ICES PGNAPES REPORT 2005

ICES RESOURCE MANAGEMENT COMMITTEE
ICES CM 2005/D:09
Ref.: G, ACFM, ACE

REPORT OF THE PLANNING GROUP ON NORTHEAST ATLANTIC PELAGIC ECOSYSTEM SURVEYS (PGNAPES)

16–18 AUGUST 2005

GALWAY, IRELAND

International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer
H.C. Andersens Boulevard 44–46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

Recommended format for purposes of citation:
ICES. 2005. Report of the Planning Group on Northeast Atlantic Pelagic Ecosystem Surveys (PGNAPES), 16–18 August 2005, Galway, Ireland. ICES CM 2005/D:09. 183 pp.

Contents

Executive Summary

The Planning Group on Northeast Atlantic Pelagic Ecosystem Surveys (PGNAPES) met in Galway, Ireland 16–18 August 2005. This report presents the acoustic, hydrographic, plankton, and fish sampling results from two main international ICES coordinated surveys in 2005. The **International blue whiting spawning stock survey** on the spawning grounds west of the British Isles in March-April 2005 with participation of Norway, Faroes, Russia and the Netherlands along with Ireland (EU coordinated), and **International ecosystem survey in the Nordic Seas** with main focus on Norwegian spring-spawning herring and blue whiting in the Norwegian Sea and Barents Sea in May 2005 with participation of Denmark (EU coordinated), Faroes, Iceland, Norway, and Russia. In addition the Norwegian Sea was covered during June-July and in August 2005. The survey results include the distribution and the biomass estimate of spawning blue whiting in March-April west of the British Isles, and the distribution, migration and stock estimates of Norwegian spring-spawning herring and blue whiting, and the environment (oceanographic conditions and biomass of zooplankton) of the Norwegian Sea, Barents Sea and adjacent waters in spring and summer of 2005. The abundance estimates are used in the fish stock assessment of Norwegian spring spawning herring and blue whiting in ICES Northern Pelagic and Blue Whiting Fisheries Working Group (WGNPBW). The collection of environmental data further improves the basis for ecosystem modelling of the Northeast Atlantic. Broad plans for the ICES coordinated surveys for 2006 are also outlined with descriptions of the relevant protocols, preliminary participants and suggested survey designs.

1 Introduction

1.1 Participants

Jørgen Dalskov	Denmark
Jan Arge Jacobsen (Chair)	Faroe Islands
Leon Smith	Faroe Islands
Suni Lamhauge	Faroe Islands
Sveinn Sveinbjørnsson	Iceland
Thorsteinn Sigurdsson	Iceland
Ciaran O'Donnell	Ireland
Leonie Dransfeld (part-time)	Ireland
Maurice Clarke,	Ireland
Mark Dickey-Collas	Netherlands
Jens Christian Holst	Norway
Mikko Heino	Norway
Webjørn Melle	Norway
Øyvind Tangen	Norway
Alexander Krysov	Russia
Irina Prokopchuk	Russia

A full address list for the participants is provided in Annex 1.

1.2 Terms of Reference

The terms of reference and sections of the report in which the answers are provided:

2D08 The **Planning Group on Northeast Atlantic Pelagic Ecosystem Surveys** [PGNAPES] (Chair: J. A. Jacobsen, Faroe Islands) will meet in Galway, Ireland, from 17–19 August 2005 to:

Item	ToR 2005	Section
a)	Critically evaluate the surveys carried out in 2005 in respect of their utility as indicators of trends in the stocks, both in terms of stock migrations and accuracy of stock estimates in relation to the stock – environment interactions	3, 4 and 5
b)	review the 2005 survey data and provide the following data for the Northern Pelagic and Blue Whiting Working Group:	
	i) stock indices of blue whiting and Norwegian spring-spawning herring	3.1.2 and 3.2.3–4
	ii) zooplankton biomass for making short-term projection of herring growth	3.2.2 and 4.2
	iii) hydrographic and zooplankton conditions for ecological considerations	3.2.1–2 and 4.1–2
	vi) aerial distribution of such pelagic species as mackerel	3.7
c)	describe the migration pattern of the Norwegian spring-spawning herring and blue whiting stocks in 2005 on the basis of biological and environmental data	4.3–4
d)	plan and coordinate the surveys on the pelagic resources and the environment in the North-East Atlantic in 2006 including the following:	
	i) the international acoustic survey covering the main spawning grounds of blue whiting in March-April 2006	5.1
	ii) the international coordinated survey on Norwegian spring-spawning herring, blue whiting and environmental data in May-June 2006	5.2
	iii) Russian investigations on pelagic fish and the environment in May-July 2006	5.2
	vi) Icelandic investigations on pelagic fish and the environment in June-July 2006	5.2
	v) Norwegian investigation on pelagic fish and the environment in August 2006	5.2
e)	evaluate the proposed protocol to ensure standardisation of all sampling tools, procedures and survey gears	6

f)	plan intensive screening of pelagic research hauls for the presence of post-smolts (small salmon, generally < 45 cm) and older salmon	7

PGNAPES will report by 15 September 2005 for the attention of the Resource Management and the Living Resource Committees, as well as ACFM and ACE.

1.3 Background and general introduction

The Norwegian spring spawning herring is a highly migratory and straddling stock carrying out extensive migrations in the NE Atlantic. After a major stock collapse in the late 1960s the stock has been rebuilt and varied from approximately 5 to 10 million tonnes of biomass during the 1990s. During this period the main spawning areas have been situated along the Norwegian coast from approximately 58–69°N, with the main spawning occurring off the Møre coast from approximately 62–64°N. After spawning in February – March the herring have migrated NW-wards towards the Norwegian Sea feeding grounds. In general, the main feeding has taken place along the polar front from the island of Jan Mayen and NE-wards towards Bear Island. During the latter half of the 1990s there has been a gradual shift of migration pattern with the herring migrations shifting north and eastwards. In 2002 and 2003 this development seems to have stopped and the herring had at more southerly distribution at the end of the feeding season than in 2001. This southwestward shift has continued in 2004 and 2005, and especially in 2005 the fishery has continued in the south-western areas throughout the summer, leading to some speculations of a change in their late autumn migrations of parts of the adult stock. After feeding, the herring have concentrated in August in the northern parts of the Norwegian Sea prior to the southern migration towards the Vestfjord wintering area (68°N, 15°E). However, during the last three winter periods an increasing fraction of the stock has wintered in the Norwegian Sea off Lofoten. In January the herring start their southerly spawning migrations.

The blue whiting and the mackerel are the two other large stocks in the Northeast Atlantic, and both stocks use the Norwegian Sea during their feeding migration during summer. Blue whiting is the fish species that currently is supporting the largest fishery of the Northeast Atlantic. The main spawning areas are located along the shelf edge and banks west of the British Isles. The eggs and larvae can drift both towards the south and towards the north, depending on location and oceanographic conditions. The northward drift spreads juvenile blue whiting to all warmer parts of the Norwegian Sea and adjacent areas from Iceland to the Barents Sea. Adult blue whiting carry out active feeding and spawning migrations in the same area as herring. Blue whiting has consequently an important role in the pelagic ecosystems of the area, both by consuming zooplankton and small fish, and by providing a resource for larger fish and marine mammals. Mackerel are usually found in warmer waters and with a shorter northward migration during summer; they also feed on plankton in the southern and central Norwegian Sea.

Since 1995, the Faroes, Iceland, Norway, and Russia, and since 1997 (except 2002 and 2003) also the EU, have coordinated their survey effort on these and the other pelagic fish stocks in the Norwegian Sea. In addition in 2005 the joint survey of blue whiting on the spawning grounds west of the British Isles was included in the total survey effort in the Northeast Atlantic. The coordination of the surveys has strongly enhanced the possibility to assess abundance and describe the distribution of the pelagic resources, and their general biology and behaviour in relation to the physical and biological environment (Table 1.3.1). Based on an ICES recommendation in 1948, similar surveys were conducted under the auspices of ICES from 1950 to the late 1970s. National surveys were continued after this time. At the 1996 Annual Science Conference, the Pelagic Committee recommended that the ICES cooperation on the planning and conducting of future surveys on herring and the environment in the Norwegian Sea should be reintroduced, resulting the present planning group. In autumn 2003 participants from Denmark, Ireland and the Netherlands joined the planning group and, in addition to the Faroes, Iceland, Norway, and Russia, one research vessel from Denmark (EU-coordinated) joined the international survey in the Norwegian Sea 2004.

The spawning areas of blue whiting west of the British Isles have most actively been surveyed by Norway and Russia. Some coordination of these survey activities took place over a number of years, until the Russian spawning stock survey was discontinued in 1996. Russia resumed the blue whiting spawning stock survey in 2001. There was, however, no further coordination between Norwegian and Russian surveys. In 2003 ACFM recommended the following: "Several surveys on blue whiting are presently going on. ICES recommends that a coordinated survey be organised covering the main spawning grounds of blue whiting. Other countries than those presently taking part in these surveys are invited to take part. It is furthermore suggested that the coordination of blue whiting surveys should be taken care of by an extended ICES Planning Group on Surveys of Pelagic Fish in the Norwegian Sea (PGSPFN)." Albeit this suggestion was not made in time to enter the ToR's of PGSPFN in 2003, the coordination task has been taken up by PGSPFN by correspondence in 2003/2004, where, in addition to Norway and Russia, also vessels from Ireland along with the Netherlands (EU coordinated) joined the survey in 2004 (ICES 2004/D:07).

In 2005 a series of surveys were carried out by vessels from Denmark, Faroe Islands, Iceland, Norway, Ireland, the Netherlands, and Russia, coordinated by the PGNAPES, resulting in a relatively good coverage of the areas and relevant species. In May-June 2005 the coverage was extended to include the Barents Sea in addition to the Norwegian Sea, vastly increasing the survey effort in the Nordic Seas and for the first time enabling a full synoptic coverage of Norwegian spring spawning herring. In addition the Norwegian Sea was covered during June-July and partly in August 2005.

The results are provided in area and time based management units in an attempt to move towards an ecosystem approach in the group. Thus the international surveys were grouped into the two main areas covered in 2005:

- on the blue whiting spawning grounds west of the British Isles;
- in the Norwegian Sea and Barents Sea.

