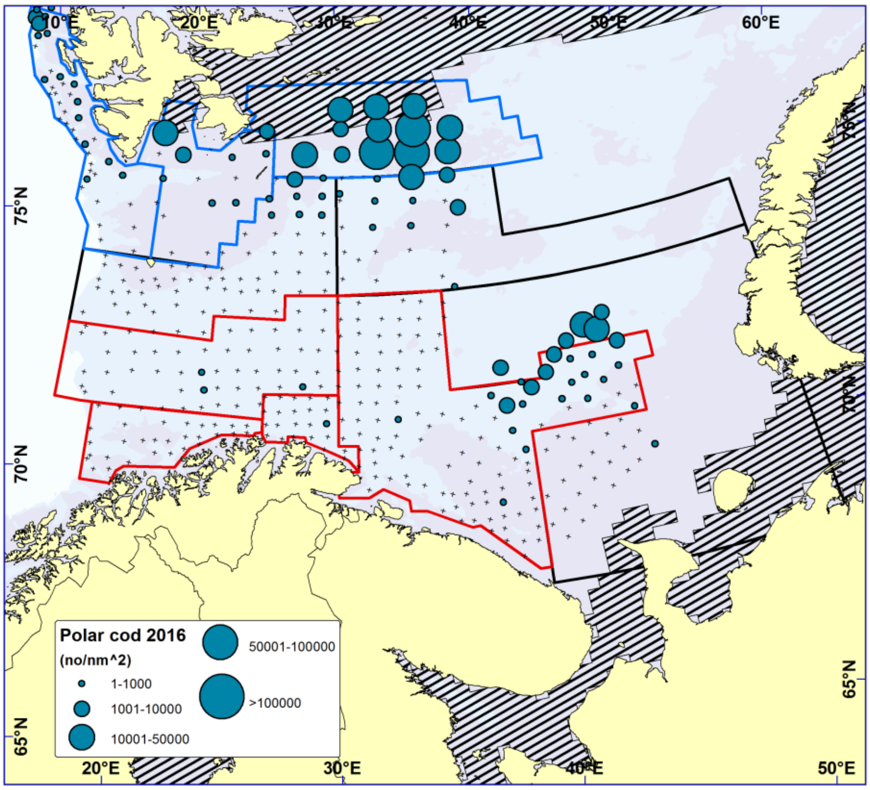

Figure 9.2 POLAR COD. Distribution in the trawl catches winter 2016 (number per nm^2). Zero catches are indicated by black points.

9.3 Blue whiting

Since 2000 the blue whiting has shown a wider distribution than usual. The echo recordings in 2001 and 2002 indicated unusual high abundance in the Barents Sea, while in 2003 it had decreased somewhat. In the 2004 survey the echo abundance increased again and peaked in 2006. Since then it has decreased considerably. Figure 9.3 shows the geographical distribution of the bottom trawl catch rates of blue whiting in 2016. 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 number of pelagic hauls has, however, been too low to properly separate the pelagic recordings. During the years with high abundance of blue whiting, recordings of pelagic redfish, haddock and small cod might have been masked by dense concentrations of blue whiting.

Table 9.1 shows the bottom trawl swept area estimates by 5 cm length groups for the years 2001-2016. High abundance of fish below 20 cm in 2001, 2002, 2004, 2005, 2012 and 2015 reflects abundant recruiting (age 1) year classes. These recruits are observed in the survey as larger fish in the following years. As for some of the other target species in the survey, there was a large increase in the indices for most length groups from 2014 to 2015. The recruitment signal is less in 2016, while the total index of fish above 20 cm and total biomass are larger than in most recent years. Only small amounts of blue whiting were found in the extended survey area (Tables 9.2-9.4).

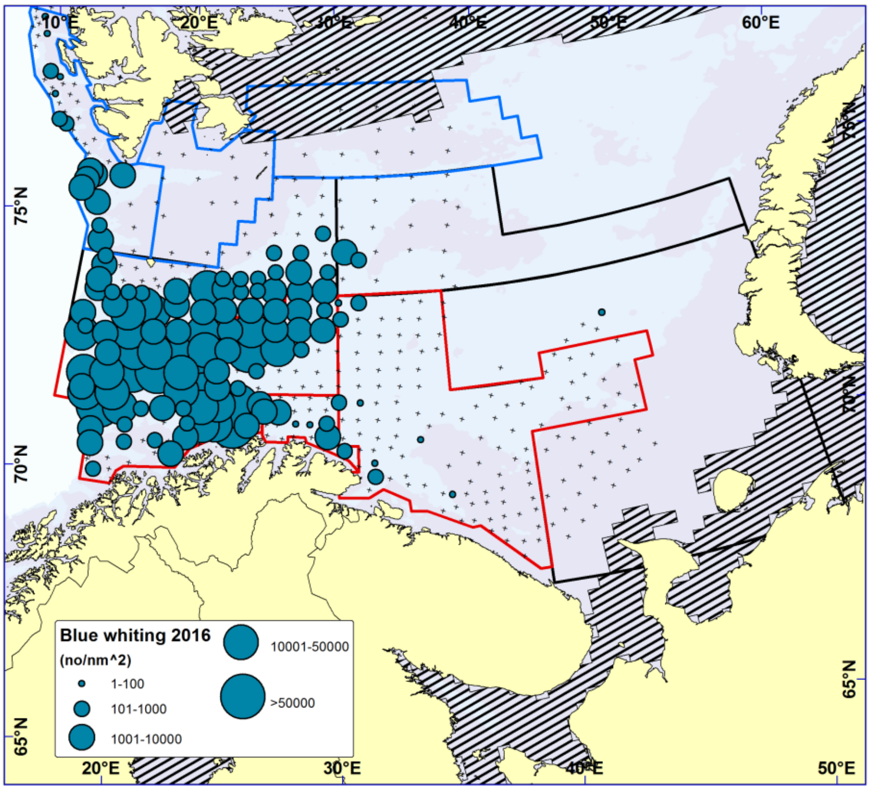

Figure 9.3 BLUE WHITING. Distribution in the trawl catches winter 2016 (number per nm^2). Zero catches are indicated by black points.

Table 9.1. BLUE WHITING. Abundance indices (wept area estimates) from bottom trawl surveys in the Barents Sea winter 2001-2016 (numbers in millions). Observations outside main areas A-S not included.

Year	Length group (cm)								Total	Biomass (tonnes)
	5-9	10-14	15-19	20-24	25-29	30-34	35-39	≥40		
2001	0.1	306.6	1391.3	616.0	44.6	5.3	1.5	0.1	2365	77706
2002	0.0	0.8	434.7	658.1	80.9	18.3	3.1	0.1	1196	58217
2003	0.0	3.2	192.0	488.8	81.8	29.7	6.3	1.0	803	53266
2004	0.0	7.2	716.0	827.6	277.4	37.6	1.1	0.2	1867	96647
2005	0.0	125.5	715.4	980.1	222.7	31.5	0.1	0.2	2076	106230
2006	0.0	0.0	162.9	1486.8	591.2	68.3	2.0	0.1	2311	171380
2007	0.0	0.0	4.0	594.6	276.1	21.5	1.5	0.3	898	73233
2008	0.0	0.0	0.3	12.0	125.5	19.7	1.3	0.1	159	19166
2009	0.0	0.0	0.02	2.7	50.0	21.0	1.4	0.02	75	10221
2010	0.0	0.0	0.71	1.9	9.4	15.1	0.8	0.0	28	4278
2011	0.0	0.0	0.05	0.2	2.5	4.7	2.1	0.0	9	1788
2012	0.0	84.3	663.9	1.1	1.5	4.6	1.9	0.3	758	18758
2013	0.0	0.0	74.9	393.6	12.5	11.4	6.8	0.05	499	28401
2014	0.0	0.0	178.1	33.7	9.6	1.6	1.5	0.04	225	8400
2015	0.0	117.0	893.7	140.3	41.4	8.8	7.4	0.0	1208	41918
2016	0.0	0.1	252.4	360.2	37.6	6.3	3.0	0.1	660	35953

Tables 9.2-9.4 present swept area abundance indices by length groups for blue whiting estimated with the new Sea2Data software StoX for new strata 24-26 in 2014-2016, standard strata 1-23 in 2012-2016 and all strata 1-26 in 2014-2016, respectively. As for the other species in this report, the estimates made with the SAS based Survey Program software used so far and the new Sea2Data software StoX are quite similar for most length groups and years (Tables 9.1 and 9.3).