The first survey is termed the **International blue whiting spawning stock survey** (Section 3.1) and aimed at assessing the spawning stock biomass of blue whiting during the spawning season in March-April. In the Norwegian Sea and Barents Sea the joint survey in late spring (late April-early June) is termed the **International ecosystem survey in the Nordic Seas** (Section 3.2) aimed at observing the pelagic ecosystem in the area, with particular focus on herring, blue whiting, mackerel, zooplankton and hydrography. In addition the Norwegian Sea was covered during June-July and in August 2005 on a national basis:

- June-July – Norwegian Sea (Russia, Section 3.3);
- August – Northern Norwegian Sea (Norway, Section 3.4).

The main objectives of these surveys were to map the distribution and migrations of blue whiting and herring and other pelagic fish and to assess their biomass. Furthermore to monitor the hydrographic and plankton conditions on the blue whiting spawning grounds and in the Norwegian Sea and adjacent waters and describe how feeding and migration of blue whiting, herring and other pelagic fishes are influenced by this. The results are presented for the different periods and areas in the same sequence as indicated above. The details of the March-April blue whiting spawning survey is presented as a separate detailed survey report (Heino *et al.*, 2005a) in Annex 2 in the present report.

A special section (Section 3.5) is devoted to young herring including the 0-group, and Section 3.6 describe the herring fishery in the Norwegian Sea in summer 2005 to aid in the understanding of the migration of herring this year. Attached is a survey manual/protocol for the surveys covered in the PGNAPES (Annex 3). It should be considered a first draft subject to revisions and improvements.

1.4 Recommendations

During sampling of the Icelandic standard sections around Iceland in May the standard sampling method is vertical WP2 net hauls from 50 m to the surface. It is recommended that in the future additional vertical net hauls from 200 m to the surface be conducted, at least on every second station and particularly on the sections north and east of Iceland. This would comply with the standard used by the PGNAPES (Annex 3).

It is recommended that a survey focusing on wintering herring be undertaken in the waters east of Iceland and north of the Faroes during the autumn of 2005 in case the present development in the feeding migration continues.

2 Material and methods

The surveyed area in March-April 2005 is shown in Annex 2 (Figure 1). Six vessels participated, the Dutch RV "Tridens", the Irish RV "Celtic Explorer", the Russian RVs "Fridtjof Nansen" and "Atlantniro", the Faroese RV "Magnus Heinason" and the Norwegian RV "G. O. Sars" (Table 2.1).

The surveyed area (cruise tracks) in May-June 2005 is shown in Figure 2.1. Six vessels participated, the Danish RV "Dana", the Norwegian RVs "G.O. Sars" and "Johan Hjort", the Icelandic RV "Árni Fridriksson", the Russian "F. Nansen" and the Faroese RV "Magnus Heinason" (Table 2.2).

The areas covered in June and July 2005 by the Russian "F. Nansen" are shown in Figure 2.2 and 2.3, respectively, and the surveyed area (and cruise tracks) in August 2005 by the Norwegian "Johan Hjort" is shown in Figure 2.4. Details of the sampling are given in Table 2.3. The Icelandic "Bjarni Sæmundsson" conducted a survey east and south of Iceland (Table 2.3), and the plankton samples east off Iceland were included to the data in the international May survey in the Norwegian Sea.

2.1 Hydrography

The hydrographic observations were made using CTD-Probes. Details of the hydrographic sampling intensity during the international surveys within the PGNAPES in 2005 are shown in Table 2.1 and 2.2. The Svinøy section plots of temperature and salinity were made with MATLAB while horizontal distribution plots of temperature were plotted with the SURFER program.

2.2 Plankton

Details of the sampling intensity of plankton made by the participating vessels are shown in Table 2.1 and 2.2. During the International ecosystem survey in the Nordic Seas in 2005 a total of 276 plankton stations were conducted. All vessels used WP2 nets (180 or 200 µm) to sample plankton according to the standard procedure for the surveys. The net was hauled vertically from 200 m or the bottom to the surface. All samples were divided in two and one half was preserved in formalin while the other half was dried and weighed. On the Danish, the Russian and the Norwegian vessels the samples for dry weight were size fractionated before drying. Additional samples were collected on Icelandic standard sections. These data were scaled to be equal to biomasses in 200–0 m using a conversion factor of 1.98 established from simultaneous 50–0 m and 200–0 m net hauls on "Bjarni Sæmundson" in 1998. All data obtained by WP2 are presented as g dry weigh m^2.

A total of 260 plankton stations were sampled during two Russian cruises in June and July. Plankton was sampled in vertical hauls by Juday net (37 cm diameter 180 µm mesh) from 50–0 m and from 200–0 m by WP2 net with a 180 µm mesh. 86 plankton samples were collected in June by Juday net and 70 samples by WP2 net. In July 113 samples were collected by Juday net and 79 samples by WP2 net. In order to compare species composition and abundance in the catches of plankton by Juday and WP2 nets, hauls from 50 m to the surface were conducted at stations along two transects at 67°30´N and 66°40´N. Plankton samples from Juday net hauls was looked through and species composition and relative abundance of plankton species and stage composition of *Calanus finmarchicus* was determined. In the present report we only show results obtained by WP2 net.

During the Norwegian survey of the Norwegian Sea in August a total of 33 WP2 hauls were made. The hauls were taken from 200 m to the surface and samples were treated according to standard procedures.

2.3 Fish sampling

During the surveys trawling was carried out opportunistically for identification of the acoustic recordings and for representative biological sampling of the population (ranging from 1–6 times per day). In most cases fishing was carried out on fish traces identified on the echo-sounders. All vessels used a large or medium-sized pelagic trawl as the main tool for biological sampling. The salient properties of the trawls are as follows:

	ARNI FRIDRIKSON	ATLANTNIRO	CELTIC EXPLORER	DANA	F. NANSEN	G.O. SARS, J. HJORT	MAGNUS HEINASON	TRIDENS
Circumference (m)	1024	716	768	n/a	716	486	640	1120
Vertical opening (m)	55	50	48	22	50	25–30	38–48	30–70
Mesh size in codend (mm)	40	16	50	16	16	22	40	±20
Typical towing speed (kn)	3.5–4.0	3.3–4.0	3.5–4.0	3.0–4.5	3.3–3.9	3.0–4.0	3.0–4.0	3.5-4.0

With ordinary rigging, the trawls could be used to catch deep fish schools, in some cases down to depth of 400 meters or more. The trawls were also rigged to catch fish near or in the surface layer by removing the weights, extending the upper bridles and/or attaching buoys to each upper wing.

Each trawl catch was sorted and weighted for species composition. Samples of 100–200 individuals of the target species (herring and blue whiting, on some vessels also of other species) were taken for length measurements (on some vessels also weight). Samples of 50–100 specimens of herring and blue whiting were taken for further biological analyses. Length, weight, sex, maturity stage and in some cases stomach contents, parasite load and liver size index were recorded. Scales (herring) and/or otoliths (herring, blue whiting) were taken for age reading.

2.4 Acoustics and biomass estimation

During the surveys, continuous acoustic recordings of fish and plankton were collected using calibrated echo integration systems using 38 kHz as the primary frequency. Some key characteristics are given below:

	ARNI FRIDRIKSON	ATLANTNIRO	CELTIC EXPLORER	DANA	FRIDTJOF NANSEN	G. O. SARS	JOHAN HJORT	MAGNUS HEINASON	TRIDENS
Echo sounder	Simrad EK 500	Simrad EK 500	Simrad EK 60	Simrad EK 60	Simrad EK 60	Simrad EK 60	Simrad EK 60	Simrad EK 500	Simrad EK 60
Frequency (kHz)	38	38	38, 18, 120, 200	38, 18, 120	38, 120	38, 18, 70, 120, 200	38, 18, 120, 200	38	38
Primary transducer	ES 38B	ES 38B	ES 38B - Serial	ES 38B - Serial	ES 38B	ES 38B - SK	ES 38B - SK	ES38B	ES 38B
Transducer installation	Drop keel	Hull (steel blister)	Drop keel	Towed body (hull)	Hull	Drop keel	Drop keel	Hull	Towed body
Transducer depth (m)	8.5	5	8.7	3–4	5	8	10	3	7
Upper integration limit (m)	11	10	15	10	10	15	15	7	12
Post processing software	BEI	Sonardata Echoview	Sonardata Echoview	Sonardata Echoview	BI60	BEI	BEI	Sonardata Echoview	Sonardata Echoview

The recordings of area back scattering strength (s_A) per nautical mile were averaged over five nautical miles, and the allocation of area backscattering strengths to species was made by comparison of the appearance of the echo recordings to trawl catches.

The equipment of the research vessels was calibrated immediately prior or during the surveys against standard calibration spheres. Vessel intercalibrations were performed during March-April blue whiting survey.

Acoustic estimate of herring and blue whiting abundance were obtained during the surveys. This was done by visual scrutiny of the echo recordings using post-processing systems (BEI/BI500-system [“Johan Hjort”, “Dana”, “G.O. Sars”], Echoview version 3.1 [“Magnus Heinason”, “Tridens”, “Celtic Explorer”] or Simrad BI60 [“Fridtjof Nansen”]). The allocation of s_A-values to herring, blue whiting and other acoustic targets was based on the composition of the trawl catches and the appearance of the echo recordings. To estimate the abundance, the allocated s_A-values were averaged for ICES-squares (0.5° latitude by 1° longitude for the May survey and by 1° latitude by 2° longitude for the March/April survey). For each statistical square, the unit area density of fish (s_A) in number per square nautical mile ($N{*}nm^{-2}$) was calculated using standard equations (Foote *et al*., 1987, Toresen *et al*., 1998). For blue whiting a TS= 21.8 log(L) – 72.8 dB has been used while Foote *et al*. (1987) recommended TS = 20 log(L) – 71.9 dB for physostom species, which has been used for herring.

To estimate the total abundance of fish, the unit area abundance for each statistical square was multiplied by the number of square nautical miles in each statistical square and then summed for all the statistical squares within defined subareas and for the total area. The biomass was calculated by multiplying abundance in numbers by the average weight of the fish in each statistical square and then summing all squares within defined subareas and the total area. The Norwegian BEAM software (Totland and Godø, 2001) was used to make estimates of total biomass and numbers of individuals by age and length in the whole survey area and within different sub-areas.

The scrutinized acoustic data from the participating vessels were reported to the Marine Institute, Bergen, to produce combined assessments of the herring and blue whiting stocks surveyed.