Table 9.5 presents estimated coefficients of variation (CV) for the redfish species by length groups in 2012-2016. Estimates are based on a stratified bootstrap approach with 500 replicates (with trawl stations being primary sampling unit). A CV of 20 % or less could be viewed as acceptable in a traditional stock assessment approach if the indices are unbiased (conditional on a catchability model). Values above this indicate a highly uncertain index. In all years CVs for most length groups are above the acceptable level. But as earlier mentioned acoustic observations would better reflect the relative density distribution for this species which is mainly found pelagic.

Table 9.2. BLUE WHITING. Abundance indices for new strata 24-26 winter 2014-2016 estimated by StoX software (numbers in millions).

Year	Length group (cm)								Total	Biomass
	5-9	10-14	15-19	20-24	25-29	30-34	35-39	≥40		(tonnes)
2014	-	-	0.3	0.3	0.1	0.2	0.1	-	1.0	118
2015	-	-	0.2	0.1	0.3	0.8	0.4	-	1.7	272
2016	-	-	2.1	5.3	1.5	0.5	0.3	-	9.8	835

Table 9.3. BLUE WHITING. Abundance indices for standard strata 1-23 winter 2012-2016 estimated by StoX software (numbers in millions).

Year	Length group (cm)								Total	Biomass
	5-9	10-14	15-19	20-24	25-29	30-34	35-39	≥40		(tonnes)
2012	-	84.4	666.2	1.1	1.7	5.3	2.0	0.3	761.1	17909
2013	-	-	75.0	394.3	12.5	11.5	6.8	0.1	500.1	28951
2014	-	-	179.9	34.1	9.6	1.6	1.5	0.04	226.7	8367
2015	-	114.9	900.2	140.7	40.8	8.8	7.4	-	1212.8	34055
2016	-	0.1	258.1	365.9	37.9	6.3	3.0	0.1	671.4	39074

Table 9.4. BLUE WHITING. Abundance indices for strata 1-26 winter 2014-2016 estimated by StoX software (numbers in millions).

Year	Length group (cm)								Total	Biomass
	5-9	10-14	15-19	20-24	25-29	30-34	35-39	≥40		(tonnes)
2014	-	-	180.2	34.4	9.7	1.8	1.7	0.04	227.7	8485
2015	-	114.9	900.4	140.8	41.1	9.5	7.8	-	1214.5	34327
2016	-	0.1	260.2	371.2	39.4	6.7	3.3	0.1	681.2	39909

Table 9.5. BLUE WHITING. Estimates of coefficients of variation (%) 2012-2016 estimated by StoX software. 2014-2016 includes strata 24-26.

Year	Length group (cm)							
	5-9	10-14	15-19	20-24	25-29	30-34	35-39	≥40
2012	-	32	30	39	45	38	29	98
2013	-	-	70	31	57	44	44	99
2014	-	-	23	22	24	23	18	137
2015	-	50	21	21	30	29	35	-
2016	-	96	33	24	16	25	27	97

10 Registrations of other species

During the 2007-2016 surveys a total of 95 fish species were recorded belonging to 35 families (Table 10.1), 50 species were recorded all years. Distribution maps for all species caught at the winter survey 2007-2012 were presented as a separate report (Wienerroither et al. 2013) similar to the Atlas of the Barents Sea fishes (Wienerroither et al. 2011, based on data from the ecosystem survey). Since the start of the winter survey in 1981 the number of fish taxa recorded has increased due to expansion of the surveyed area, better taxonomic skills and identification keys (Johannesen et al. 2009). Routines for freezing difficult specimens for later identification on land by taxonomists have been established and given good results, but there is room for improvement and some groups pose unresolved taxonomic challenges, mainly liparids (see also footnotes in Table 10.1).

Table 10.1. Fish species recorded at the winter survey 2007-2016, all gears included. The number of years each species was recorded is shown and for species not caught every year the capture history (1 = caught and 0 = not caught) is shown in parenthesis for consecutive years 2007-2016. Some clear misidentifications have been left out.