3 Survey results

3.1 International blue whiting spawning stock survey

An international blue whiting spawning stock survey was carried out on the spawning grounds west of the British Isles in March-April 2005. Six research vessels participated in the survey: “Atlantniro”, “Celtic Explorer”, “Fridtjof Nansen”, G. O. Sars”, “Magnus Heinason” and “Tridens”. This is the second international survey with such a broad international participation, which allowed for broad spatial coverage as well as a relatively dense net of trawl and hydrographic stations. The results from the international blue whiting spawning stock survey have been described in detail in the joint cruise report (Heino *et al.*, 2005a) reproduced as Annex 2 in this report, as well as in reports from individual vessels (“Celtic Explorer”: O’Donnell *et al.*, 2005; “G. O. Sars”: Heino *et al.*, 2005b; “Magnus Heinason”: Jacobsen *et al.*, 2005, “Tridens”: Ybema *et al.*, 2005).

3.1.1 Hydrography

CTD stations by “G. O. Sars”, “Fridtjof Nansen” and “Tridens” are shown in Figure 3 of Annex 2. Figures 10–20 in Annex 2 summarise the hydrographic observations. In general, there is tendency towards colder temperatures and, to some extent, also towards lower salinities as compared to the preceding years. Temperatures are still somewhat warmer than average.

3.1.2 Blue whiting

The highest abundances of blue whiting were observed along the shelf edge from the northern Porcupine bank to the Hebrides and towards the Rosemary bank, and west of Rockall. Limits of the distribution were not clear because of the patchy distribution of blue whiting in the western and southern areas. Nevertheless, in south and southwest densities were generally very low. Schematic distribution of acoustic backscattering densities for blue whiting is shown in Figure 5 of Annex 2. In comparison to earlier years, the bulk of the biomass was further away from the shelf break.

Blue whiting spawning stock estimate based on the international survey is 7.6 million tonnes and 83 x 10^9 individuals, a considerable decrease from estimated 10.9 million tonnes and 128 x 10^9 individuals in 2005. The age-disaggregated total stock estimate is presented in Table 3 of Annex 2, showing that the stock was still dominated by blue whiting of 5 years in age (2000 year class). Contrary to what is stated in the original report, the presented stock estimate contains age readings from all participants (301 otoliths from “Magnus Heinason” are missing from Table 1 of Annex 2) except for “Atlantniro” (532 otoliths read but the results are not available) and “Tridens” (uncertainty in readings). Blue whiting of ages 4–5 years made up 60% of spawning stock biomass. There was some variability in the age structure between different areas with the highest mean age observed in the Hebrides area.

In recent years, the time series from Norwegian blue whiting spawning stock surveys has been the only regularly updated survey time series used in WGNPBW’s blue whiting stock assessment. The Norwegian survey was therefore run such that the results from this survey could be used to calculate a stock estimate that is comparable with the results from earlier years. The age- and size-stratified stock estimate from this survey is given in Table 3.1.2.1. However, due to bad weather, sampling was not very good along the shelf edge at the Porcupine Bank, and round Lousy and Bill Bailey Banks. Therefore an updated age- and size-stratified stock estimate from this survey utilizing additional samples collected by RVs “Celtic Explorer”, “Fridtjof Nansen” and “Magnus Heinason” in these areas is given in Table 3.1.2.2. This is very similar to the original estimate in overall abundance of blue whiting (Table

3.1.2.1), but shows slightly different age composition (higher numbers at ages 1–2 and 5 years).

3.2 International ecosystem survey in the Nordic Seas

3.2.1 Hydrography

Two main features of the circulation in the Norwegian Sea, where the herring stock is grazing, are the Norwegian Atlantic Current (NWAC) and the East Icelandic Current (EIC). The NWAC with its offshoots forms the northern limb of the North Atlantic current system and carries relatively warm and salty water from the North Atlantic into the Nordic Seas. The EIC, on the other hand, carries Arctic waters. To a large extent this water derives from the East Greenland Current, but to a varying extent, some of its waters may also have been formed in the Iceland and Greenland Seas. The EIC flows into the southwestern Norwegian Sea where its waters subduct under the Atlantic waters to form an intermediate Arctic layer. While such a layer has long been known in the area north of the Faroes and in the Faroe-Shetland Channel, it is only in the last three decades that a similar layer has been observed all over the Norwegian Sea.

This circulation pattern creates a water mass structure with warm Atlantic Water in the eastern part of the area and more Arctic conditions in the western part. Due to the influence from the EIC, the NWAC is rather narrow in the southern Norwegian Sea, but when meeting the Vøring Plateau off Mid Norway it is deflected westward. The western branch reaches the area of Jan Mayen at about 71°N. Further northward in the Lofoten Basin the lateral extent of the Atlantic water gradually narrows again, apparently under topographic influence of the mid-ocean ridge.

It has been shown that atmospheric forcing largely controls the distribution of the water masses in the Nordic Seas. Hence, the lateral extent of the NWAC, and consequently the position of the Arctic Front in the Norwegian Basin, is correlated with the large scale distribution of the atmospheric sea level pressure. This is clearly indicated for example by the correlation with the winter index of the North Atlantic Oscillation (NAO). As a result, the Atlantic water now has a far more easterly distribution than it had during the 1950s. Current measurements south in the Norwegian Sea have also shown that high NAO index gives larger Atlantic inflow, along the shelf edge, in the eastern part of the Norwegian Sea. In winter 2005 the NAO index was, as also in winter 2004, close to the long-term average (see Figure 3.2.1.1).

Figure 3.2.1.2 shows the temperature in the Svinøy section for 9–11 May. The influence of the EIC is seen in the intermediate layer lying under the Atlantic layer. The intermediate water is of Arctic origin and is characterized by salinities below 34.90 and temperatures below 1^{o}C. In 2005 the temperatures in the AW were lower than compared to 2004, except for the area over the slope at the shelf. In some areas the Atlantic water was 1^{o}C colder in 2005 than for 2004. This is seen in the upper 100 m over the western part of the section.

Figures 3.2.1.3–8 shows the horizontal temperature distributions at surface, 20, 50, 100, 200 and 400 m depth from the end of April to the beginning of June 2004. The distribution of the waters carried into the Norwegian Sea by the EIC is clearly indicated at all depths. A body of relatively cold and fresh water extends eastward from the Iceland Sea. Arctic waters are separated from Atlantic by the Arctic Front, which is indicated by closely spaced isotherms. In general, the influence of the EIC was somewhat larger in 2005 compared to 2004. For example, at 200 m depth the 4^{o}C isotherm in the southern Norwegian Sea, at 64^{o}N, was displaced more to the east in 2005 than in 2004. Also, northeast of the Faroese the isotherm reached further to the south in 2005 compared to 2004.

In the central Norwegian Sea (~68–70^{o}N) there was significant colder water on the western side compared to 2004. While the 5^{o}C isotherm at 100 m depth in 2004 reached to the 0^o meridian it reached only to 7^{o}E in 2005. Further north in the Norwegian Sea the temperature condition in 2005 looked similar as in 2004.

On the eastern side of the Norwegian Sea, the Atlantic layer was colder in 2005 than in 2004. At 50 m depth the difference was as large as 1^{o}C in the southern areas (62–64^{o}N).

3.2.2 Zooplankton

As usual the zooplankton biomass was highest in the cold water of the East Icelandic current (Figure 3.2.2.1). Biomass was also higher in the area west of Vesterålen and Troms in Northern Norway, a feature that is observed from year to year. The sampling stations were fairly evenly spread over the area, and increased ship time compared to last year facilitated good coverage of most oceanographic regions. The biomass of zooplankton in May 2005 was equal to what we measured in 2004. For the total area, the average biomass of zooplankton was lower than the mean for the years 1997–2005. Still biomass was somewhat higher than in 1997, when the lowest biomass of the time series was measured (Table 3.2.2.1). The zooplankton biomass in the two areas west and east of 2°W was also lower than the mean for the time series, but biomass increased slightly in both regions compared to 2004 (Table 3.2.2.1).

3.2.3 Norwegian spring spawning herring

The international coordinated survey in May was carried out with six vessels, one from the Denmark (EU coordinated), one from Faroes, one from Iceland, one from Russia and two from Norway (Table 2.2). The survey was extended from earlier years to cover also the southern Barents Sea in order to include the juvenile areas of the Norwegian spring spawning herring. The PGNAPES coordinated survey in May thus continuously covered the southern Barents Sea north to about 73°N and the central and eastern Norwegian Sea approximately limited by the Faroe Isles, Iceland, Jan Mayen Island, Bear Island and the Norwegian coast from 70°N to 62°N. The planned cruise tracks are shown in Figure 3.2.3.1. The first vessel started surveying 29 April while the last survey ended 8 June (Table 2.2). The weather in May 2005 was characterised by heavier winds than normal in May and hampered the activity of the vessels. This may have affected in particular the herring estimate west of 20°E.

Herring were recorded throughout most of the surveyed area as shown in Figure 3.2.3.2. The distribution in 2004 is included for comparison (Figure 3.2.3.3). As compared to 2004 the herring in May 2005 was more south-westerly distributed. As in 2004 there were only low concentrations of herring in the northern area in 2005, also reflecting the general southern displacement of the stock observed in recent years. The southern displacement is furthermore reflected in a more southern centre of gravity in 2005 (Figure 3.2.3.4–5) as compared to 2004. The amount of herring in the westernmost area was lower in 2005 than in 2004.

The acoustic herring estimate from the Nordic Seas in May 2005 is given in Table 3.2.3.1, and the corresponding length and age distributions are given in Figure 3.2.3.6. The estimate of 7.0 million tonnes is smaller than that obtained in May 2004 (8.9 million tonnes, ICES 2003/D:10).

There was a clear structure in size of herring throughout the area of distribution. The smallest fishes are found in the eastern Barents Sea with steadily larger fish to the west and south. A particular characteristic in 2005 is two groups of larger fish, in the southwest (up to 35 cm, 1991, 1992 and 1998 year classes) and in north (up to 33 cm, 1998 and 1999 year classes) with a group of smaller fish (up to 31 cm, 1999 and 2002) in between from approx. 68°N to 72°N. (Figure 3.2.3.7).

A special feature in the May survey in 2005 was the mixture of autumn spawning herring and Norwegian spring spawning herring in the Faroese area. In the northern part of the EU zone it is common to observe a component of autumn spawning herring during the May surveys, but in 2005 the north- and westward migration of autumn spawning herring seems unusually large, as it was observed by the Faroese RV "Magnus Heinason" in the northeastern part of the Faroese area around 64–64°30'N 04°W. The autumn spawning herring was distributed east and southeast in slightly warmer water than the Norwegian spring spawning herring, which where found west and northwest of this area. The autumn-spawners were generally smaller than the Norwegian spring-spawning herring (around than 100 g lighter).

3.2.4 Blue whiting

Blue whiting were observed in most of the survey area, with the highest densities off the north-western Norway and in the south, between the Faroes and Norway and the Faroes and Iceland (Figure 3.2.4.1). There is a tendency of mean length to increase away from the Norwegian coast towards northeast (Figure 3.2.4.2). Both distribution and size structure of the stock are broadly similar compared to the survey in previous year.

Stock estimate for the total survey area is given in Table 3.2.4.1. Blue whiting of age 1 year dominate the stock both in terms of numbers and biomass. The stock biomass estimate, 6.6 million tones, is 36% lower than in 2004, 10.4 million tonnes. Also stock numbers are decreased, from $152 \cdot 10^9$ in 2004 to $120 \cdot 10^9$ in 2005. These rather dramatic decreases are largely due to the more restricted coverage in the south-western part of the survey area where post-spawning fish aggregate at the time of the survey. For the standard survey area that has been covered each year (between 8°W-20°E and north of 63°N) the estimate is 4.7 million tonnes, down 14% from 5.4 million tonnes measured in 2004. The stock estimate in numbers at $95 \cdot 10^9$ is virtually unchanged from 2004. As seen in Figure 3.2.4.3, the proportions of large and old blue whiting are slightly lower in the standard survey area than in the total survey area; this is expected as the post-spawner aggregations in the southwest are largely excluded from the standard area. Time series of stock estimates for the standard area are given in Table 3.2.4.2.

Mean weight and length of blue whiting in the standard area in 2005 are for most age groups lower than in 2004. There is a suggestive negative relationship between strength of year class and size at age 1 year (Figure 3.2.4.4).

3.2.4.1 Blue whiting off the southern Icelandic coast

In the beginning of the Icelandic survey (16 June–2 July) a special survey for blue whiting in the area from the Reykjanes ridge along the shelf to the southeast coast was conducted (Figures 3.2.4.5–6) The aim of this additional coverage was to obtain information about the biomass and age/maturity of the blue whiting at this time of the year in that area.

From about 26°W to about 15°W the total biomass of blue whiting was 445 thousand tonnes (Table 3.2.4.3) and both the maturity and the age distribution were quite different from the fish further east (Figure 3.2.4.7). About 70% of the blue whiting at the south of Iceland was at an age of 2–3 years but at south-east Iceland was about 64% of the age of 4–5. All the fish at south Iceland were estimated immature but the fish at south and southeast Iceland were mainly mature.

3.3 June-July – Norwegian Sea

3.3.1 Hydrography

The horizontal temperature distribution in June and July 2005 at the surface, 50 and 100 m depth is show on the Figures 3.3.1.1–12. In June the surface temperature varied from 3.8°C in the East Icelandic Current (EIC) water to 10.7°C in the Coastal Water and Norwegian Atlantic Current (NWAC) water. In July the temperature changed from 4.5° near Jan-Mayen to 13.0°C near the Lofoten Isles. In the upper 200 m the temperature varied from 1.0°C in the Jan-Mayen area and 2.0°C in the EIC area to 9.5°C in eastern part of the Faroe-Shetland Channel (FSC) and the East Branch of the NWAC. In the southern, eastern and the northern parts of the Norwegian Sea the temperature in the upper 50 m was 0.3–1.0°C higher than long-term mean (1951–1990). In the west and southwest waters of the EIC, the temperature was 0.5–1.5°C colder than normal. In the 0–200 m layer the distribution of areas with positive and negative anomalies were similar to last year as a whole, but the absolute values of anomalies were higher, positive to 0.7–1.5°C and negative to 1.0–2.0°C.

The Atlantic Water entered the Norwegian Sea through the eastern part of the FSC within the layer 0–400 m. On the south of sea the temperature was about normal in the upper 200 m. In the deeper layers the temperature was more than 1°C lower than normal due to the wide penetration of cold waters eastward. Between 63–65°N the core of the NWAC was shifted eastward to the continental slope compared the long-term mean position. Northward 65°30′N the Atlantic Water was situated 30–50 nm westward than usual. The temperature of the NWAC in the upper 200 m layer in the central Norwegian Sea was 0.4–0.7°C higher than long-term mean and close to the level of 2002 and northward from 68°N the temperature was 0.8–1.2°C higher than normal and 0.2–0.4°C lower compared with 2002. The temperature of mixed waters in the upper 200 m in the central Norwegian Sea was 0.4–0.6°C higher than long-term mean and 0.2–0.4°C higher compared with 2002. It took place due to increased temperature and shifted to the west the West Branch of the NWAC.

The influence of the EIC on the west and south-west areas of the sea was greater in 2005 compared with the norm (1951–1990) and 2003–2004. The temperature of the EIC waters was 1.0–1.5°C lower than long-term mean there. In the southern part of the sea between 62°30′ and 65°30′N cold and relatively fresh waters penetrate eastward up to 1°W (at 50-200 m depth) and to 2°E (below 200 m). However, in the upper 400 m these Arctic waters were not exceeded 62°30′N and were separated from the Atlantic Water by very sharp frontal zone (the Arctic front). In the western part of the investigated area the boundary separating cold waters from Atlantic and mixed waters was displaced 30–40 nm westward than usual. In the central Norwegian Sea the frontal zone was between 63–66°N and 4–2°W in the layer 20–100 m and between 63–68°N along 1–2°E in the layer 100–400 m. In the north-west of the sea to east from Jan-Mayen the sharp east-west gradient was observed from 8°W at latitude 70° to 4°W at latitude 71°10’N.

3.3.2 Zooplankton

In June the highest plankton biomass was observed on the central part of transect 65°45´N (at 0°) and in the south-east part of the investigated area i.e., at sharp frontal zones between warm Arctic and cold East Icelandic Waters (Figure 3.3.2.1). The major contributors to plankton biomass were *Calanus finmarchicus* copepodid stages CIV-V.

In July the highest plankton biomass was observed in the south at about 0° (Figure 3.3.2.1). Similar to June, the main contributors to plankton biomass were *Calanus finmarchicus* copepodid stages CIV-V. An unusual feature of this year was a wide spread of Cladocera (mainly *Evadne nordmanni*) to the open sea in the northern part of the investigated area. Unusual amounts of gelatinous plankton of the species, *Beroe cucumis, Mertensia ovum* and *Obelia* sp., were also found in the northern region.

3.3.3 Norwegian spring spawning herring

During the Russian survey in June 2005, herring was found in the western part of the survey area (62°30’–66°00’N) from 02° W to 10°W (Figure 3.3.3.1). The herring were recorded in the uppermost 40 m water layer as separate small and average schools with a vertical extension 5–15 m. The densest herring concentrations were distributed in the Icelandic and in northern part of the Faroese zone and the maximum recording was 1172 tonnes/nm^2.

As in May, autumn-spawning herring was mixed with the Norwegian spring-spawning herring in the southeastern part of the surveyed area south of 64°30’N, i.e., in the southeastern part of the Faroese EEZ and in the EU zone (Figure 3.3.3.1).

The mean length and age of the Norwegian spring-spawning herring increased on from the southeast to the northwest in the surveyed area. Within the total area investigated area (91,702 square nautical miles) the total number was estimated to be 4,75 billion individuals corresponding to a biomass of 1.49 million tonnes (Table 3.3.3.1). The 1998–1999 and 1992 year classes dominated in the survey area in June. In July the main herring recording, up to 1300 tonnes/nm^2, were found in Jan Mayen and Norwegian’s zone (Figure 3.3.3.2). As in June the herring was concentrated in the uppermost 40 m layer of the sea. Total number was estimated to be 8.42 billion individuals corresponding to a biomass of 2.23 million tonnes (Table 3.3.3.2). The 1998–1999 and 2002 year classes dominated in the survey area in July.

3.3.4 Blue whiting

In June-July, blue whiting were distributed over most of the survey area, with main concentrations between 1°W and 4°E in the eastern part of the area. Another concentration was observed in the Faroese and Icelandic zone. Distribution is presented in Figures 3.3.4.1–3.3.4.2. Blue whiting echo recordings were registered mainly as scattered layers at different depths from 50 m to 300 m. The length of blue whiting ranged between 15 and 36 cm with fish of 19–28 cm in length dominating the size distribution. The stock in the survey area of RV “F. Nansen” was estimated to comprise 43.9 x 10^9 individuals with a total biomass of 3.2 million tones in June and 27.5 x 10^9 individuals with a total biomass of 2.3 million tones (Table 3.3.4.1). An age-disaggregated estimate is not available.

3.3.5 Mackerel

During the Russian survey in the Norwegian Sea in June-July 2005, mackerel was observed distributed in upper 40 m layer on a wide area from 61°N to northern direction up to 71°N (Figure 3.3.5.1). All samples of mackerel were taken from near surface catches with water temperature 7–13°C. Mean length of mackerel in June was 31–36 cm, in July 35–44 cm (Figure 3.3.5.2).

3.4 August – Northern Norwegian Sea

3.4.1 Hydrography

Figures 3.4.1.1–3.4.1.6 show horizontal distribution of temperature at surface, 20, 50, 100, 200 and 400 m depth in the northern Norwegian Sea. Since there were no cruises at that area during August in 2004 the temperatures for 2005 are compared with the temperatures in 2003. From 50 m depth and below the temperatures were considerably higher in 2005 than in 2003. The difference is about 1^{o}C and in some areas even more. This can be seen by, for instance, comparing the temperatures at 100 m depth in the northern area for the two years (compare Figure 3.4.1.4 with Figure 3.1.18 in the 2003 PGSPFN-report, ICES 2003/D:10). At the surface in the southern (~70–72^{o}N) and eastern areas the temperatures were lower in 2005 than in 2003, probably due to local heat flux difference between the two years. In the southern Norwegian Sea, i.e., Svinøy section, for August lower temperatures for both the averaged value over the whole Atlantic layer and in the core of the Norwegian Atlantic Slope Current (i.e., near the shelf) were also observed in 2005 compared to both 2004 and 2003 (not shown).