Order	Family	Species	Number of years caught
Myxiniformes	Myxinidae	*Myxine glutinosa*	4 (0,1,0,1,1,0,0,0,1,0)
Squaliformes	Dalatiidae	*Etmopterus spinax*	4 (1,1,0,0,1,1,0,0,0,0)
		Somniosus microcephalus	5 (1,0,1,0,1,0,0,0,1,1)
Rajiformes	Arhynchobatidae	*Bathyraja spinicauda*	10
	Rajidae	*Amblyraja hyperborea*	9 (1,1,1,1,1,1,0,1,1,1)
		Amblyraja radiata	10
		Rajella fyllae	10
		Rajella lintea	6 (0,1,1,0,1,0,1,0,1,1)
Chimaeriformes	Chimaeridae	*Chimaera monstrosa*	10
Clupeiformes	Clupeidae	*Clupea harengus*	10
		Clupea pallasii suworowi	5 (0,1,0,0,1,0,1,1,0,1)
Osmeriformes	Argentinidae	*Argentina silus*	10
	Alepocephalidae	*Xenodermichthys copei*	1 (0,0,0,0,0,0,0,0,1,0)
	Osmeridae	*Mallotus villosus*	10
Salmoniformes	Salmonidae	*Oncorhynchus gorbuscha*	1 (0,0,0,0,0,0,0,1,0,0)
Stomiiformes	Sternoptychidae	*Argyropelecus hemigymnus*	3 (0,0,0,1,0,1,0,0,0,1)
		Maurolicus muelleri	10
Aulopiformes	Paralepididae	*Arctozenus risso*	10
Myctophiformes	Myctophidae	unidentified	9 (1,1,1,1,1,1,0,1,1,1)
		Benthosema glaciale	8 (0,0,1,1,1,1,1,1,1,1)
Gadiformes	Macrouridae	*Macrourus berglax*	10
	Gadidae	*Boreogadus saida*	10
		Gadiculus argenteus	10
		Gadus morhua	10
		Melanogrammus aeglefinus	10
		Merlangius merlangus	10
		Micromesistius poutassou	10
		Pollachius pollachius	1 (0,0,0,0,0,0,0,1,0,0)
		Pollachius virens	10
		Trisopterus esmarkii	10
		Trisopterus minutus	2 (0,0,0,1,0,0,0,0,0,1)
	Lotidae	*Brosme brosme*	10
		Enchelyopus cimbrius	10
		Gaidropsarus argentatus	4 (0,0,1,0,1,0,1,0,1,0)
		Molva dypterygia	1 (0,0,0,0,0,0,0,0,1,0)
		Molva molva	10
	Phycidae	*Phycis blennoides*	8 (0,0,1,1,1,1,1,1,1,1)