3.4.2 Zooplankton

No data.

3.4.3 Norwegian spring spawning herring

The survey covered a limited area in the northern part of the herring distribution area (Figure 2.4). The data does not seem appropriate to evaluate the herring migrations in the northern area in August 2005. However, the herring in this area was dominated by the 2002 year class (Figure 3.4.3.1 and Table 3.4.3.1).

3.4.4 Blue whiting

As for herring the coverage was rather limited (Figure 3.4.4.1), and the data will not be used in any evaluation of blue whiting. However, most of the fish was young blue whiting with the 2002 year class dominating (Figure 3.4.4.2 and Table 3.4.4.1).

3.5 Young herring

3.5.1 May/June – Hydrography

The horizontal temperature distribution at the surface, 50 and 100 m depth is shown on the Figures 3.5.1.1–4. During May the surface temperature changed from 0°C in the north-west of the sea near the Bear Island to 6.1°C in the south-west of the investigated area. In the Murman Current Water at the surface the isotherm 5°C reached as far as 33°E (the long-term location is 22–24°E), the isotherm 4°C reached longitude 36°E i.e., more eastern than long-term position (30–31°E). Consequently at most area the surface water was 0.8–1.5°C warmer than normal (for the last 40 years). At 50 m depth in the Coastal Branch of the Northcape Current the 5°C isotherm in 2005 was displaced at about 100 nm eastward than usual. At 100 m depth the water with temperature exceeded 5°C was extended at wide area limited 73°N and 27–28°E. Consequently the water temperature was increased at the investigated area and it was close to the level of anomalous warm 1990 and 1992. Those positive anomalies took place due to intense advection of warm Atlantic Water and increased seasonal warming as well. The maximal positive anomalies of temperature were observed within the Northcape Current and the Main Branch of the Murman Current. The surface temperature was greatly lower in 2005 compared to 2004 at most area. In the intermediate layers (deeper 200 m) the temperature was close to the level of 2004 in the Main Branch of the Murman Current and slightly lower in the Central Branch of the Northcape Current.

3.5.2 May/June – Young herring in the Barents Sea

RV "F. Nansen" and "Johan Hjort" carried out a survey in the Barents Sea from 20 to 39°E along the Russian and Norwegian coast during the period 21/5– 07/6 2005 in order to map the distribution and produce an abundance estimate of young herring in this area. Young herring were observed mainly within a distance of 60–100 nautical miles along the Russian and Norwegian coastline (Figure 3.5.2.1). The herring were mostly recorded as schools of various densities, from 200 m up to surface. The herring in the surveyed area consisted mainly of 1 year old fish (80%), which distributed mainly to the east from 30 °E. Good concentration of 1 year old herring have been found east of survey area where it was not possible to reach 0 borders of distribution of herring. Therefore the estimated is considered an underestimate of the stock of the young herring in the Barents Sea.

The total biomass was estimated to be 870 000 tonnes and the total numbers 32.6 billion individuals (Table 3.5.2.1).

3.5.3 May/June – 0-group herring in the Barents Sea

Herring larvae were recorded to the west from 25°E during the Russian acoustic survey of juvenile herring in the Barents Sea in May-June. The length of the larvae was 20–35 mm.

3.5.4 June/July – 0-group herring in the Norwegian Sea

During the Russian survey in June-July herring larvae and 0-group were recorded in the Norwegian Sea. The length of these herring was 2–5 cm. Observations of 0-group herring in the Norwegian Sea. These 0-group herring concentrations were recorded in the international water in the Norwegian Sea and in the Norwegian EEZ.

3.6 Information from the fishery for Norwegian spring spawning herring May

The distribution of the catches, by month, in the Icelandic and Faroese fishery is shown in Figure 3.6.1. Both Icelandic and Faeroese vessels started their fishery in middle/late May, in international waters north of the Faroes and within the EEZ of Faroe Island and Iceland, approximately between 5°W and 8°W. The Icelandic fleet caught 11 thousand tonnes in May and the Faroese vessels caught 5300 tonnes. Samples from the fishery show that the 1992 year class was the most dominant but 1997–1999 year classes were also abundant in the catches. Information from the industry also shows that the herring fished in Faroese and Icelandic waters throughout the summer 2005 were large (390–400g).

June

In June the Icelandic and Faroese fishery continued within the EEZ of Iceland and Faroe Islands and the fishery extended further west than it has done in decades, with highest effort and catches between 9°W and 13°W between 64°N and 66°N. As the catch rates decreased in this area, the fishery also started in international waters northeast of Jan Mayen and 100–150 nm south - southwest of Spitsbergen. The Icelandic fleet caught around 36 thousand tonnes in June and the Faroese fleet 8500 tonnes. In Icelandic and Faroese waters, the age distribution was similar as in May with the 1992 year class most dominant in numbers and biomass, but in the Svalbard area the herring was consisted mainly of the 1998–2002 year classes with the 1999 year class most dominant. Length distributions from the fishery, north and south of 68°N are shown in Figure 3.6.2. As can bee seen, the herring in the southern area is considerable larger than in the northern area. The average length in the southern area was 33.3 for the whole period from May - July and in the northern area the mean length was 28.7 cm.

July/August

In early July, the Icelandic and Faroese vessels continued fishing within the 200 miles of Svalbard but the Faroese vessels fished also in an area close to the Iceland-Faroe Ridge, within the EEZ of Faroes at the same time. In late July, Norwegian spring spawning herring was caught in the northeastern part of the Faroese area (64–64°30’N 04°W) together with some North Sea herring. A fishery developed in this area, but the herring migrated westwards and consisted of Norwegian spring spawning herring completely without any mix of North Sea herring. This fishery continued in early August westward to around 7°W. In the first week of August a small proportion of mackerel was caught as bycatch, but during the second week the bycatch proportions increased and the vessels fled the area further to the north to avoid the mackerel. Some catches of large herring were taken by Faroes vessels at around 69°N – 01°W (International area east of the Jan Mayen zone) and by the third week of August the Faroese and Icelandic vessels were fishing in the Svalbard area around 72–74°N, catching relatively small herring (180–200 g). The group had information on the Russian fleet fishing herring in the middle of August north of the Faroes at around 65°Nand 6°W.

By the end of July, a total of 109 thousand tonnes had been reported to the Icelandic and Faroese authorities, split on areas as given in the table below:

Area/Country	Iceland	Faroes	Total
Iceland EEZ	37829	5270	43099
Faroe Island EEZ	4986	13753	18739
International Waters	17829	3665	21494
Svalbard area	14654	11205	25859
Total	75448	33893	109341

No information on other national fisheries was available to the group.

3.7 Aerial surveys

In the second part of July in the Norwegian Sea, during feeding migrations of mackerel, Russia (PINRO) carried out annual comprehensive aerial surveys. Within the framework of aerial surveys, conducted were experimental and calibration works, as well as the surveys with the two Norwegian fishing vessels executed trawl-acoustic survey for mackerel and the Russian vessel “F. Nansen” and “Persey-4”.

The results of the above mentioned surveys will be presented in details and considered at the Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy in September 2005.

4 Discussion

4.1 Hydrography

The winter NAO index was in 2005 close to both the long-term-mean and the 2004 value. However, a closer look into the monthly values show that the NAO index for winter 2005 was relatively high in both December and January but low in both February and March while for winter 2004 the index had less variability (i.e., lower absolute values). The high values in December-January during winter 2005 can then explain the more eastward displacement of the EIC in 2005 compared to 2004. In the period 2002–2004 there have been observed record-high values of both temperature and salinity in both the Faroe-Shetland Channel and at the Svinøy section. The cooling of the upper layer (0.5–1^{o}C) in the AW in the eastern part of the Norwegian Sea from 2004 to 2005 was probably due to a combination of colder inflowing AW through the Faroe-Shetland Channel and increased influence of EIC.

4.2 Plankton

From 2004 to 2005 there was no change in zooplankton biomass in the Norwegian Sea as measured in May. The overall distribution pattern of zooplankton biomass during the two years was also very similar, including high biomass in the cold water of the EIC and in the eastern part of the Norwegian Sea, off Northern Norway (Figure 4.2.1). This is consistent with the similarity in atmospheric (NAO) and hydrographic conditions these years. After a high NAO and a high inflow of cold water in the south-western Norwegian Sea in 2002, NAO close to the long term mean coincided with reduced flow of cold water into the south-western Norwegian Sea in 2003 and 2004. Due to high NAO during early winter in 2004/5 some cooling had occurred in the southern Norwegian Sea before May 2005. However, the hydrographic situation was still similar to what was observed in 2004.

From May to June and July the concentration of biomass did not seem to change very much and generally ranged between 5 to 30 g dry weight m^{-2}. However, the distribution of biomass changed, probably in accordance with seasonal production cycles differing between water masses.

During June and July coastal species of zooplankton and herring larvae was observed in the central and western Norwegian Sea. This may be related to the persistence of northerly winds during May to July in the eastern Norwegian Sea. Northerly winds tend to force the surface layer of coastal water off the Norwegian shelf and into the Norwegian Sea, bringing coastal plankton into the oceanic realm.

Average zooplankton biomass in May 2005 was lower than the mean for the time series from 1997 to 2005, and close to the lowest values observed in 1997. In 1997 the low biomass measured in May coincided with extremely poor feeding conditions for the herring, and in the wintering areas in December we measured the lowest condition for the herring that has been recorded during the time series. Both in 2004 and 2005 relatively high plankton concentrations were observed in the eastern part of the Norwegian Sea. This may indicate that the overall migration distance for the younger herring feeding in this area may be reduced, and that less energy is used to obtain the fat reserve that is required for a successful overwintering. Therefore, we may expect the feeding conditions for the herring feeding in the northern Norwegian Sea during 2005 to be moderate and herring condition in December to be below average.

4.3 Norwegian spring spawning herring

It was decided not to draw up a suggested herring migration pattern for 2004. However, the general migration pattern is believed to resemble that of 2003 with the exception that the herring had a somewhat more southerly distribution in 2004.

Like in 2002 significant amounts of herring 0-group was observed in the Norwegian Sea in 2005. The drift of herring larvae into the area is dependent on appropriate wind and current regimes. This western distribution of larvae is not a yearly happening and has only been described in the years 1950 and 2002.

The Norwegian spring spawning herring is at present characterised by a state of large dynamics with regard to migration pattern. This applies to the wintering, spawning and feeding area. The main wintering area seems to have moved out from the fjords in the recent three years, and in the winter 2004/2005 more than 70% of the adult stock seemed to overwinter in the oceanic off the northwestern shelf of northern Norway (Figure 4.3.1). However, the following discussion will in particular concentrate on the situation in the feeding areas.

The Barents Sea component of the 2002 year class migrated into the Norwegian Sea during the spring 2005. During the May survey it was found in the areas west and northwest of the Lofoten/Vesterålen area. The Barents Sea component now seems to have mixed partly with the faster growing Norwegian Sea component of the same year class in this area. The year-class was found in somewhat the same area in August. This is in accordance with historic migration patterns of corresponding ages. A high proportion of the Norwegian Sea component is expected to recruit to the spawning stock in 2006 while the Barents Sea component will recruit mainly in 2007.

The Norwegian spring spawning herring stock shows a dynamic migration pattern with gradual changes in feeding migrations from year to year. During the period from 1996 to 2001 the migration pattern showed a northeasterly trend with the centre of gravity in May moving further to the NE year by year (Figures 3.2.3.4–5). The same trend was obvious also during the late feeding (August) season. The NE trend stopped in 2002 and the stock started moving in southwesterly direction. There is obviously no simple explanation to this behaviour and many factors could be proposed as covariates. It is well known that the size of the feeding area is stock size dependent, so are the ocean climate and current systems as obvious candidates with more northerly migrations in warming periods. Other factors could be the entrance of large year classes of young herring from the Barents Sea into the Norwegian Sea and asymmetrical plankton concentrations throughout the potential feeding area.

The recent southwestern extension of the herring feeding area started in 2003. The concentration of herring in the southwestern area increased somewhat in 2004 but showed a more significant increase in 2005. The increased concentrations are reflected both in the surveys and through a significant fishery in the southwestern area during the 2005 season. As seen from the fishery pattern in 2005 there is a split in a southwestern and northern fishing area, which can be explained by the division of the larger fish in the southwestern and northern area as observed during the May survey. In the Russian June-July survey, increasing concentrations of large herring was observed in the western area towards Jan Mayen Island. These concentrations were, however, not fished by Icelandic and Faroese vessels, as they did not have fishing opportunities in the area. The Russian fleet was mainly occupied with the mackerel fishery during that period. While the fleets had more free access to the different zones in years with international agreements the present regimes give biased fishing patterns. The fishery data should consequently be handled with care in interpreting the migration pattern but they are of great value to the group also under the present regime.

Most of the oldest herring (1992 year class) and an increasing fraction of the 1998 and 1999 year class fed in the southwestern area during 2005. The plankton concentration during May in this part of the ocean is consistently higher than further north and east. The herring feeding in this region have been shown to have a higher condition factor than the rest of the stock, indicating good feeding conditions and possibly also a shorter migration route for this part of the herring stock. Using the dry weight data obtained by WP2 it can be seen that in June and July the biomass of zooplankton of the southwestern Norwegian Sea was fairly high, although the maximum concentration seem to be shifted somewhat eastward compared to the situation in May. The older herring feeding in this region may be expected to have had good feeding conditions during the whole summer of 2005. Through summer an eastward shift in the herring distribution may be expected if the herring follows the gradient towards higher plankton biomass. There is not enough data to conclude on this, but circumstantial evidence, such as the herring being fished in the southwestern region all summer and a lower estimate of old herring in the northern Norwegian Sea in July compared to in June, indicates that this herring may migrate directly to the Norwegian coast for wintering instead of following the traditional northern route along the Arctic front.

An emerging question, however, is if we could see further changes in the wintering pattern of the herring. Based on sampling of catches of Icelandic summer spawning herring taken along the Icelandic east coast during autumn 2004 it is apparent that a small amount of Norwegian spring spawning herring wintered in the area. Whether the increased feeding in the southwestern area will lead to an increase in wintering concentrations of Norwegian spring spawning herring in the southwestern areas is at present uncertain, but should certainly be followed closely, preferably through dedicated surveys. It is recommended that such a survey be undertaken during the autumn 2005 in case the present development continues.

During the surveys in the Norwegian Sea during spring, autumn spawning herring has always been observed in the southeastern part of the Norwegian Sea, i.e., in the southeastern part of the Faroese zone and in the northern part of the EU zone. However, in 2005 the north- and westward migration of autumn spawning herring seems unusually large, as it was observed by the Faroese RV “Magnus Heinason” during the international herring survey in May in the northeastern part of the Faroese area around 64–64°30’N 04°W. Also in June 2005 during the Russian survey, autumn spawning herring was mixed with the Norwegian spring spawning herring in the southeastern part of the surveyed area south of 64°30’N, i.e., in the southeastern part of the Faroese EEZ and in the EU zone (Figure 3.3.3.1). The autumn spawning herring was distributed east and southeast in slightly warmer water than the Norwegian spring spawning herring, which where found west and northwest of this area. The autumn-spawners were generally smaller than the Norwegian spring-spawning herring (around than 100 g lighter).

The origin of the autumn spawners in this area is not known, but it could be postulated that they originated from the northern North Sea and/or from the ground west of the Shetland, migrated northwards from then spreading westwards once in the southern Norwegian Sea on their feeding migration. An indirect support is the observation that the autumn spawners are found in warmer water than the Norwegian spring spawning herring. The stock size of the local Faroese autumn spawning stock is not known, but is thought not to spread off the Faroe Plateau.

4.4 Blue whiting

We comment here on two surveys where blue whiting is the/one main target.

4.4.1 Spawning stock surveys

International blue whiting spawning stock survey is a new survey, and we still have little data to evaluate its performance. In comparison to the Norwegian blue whiting spawning stock survey (which is part of the international survey), the results have been similar in both years when the current international survey has been in existence. As the international survey represents substantial survey effort with wider coverage, denser network of cruise tracks and larger number of trawl stations than the Norwegian survey, there is added confidence to the results from the Norwegian survey. Results from the Norwegian survey are needed to assess the development of the blue whiting spawning stock before the conception of the international survey; the time series from the Norwegian survey is used in WGNPBW in tuning blue whiting assessment.

During last four years the Norwegian blue whiting surveys have provided consistent results. The latest survey suggests a clear reduction in stock numbers (30%) and biomass (25%); correcting for the change in area covered, the reduction in biomass is about 20%. The stock is dominated by the same year class (2000) as in 2002–2004, supporting the view that this year class is of unprecedented strength. Later year classes appear as either moderately strong (2001) or weak (2002–2004). However, this survey covers only small parts of the distribution area of immature blue whiting, such that information on year classes 2003–2004 is not reliable. Furthermore, estimates on the abundance of year classes 2001–2002 could be affected by changes in maturation. These uncertainties withstanding, the survey suggests that recruitment to the spawning stock has been much reduced now that the 2000 year class is fully recruited.

Blue whiting had a distribution further away from the continental slope than observed in earlier years.

4.4.2 Norwegian Sea May survey

Estimates are available both for the total survey area and for the “standardised” survey area in 2000–2004 (between 8° W–20° E and north of 63° N). The latter is more meaningful as the survey coverage has been rather variable in the south where post-spawning blue whiting are entering the Norwegian Sea. As these variations reflect factors that have nothing to do with migrations of blue whiting, the resulting noise is highly undesirable. The discussion below is therefore based on the estimate for the standard survey area.

The stock estimate in numbers is essentially unchanged from 2003–2004. Biomass estimate is somewhat lower (~14%) than in 2004 and clearly less (~28%) than in 2003. Year classes 2000–2002 all appear as moderate in the survey area in comparison to surveys in 2000–2004 (these year classes may not be representatively sampled in this survey as many individuals are not in the survey are due to post-spawning migration). 2003 year class is on the weak side but the youngest year class observed in this survey, 2004, is the second strongest in this six year time series. In conclusion, this survey suggests that the blue whiting biomass in the survey area is declining, but gives a positive indication on the strength of the 2004 year class. However, performance of this survey in predicting recruitment is not yet known, as the overlap with the assessment estimate is only three years.

Distribution observed this years looks similar to that observed in earlier years, although lack of coverage south of 62°30’ N means that the survey largely missed the post-spawning adults.

In summary the two surveys targeting blue whiting provide somewhat different outlooks on the stock as they cover partly different stock components. Both surveys suggest that the stock biomass is declining. Stock numbers in the Norwegian Sea survey are stable due to the strong recruiting year class that offsets the declining numbers in other age classes. However, spawning stock numbers appear to be strongly declining, as year classes that are recruiting to the spawning stock are much weaker than the record-strong year class 2000.

5 Planning

5.1 Planned acoustic survey of the NE Atlantic blue whiting spawning grounds in 2006

In 2004, PGNAPES produced a plan for achieving the optimum coverage that could be achieved for the spawning area blue whiting surveys. This plan was followed in the survey in spring 2005. Based on experiences gained this year and before, the timing of the survey (from mid-March to mid-April) appears appropriate. However, small revisions to the target areas are suggested (Figure 5.1.1):

1) Core area spawning area: northern Porcupine-Hebrides shelf edge
   - a. western Porcupine
   - b. Rockall and Hatton Banks
   - c. southern Faroes

2. a. Porcupine seabight
   b. South east Iceland and northern Faroes

Every year the target areas will be allocated to ships, but the highest priority will always be target area 1 (this area has usually hosted about half of blue whiting biomass in the survey area). The survey must follow the standardised survey protocol given in Section 6.

It is probable that at least four and as many as six parties will contribute to the blue whiting survey in 2006. Norway and Russia (PINRO) as in previous years will survey the core spawning area in late March and early April (Figure 5.1.1). This maintains the integrity of the existing (Norwegian) tuning series. In addition, the group considered that a 2-vessel EU contribution is the best means to achieve coverage of the Porcupine slope spawners and aggregations to the southwest, whilst avoiding double counting. Russia (AtlantNIRO) may participate, by surveying the international waters west of Rockall and Porcupine Bank. It was also suggested that participation by Iceland would be beneficial to overall international effort on spawning fish.