Order	Family	Species	Number of years caught
Ophidiiformes	Carapidae	*Echiodon drummondii*	1 (0,0,0,0,0,0,0,1,0,0)
Lophiiformes	Lophiidae	*Lophius piscatorius*	6 (1,1,1,1,0,1,0,1,0,0)
Gasterosteiformes	Gasterosteidae	*Gasterosteus aculeatus*	10
Syngnathiformes	Syngnathidae	*Entelurus aequoreus*	2 (1,1,0,0,0,0,0,0,0,0)
Scorpaeniformes	Sebastidae	*Sebastes mentella*	10
		Sebastes norvegicus	10
		Sebastes viviparus	10
	Triglidae	*Eutrigla gurnardus*	8 (1,1,1,0,1,1,1,1,0,1)
	Cottidae	*Artediellus atlanticus*	10
		Gymnocanthus tricuspis	3 (0,1,1,0,0,0,0,1,0,0)
		Icelus spp.[1]	10
		Myoxocephalus scorpius	8 (1,1,1,1,0,1,0,1,1,1)
		Triglops murrayi	10
		Triglops nybelini	6 (1,1,1,1,0,0,0,1,0,1)
		Triglops pingelii	6 (1,1,0,1,1,0,0,1,0,1)
	Psychrolutidae	*Cottunculus microps*	10
	Agonidae	*Agonus cataphractus*	1 (0,0,0,0,0,0,1,0,0,0)
		Aspidophoroides olrikii	5 (0,1,0,1,1,0,1,0,1,0)
		Leptagonus decagonus	10
	Cyclopteridae	*Cyclopterus lumpus*	10
		Eumicrotremus derjugini	4 (0,0,0,0,1,1,0,0,1,1)
		Eumicrotremus spinosus	9 (1,1,1,1,1,1,0,1,1,1)
	Liparidae	*Careproctus* spp.[2]	10
		Liparis bathyarcticus	6 (1,1,0,0,0,1,0,1,1,1)
		Liparis fabricii	8 (1,1,0,1,1,1,0,1,1,1)
		Liparis liparis[3]	9 (1,1,1,1,1,1,0,1,1,1)
		Liparis montagui[3]	2 (0,0,0,1,0,0,0,0,0,1)
		Liparis tunicatus[3]	3 (0,0,0,1,0,0,0,1,1,0)
Perciformes	Zoarcidae	*Gymnelus* spp.[4]	9 (1,0,1,1,1,1,1,1,1,1)
		Lycenchelys kolthoffi	3 (0,0,0,0,0,0,1,1,1,0)
		Lycenchelys muraena	1 (0,0,0,1,0,0,0,0,0,0)
		Lycenchelys sarsii	4 (0,0,0,0,0,1,1,0,1,1)
		Lycodes esmarkii	10
		Lycodes eudipleurostictus	10
		Lycodes gracilis	10
		Lycodes pallidus	10
		Lycodes polaris	1 (0,1,0,0,0,0,0,0,0,0)
		Lycodes reticulatus	10
		Lycodes rossi	10
		Lycodes seminudus	8 (1,1,1,1,1,1,0,1,1,0)
		Lycodes squamiventer	3 (1,0,0,0,0,1,0,1,0,0)
	Stichaeidae	*Anisarchus medius*	7 (1,0,1,1,1,1,0,1,0,1)
		Leptoclinus maculatus	10
		Lumpenus fabricii	1 (0,1,0,0,0,0,0,0,0,0)
		Lumpenus lampretaeformis	10
	Anarhichadidae	*Anarhichas denticulatus*	10
		Anarhichas lupus	10
		Anarhichas minor	10
	Ammodytidae	*Ammodytes* spp.[5]	4 (0,1,0,1,0,0,0,0,1,1)
	Centrolophidae	*Schedophilus medusophagus*	1 (0,0,1,0,0,0,0,0,0,0)

[1] *I. bicornis* has been verified each year, the occurrence of *I. spatula* is uncertain.

[2] Due to open taxonomic issues fishes in the genus *Careproctus* are not identified to species level, but two morphologically different types are registered since 2015.

[3] Early records of this species might represent misidentifications.

[4] *G. retrodorsalis* has been verified each year, the occurrence of other *Gymnelus*-species is uncertain.

[5] *A. marinus* has been verified in the catches, but due to high numbers not all specimens could be checked.

Order	Family	Species	Number of years caught
Pleuronectiformes	Scophthalmidae	*Lepidorhombus whiffiagonis*	10
	Pleuronectidae	*Glyptocephalus cynoglossus*	10
		Hippoglossoides platessoides	10
		Hippoglossus hippoglossus	10
		Limanda limanda	9 (0,1,1,1,1,1,1,1,1,1)
		Microstomus kitt	10
		Pleuronectes platessa	10
		Reinhardtius hippoglossoides	10

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Appendix 2. Changes in survey design, methods, gear etc.

Year	Change from	To
1984	Representative age sample, 100 per station	Stratified age sample, 5 per 5-cm length group
1986	1 research vessel, 2 commercial trawlers	2 research vessels, 1 commercial trawler
1987	60 min. tow duration	30 min. tow duration
1989	Bobbins gear	Rock-hopper gear (time series adjusted for cod and haddock)
1990	Random stratified bottom trawl stations	Fixed station grid, 20 nm distance
	Simrad EK400 echo sounder	Simrad EK500 echo sounder and BEI post processing
1993	TS = 21.8 log L – 74.9 for cod and haddock	TS = 20 log L – 68 for all demersal species (time series corrected)
	Fixed survey area (ABCD), 1 strata system, 35 strata	Extended, variable survey area (ABCDD'ES) 2 strata systems, 53 + 10 strata
	Fixed station grid, 20 nm distance	Fixed station grid, 20/30/40 nm distance
	No constraint technique (strapping) on bottom trawl doors	Constraint technique on some bottom trawl hauls
	5 age samples per 5-cm group, 2 per stratum	2 age samples per 5-cm group, 4 per stratum (cod and haddock)
	Weighting of age-length keys by total catch	Weighting of ALK by swept area estimate
1994	35-40 mm mesh size in cod-end	22 mm mesh size in cod-end
	Strapping on some hauls	Strapping on every 3. haul
	Hull mounted transducers	Keel mounted transducers Johan Hjort
1995	Variable use of trawl sensors	Trawl manual specifying use of sensors
	Constant effective fishing width of the trawl	Fish size dependent effective fishing width (time series corrected)
	Strapping on every 3. haul	Strapping on every 2. haul
	2 research vessels, 1 commercial trawler	3 research vessels
1996	2 strata systems and 63 strata, 20/30/40 nm distance	1 strata system and 23 strata, 16/24/32 nm distance
	2 age samples per 5-cm group, 4 per stratum	1 age sample per 5-cm group, all stations with > 10 specimens (cod and haddock)
1997	16/24/32 nm distance	20 nm distance
	Hull mounted transducers	Keel mounted transducers G.O. Sars (Sarsen)
1998	Strapping on every 2. haul	Strapping on every haul
	20 nm distance	20/30 nm distance
2000	3 Norwegian research vessels	2 Norwegian and 1 Russian research vessel
2002	20/30 nm distance station grid	16/20/24/32 nm distance station grid
2003	Height trawl sensor for opening and bottom contact	Trawl eye for opening and bottom contact
2004	Vaco trawl doors	V- doors G.O. Sars and Johan Hjort
	EK 500 and BEI Sarsen	ER60 and LSSS G.O. Sars
2005	EK 500 and BEI	ER60 and LSSS Johan Hjort
	EK 500	ER60 Russian vessels
2006	Standard Campelen rigging	"Tromsø rigging" on Norwegian vessels
2008	V trawl doors	Thyborøn doors Jan Mayen/Helmer Hanssen
2010	V trawl doors	Thyborøn doors G.O. Sars and Johan Hjort
2011	30 min. tow duration	15 min. tow duration
2015	"Tromsø rigging" on Norwegian vessels	Standard Campelen rigging

Appendix 3. Scientific participants 2016

Research vessel	Participants
"Fridtjof Nansen" (05.02- 26.02)	**A. Amelkin (cruise leader)**, Rybakov M., Golovin A., Murashko P., Orlova A., Kanishcheva O., Kanishchev A., Velikzhanin A., Gubanishchev M., Puodzhyunas N., Antipin R., Zubov V., Kalinin E., Gavrilik T., Osipov M., Lukin N., Kalashnikova M., Kornilov K.
"J. Hjort" (24.01 – 12.03)	**Part 1a (24.01 – 03.02)** **E. Olsen (cruise leader),** K. Korsbrekke**,** B. Kvinge, O.S. Fossheim, A. Storaker, E. Holm, H. Senneset, J. Saltskår, E. Odland, A. Kristiansen. **Part 1b (03.02 – 12.02)** **E. Olsen (cruise leader),** J. E. Nygaard, J.A. Vågenes, A. Storaker, E. Holm, H. Senneset, J. Saltskår, E. Odland, A. Kristiansen, S. de Lange. **Part 2 (12.02 – 02.03)** **A. Aglen (cruise leader),** J. E. Nygaard, T. Haugland, E. Holm, J. Vedholm, I. Huse T. de L. Wenneck. **Part 3 (02.03 – 12.03** **S. Mehl (cruise leader),** T. Haugland, L. Drivenes, A. Storaker, S.E. Seim, C. Irgens, E. Odland, A. B. Rolland, V. Fauskanger (NIFES).
"Helmer Hanssen" (28.01 – 08.02)	**T. Wenneck (cruise leader),** T. Haugland, S.E. Seim, A. B. Rolland, F. Midtøy, L. Heggebakken, J.-T. Eilertsen (UiT)

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Institute of Marine Research
Nordnesgaten 50,
5817 Bergen
Norway

Polar Research Institute of Marine Fisheries and Oceanography (PINRO)
6 Knipovich Street,
183763 Murmansk
Russia