The preliminary sea programme with the target areas for each vessel is:

Ship	Nation	Vessel time (days)	Active survey time (days)	Preliminary effective survey dates	Primary target area [secondary]
Celtic Explorer	EU (Ireland)	21	18	23/3–10/4	2b [1]
F. Nansen/Smolensk	Russia		~30	~18/3–16/4	1 [2c]

G. O. Sars	Norway	35	30	~18/3–16/4	1 [2b]
Magnus Heinason	The Faroes	15	11	1–11/4	2c
Tridens	EU (Netherlands)	18	14	13/3–26/3	2a [1]
Atlantniro?	Russia	?	?	?	2b–c?

? denotes no information at present.

Progress of survey and conditions allowing, parties should extend their efforts to secondary target areas. Norway will act as the survey coordinator, acting as the contact point both before and during the survey and collating data during the survey. Norwegian vessel will also be used as the reference vessel for pair-wise acoustic intercalibrations.

The results of the cruises will be collated at a two-day meeting in Tórshavn, after the effective end of the surveys. The results will be added to the existing international time series.

5.2 Planned acoustic survey of pelagic fish and the environment in the Norwegian Sea and in the Barents Sea, spring/summer 2006

It is planned that five parties; Denmark (EU-coordinated), Faroe Islands, Iceland, Russia and Norway, will contribute to the survey of pelagic fish and the environment in the Norwegian Sea and the Barents Sea in May 2006. The participation and area coverage for the different parties are given in Figures 5.2.1 and 5.2.2.

The area covered by the international survey in May is divided in two standard areas defining the Norwegian Sea and the Barents Sea. The two subareas are limited by the 20°E north of northern Norway, the following latitudes and longitudes confines the two Subareas:

- Norwegian Sea: 63°30'N-75°N, 15°W-20°E
- Barents Sea: Coast-75°N, 20°E-45°E

All estimates should be run for each of these subareas separately and for the total area. By definition all data series collected by all boats within the two subareas are included in the data series of the international May survey, irrespective of which vessels were planned to be included.

As coordinator of the survey for 2006 Jens Chr. Holst, Norway has been appointed.

It is proposed that the Danish vessel start its survey in the end of April. The plan will be to start the survey by calibrate the acoustic equipment and then start surveying the area north of 62°N and east of 2°W with east-west cruise-lines. The Norwegian vessel(s) will start at the end of April/beginning of May (the date(s) and name(s) of vessel(s) will be decided by mid October 2005) and start by conducting the Svinøy hydrographic section. After this it will start surveying the area north of 66°N. The Faroes will survey the area south of 62°N in the first half of the survey and the area north of 62°N in the second half. The Icelandic vessel has planned to conduct their survey in May covering mostly Icelandic waters.

It is however important that an acoustic intercalibration between the vessels takes place. It has been agreed that during the May survey that intercalibration will be attempted carried out between the Faroes, Danish and Norwegian vessels. No intercalibration did take place at the 2005 survey due to bad weather condition during most of the survey. Therefore, effort should be put into this task at the 2006 survey. Fishing would also be carried out during this intercalibration exercise and the trawl selectivity compared.

The Russian vessel will start the survey at the middle of May from Barents Sea to the west direction and will continue in the Norwegian Sea in June-July. The Barents Sea part of the survey will cover young herring (1–3 years old) and it is the intention that the second Norwegian vessel will cover the western part of the immature herring (2002 year class). An acoustic intercalibration should also be carried out between these two vessels.

There are planned areas of overlap (Figures 5.2.1–2). If possible east-west cruise lines should be applied. The surveys will be carried according to survey procedures described in the Manual for Acoustic Surveys on Norwegian Spring Spawning Herring in the Norwegian Sea and Acoustic Surveys on Blue whiting in the Eastern Atlantic (Annex 3).

Norway plan to hire three commercial vessels on a three-week survey in the northern herring areas in the Norwegian Sea in July-August 2006.

Iceland will apply for vessel time for three weeks in June-July 2006 to cover the southeast and east coast of Iceland focusing on herring and blue whiting.

Russia plan to survey the Norwegian Sea during one cruise in June and one in July 2006 to investigate the distribution, biomass, and the environment in the area (Figure 5.2.2).

The proposed programme is shown in the text table below:

Ship	Nation	Vessel time (days)	Active survey time (days)	Preliminary dates
G.O. Sars	Norway	39	32	28/4 – 5/6
Johan Hjort	Norway	30	25	10/5 – 8/6
Fridtjof Nansen	Russia	15	15	15/5 – 30/5
Dana	Denmark (EU)	30	22	25/4 – 24/5
Magnus Heinason	Faroes	18	14	3/5 – 17/5
Arni Fridriksson	Iceland	21	18	10/5 – 31/5
Fridtjof Nansen	Russia	61	56	June – July
Bjarni Sæmundsson	Iceland	18	14	12/5 – 2/6

Final dates will be decided by the end of the year 2005.

The following investigations should be targeted:

- Norwegian spring-spawning herring
- Blue whiting
- Plankton
- Temperature and salinity

If possible the participating vessels should be rigged for surface trawling. For age-reading of the Norwegian spring-spawning herring scales should be utilised, and if possible the cod-end of the trawls should be equipped with some device (cage or other) for reduction of scale losses.

Standardisation of sampling procedures

The PG participants agreed to conduct their acoustic surveys in May 2006 using the standardised sampling procedures given in the Manual for Acoustic Surveys on Norwegian Spring Spawning Herring in the Norwegian Sea and Acoustic Surveys on Blue whiting in the Eastern Atlantic (Annex 3).

Zooplankton

In the Russian cruise zooplankton will be sampled by both Djedy and WP-2 nets. WP-2 will be used in order to get samples for dry weight of zooplankton. The zooplankton samples will be weighed in the laboratory PINRO. Zooplankton will be sampled in vertical hauls mainly from 50–0 m by Djedy with mesh size 180 µm. Samples by WP-2 net (180 µm mesh) will be taken in vertical hauls from 200 m to the surface in order to have suitable data for comparison.

Special task (outside standard sampling programme)

The PG has not been asked to include any special tasks during the surveys.

6 Survey protocol and standardisation, ToR (e)

The group was asked to evaluate the proposed protocol in last years report to ensure standardisation of all sampling tools, procedures and survey gears. This has been done at the present meeting, and a draft is attached as Annex 3, termed the "ICES Planning Group on Northeast Atlantic Pelagic Ecosystem Surveys Manual. Manual for acoustic surveys on Norwegian spring spawning herring in the Norwegian Sea and acoustic surveys on blue whiting in North-eastern Atlantic". Version 1.0, August 2005. This should be considered our first draft of such a manual and will be subject to further revision and refinements during the year.

7 Screening of pelagic research catches for salmon, ToR(f)

PGNAPES considered the Study Group on the Bycatch of Salmon in Pelagic Trawl Fisheries (SGBYSAL) report (ICES, 2005/ACFM:13) with the objective of contributing to better quantification of salmon bycatch in pelagic fisheries. All trawl catches handled within the framework of PGNAPES are properly screened and salmon catches in the scientific catches are available to the SGBYSAL group. It seems difficult to increase the scientific sampling of salmon within the present frames of PGNAPES.

In the Faroes, there has not been any systematic land-based sampling in the past years, only a few samples by observers from the Faroese Fishery Ministry. However, screening on board one of the larger blue whiting vessels have been done during two fishing trips in 2005. All catches were screened, and the results indicate a very low rate of occurrence of salmon in these fisheries. The first survey during mid November to early December 2004 no salmon was found in 1,968 tonnes of blue whiting. In the second trip during late May to early June, one salmon (92 cm fork length, 10 kg) was caught in Icelandic fishing zone at 63°14'N and 12°18'W in the end of May in a total catch of 2,120 tonnes blue whiting.

In general, bycatch has been relatively rare occurrence, but associated with rather wide confidence limits. In Iceland there has been made systematic sampling since 2003 in the blue whiting fishery, and results indicated that mainly saithe and some cod were recorded as bycatch. Spatial distributions indicate that saithe were primarily caught on the Iceland-Faroe Ridge during summer, while bycatches of cod mainly occurred in Icelandic waters. In terms of the effect of the bycatch on non-targeted fish stocks, concerns are mainly raised with respect to saithe and cod. In 2005 extensive areas within the Icelandic EEZ off southeast Iceland have been closed to the blue whiting fishery due to of large bycatches of mainly saithe and some cod.

8 Database and reporting procedures

PGNAPES database status:

At the 2004 PGNAPES meeting in Murmansk, Russia, it was agreed that all participating institutes should deliver data collected during the surveys within the PGNAPES to the PGNAPES database.

In order to ensure that data stored in the PGNAPES database will not be misused, the members of the PGNAPES agreed that the data in the database only may be used by PGNAPES and the associated ICES Working Group, i.e., the Northern Pelagic and blue whiting Working Group (NPBWWG).

Furthermore, for the data collected during the May surveys in 2006 that these data should be submitted to the database-coordinator, Leon Smith, Faroe Islands, at within 14 days after completion of each individual May-survey. It will then be possible for Øyvind Tangen, Norway, which has been appointed as responsible for compiling the data from the different surveys, to process the combined data for the final joint survey report.

It should be stressed that data should be supplied strictly in the agreed database format (Section 6 and Annex 3).

To facilitate the work for the database-coordinator, it is recommended that the data should be collected on-the-fly during the cruise in the supplied PGNAPES_TEST access database. This will ensure that the data integrity is correct already from the beginning.

As there is full consensus by the PG members, that if the PG members do not put enough commitment in supplying the data in the right format at the right time, this will be the last call for the life of the PGNAPES database.

It was agreed that at the PGNAPES meeting in 2006, a report on the status of the database will be submitted by Leon Smith. On the basis of this report, a decision will be made on whether continuation of the work put into maintenance of the database should continue.

9 Recommendations for future work and election of new Chair

The PGNAPES unanimously recommends that Dr A. I. Krysov, PINRO, Murmansk, Russia should be invited to Chair PGNAPES from 1 January 2006.

Below are the suggested terms of reference for PGNAPES in 2006:

“The **Planning Group on Northeast Atlantic Pelagic Ecosystem Surveys** [PGNAPES] (Chair: A. I. Krysov, Russia) will meet in Reykjavik, Iceland, from 15–18 August (15 August finalizing survey reports, 16–18 PGNAPES meeting) 2006 to:

Item	ToR 2007
a)	Critically evaluate the surveys carried out in 2006 in respect of their utility as indicators of trends in the stocks, both in terms of stock migrations and accuracy of stock estimates in relation to the stock – environment interactions
b)	review the 2006 survey data and provide the following data for the Northern Pelagic and Blue Whiting Working Group:
	i) stock indices of blue whiting and Norwegian spring-spawning herring
	ii) zooplankton biomass for making short-term projection of herring growth
	iii) hydrographic and zooplankton conditions for ecological considerations
	vi) aerial distribution of such pelagic species as mackerel
c)	describe the migration pattern of the Norwegian spring-spawning herring and blue whiting stocks in 2006 on the basis of biological and environmental data
d)	plan and coordinate the surveys on the pelagic resources and the environment in the North-East Atlantic in 2007 including the following:
	i) the international acoustic survey covering the main spawning grounds of blue whiting in March-April 2007
	ii) the international coordinated survey on Norwegian spring-spawning herring, blue whiting and environmental data in May-June 2007
	iii) Russian investigations on pelagic fish and the environment in June-July 2007
	vi) Icelandic investigations on pelagic fish and the environment in June-July 2007
	v) Norwegian investigation on pelagic fish and the environment in July-August 2007
e)	Finalise and adopt the proposed protocol to ensure standardisation of all sampling tools, procedures and survey gears

PGNAPES will report by 15 September 2006 for the attention of the Resource Management and the Living Resource Committees, as well as ACFM and ACE."

10 References

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Table 1.3.1: Organisational frame of the coordinated herring investigations in the Norwegian Sea, 1995–2005.

Year	Participants	Surveys	Planning meeting	Evaluation meeting
1995	Faroe Islands, Iceland Norway, Russia	11	Bergen (Anon., 1995a)	Reykjavík (Anon., 1995b)
1996	Faroe Islands, Iceland Norway, Russia	13	Tórshavn (Anon., 1996a)	Reykjavík (Anon., 1996b)
1997	Faroe Islands, Iceland Norway, Russia, EU	11	Bergen (ICES CM 1997/H:3)	Reykjavík (Vilhjálmsson, 1997/Y:4)
1998	Faroe Islands, Iceland Norway, Russia, EU	11	Reykjavík (ICES CM 1997/Assess:14)	Lysekil (Holst *et al.*, 1998/D:3)
1999	Faroe Islands, Iceland Norway, Russia, EU	10	Lysekil (Holst *et al.*, 1998/D:3)	Hamburg (Holst *et al.*, 1999/D:3)
2000	Faroe Islands, Iceland Norway, Russia, EU	8	Hamburg (no printed planning report)	Tórshavn (Holst *et al.*, 2000/D:03)
2001	Faroe Islands, Iceland Norway, Russia, EU	11	Tórshavn (no printed planning report)	Reykjavik (Holst *et al.*, 2001/D:07)
2002	Faroe Islands, Iceland Norway, Russia	8	Reykjavik (no printed planning report)	Bergen (ICES CM 2002/D:07)
2003	Faroe Islands, Iceland Norway, Russia, EU	5	Bergen (ICES CM 2002/D:07) + correspondence	Tórshavn (ICES CM 2003/D:10)
2004	Faroe Islands, Iceland Norway, Russia, EU	5	Tórshavn (ICES CM 2003/D:10) + correspondence	Murmansk (ICES CM 2004/D:07)
2005	Faroe Islands, Iceland Norway, Russia, EU	13	Murmansk (ICES CM 2004/D:07) + correspondence	Galway (this report)

Table 2.1: Surveys conducted in March-April 2005 by Norwegian, Russian and EU (Ireland and Holland) vessels in the North Atlantic, targeting blue whiting on the spawning grounds west of the British Isles.

Platform	Country	Survey area	Period	Blue whiting samples	Mackerel samples	Ichthyo-plankton samples	CTD stations
Celtic Explorer	IR	50°20’N-56°N, 16°W–9°W	25.3–15.4	11	11	0	15
G.O.Sars	NO	53°30´N-62°00´N 17°00´W–02°00’W	17.3–13.4	43	1	50	91
Tridens	NL	49°N-55°20’N, 18°W–10°W	7.3–25.3	6	1	0	21
Fridtjof Nansen	RU	53°15’N-60°15’N, 18°W–8°W	18.3–14.4	40	5	–	117
Atlantniro	RU	54°30’N-60°N, 19°W–14°W	15.3–8.4	30	0	30	55
Magnus Heinason	FA	59°30’N-62°N, 13°W–5°30’W	30.3–13.4	8	0	0	3

Table 2.2: Surveys conducted in spring 2005 by Faroese, Icelandic, Norwegian, Russian and Danish vessels in the North Atlantic, which are related to the Norwegian spring-spawning herring and blue whiting.

Platform	Country	Survey area	Period	Herring samples	Blue whiting samples	Mackerel samples	Plankton samples	CTD stations
Dana	DK	62°N–72°30'N, 2°W–15°E	26.4–25.5	18	19	0	50	50
Johan Hjort	NO	68°20´N-74°30´N 10°00É-39°30É	13.5–8.6	9	5	0	62	78
Magnus Heinason	FA	62°N–66°30'N, 9°W–0°30'W	4–18.5	11	8	0	36	38
G.O. Sars	NO	62°00-75°30´N 05°00W-19°00E	9.5–7.6	28	24	1	87	97
Arni Fridriksson	IS	71°40'N–62°00'N, 26°W–0°W	16.5–2.6	15	22	0	41	41
F. Nansen	RU	67°00'N–74°30'N, 20°00'E–38°00'E	21.5–03.6	15	2	0	44	50

Table 2.3: Surveys conducted in summer 2005 by Russian, Icelandic and Norwegian vessels in the North Atlantic, which are related to the Norwegian spring-spawning herring, blue whiting and mackerel.

Platform	Country	Survey area	Period	Herring samples	Blue whiting samples	Mackerel samples	Plankton samples	CTD stations
Bjarni Sæmundsson	IS	62°00´N– 68°00´N 16°00'W–09°'W	23.5–28.5	0	0	0	27	24
F. Nansen	RU	61°00'N–72°30'N, 10°00'W–15°00'E	05.6–30.7	35	18	31	216	230
Johan Hjort	NO	68°20´N-74°30´N 10°00É-39°30E	1.8.–14.8	8	1	0	33	39

Table 3.1.2.1: Age- and length-stratified abundance estimate of blue whiting in the spawning area, west of the British Isles. Data from RV "G. O. Sars", March–April 2005. Target strength used for blue whiting: 21.8 log L – 72.8 dB.

	Age in years (year class)										Numbers (10^6)	Biomass (10^6 kg)	Mean weight (g)	Mature %
Length	1	2	3	4	5	6	7	8	9	10				
(cm)	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995				
14.0 – 15.0	16	0	0	0	0	0	0	0	0	0	16	0.2	14	0
15.0 – 16.0	48	0	0	0	0	0	0	0	0	0	48	0.8	16.8	0
16.0 – 17.0	41	0	0	0	0	0	0	0	0	0	41	0.8	19	0
17.0 – 18.0	11	0	0	0	0	0	0	0	0	0	11	0.3	24.2	0
18.0 – 19.0	98	26	0	0	0	0	0	0	0	0	124	3.4	27.1	0
19.0 – 20.0	95	109	0	0	0	0	0	0	0	0	203	6.4	31.6	11
20.0 – 21.0	23	602	0	0	0	0	0	0	0	0	624	21	34.1	14
21.0 – 22.0	23	78	103	0	0	0	0	0	0	0	204	9.4	46	54
22.0 – 23.0	15	0	534	0	0	0	0	0	0	0	549	28	50.7	94
23.0 – 24.0	0	409	2822	384	13	0	0	0	0	0	3627	215	59.3	98
24.0 – 25.0	0	124	4918	2439	1876	0	0	0	0	0	9356	618	66.1	99
25.0 – 26.0	0	110	6309	7595	3801	734	0	0	0	0	18549	1385	74.7	100
26.0 – 27.0	0	0	2764	8872	8126	344	0	0	0	0	20105	1664	82.8	100
27.0 – 28.0	0	0	1798	5806	6301	976	26	0	0	0	14907	1384	92.8	100
28.0 – 29.0	0	0	571	3367	4246	1254	425	165	0	0	10028	1052	104.9	100
29.0 – 30.0	0	0	150	1657	4325	1560	372	36	0	0	8100	938	115.8	100
30.0 – 31.0	0	0	0	206	1613	907	37	343	0	0	3106	401	129	100
31.0 – 32.0	0	0	0	29	1318	979	286	16	29	0	2658	384	144.4	100
32.0 – 33.0	0	0	0	103	39	233	413	0	25	0	813	131	161.5	100
33.0 – 34.0	0	0	0	0	37	230	113	132	0	0	512	92	179	100
34.0 – 35.0	0	0	0	0	0	16	295	2	189	15	516	99	190.7	100
35.0 – 36.0	0	0	0	0	0	12	3	0	91	0	106	23	216.3	100
36.0 – 37.0	0	0	0	0	14	175	14	13	0	0	215	48	220.8	100
37.0 – 38.0	0	0	0	0	0	0	0	0	0	0	0	0		
38.0 – 39.0	0	0	0	0	0	27	7	38	0	0	71	20	285	100
39.0 – 40.0	0	0	0	0	0	8	2	2	0	0	12	3.1	262.6	100
40.0 – 41.0	0	0	0	0	0	1	0	0	0	0	1	0.4	410	100
TSN (10^6)	370	1456	19968	30459	31708	7455	1993	747	333	15	94503			
TSB (10^6 kg)	11	69	1469	2608	3025	882	287	107	64	2.9	8527			
Mean length (cm)	18.4	22	25.3	26.7	27.6	29.4	31.3	31.1	34.4	34.5	27.0			
Mean weight (g)	29.4	47.5	73.6	85.6	95.4	118.4	143.9	143.3	193.5	191.9	90.2			
Condition	4.7	4.5	4.5	4.5	4.5	4.7	4.7	4.8	4.8	4.7	4.6			
% mature	10	50	99	100	100	100	100	100	100	100	99.5			
% of SSB	0	0	17	31	36	10	3	1	1	0				

Table 3.1.2.2: Updated age- and length-stratified abundance estimate of blue whiting in the spawning area, west of the British Isles. Acoustic and trawl data from RV "G. O. Sars", supplemented with trawl data from RVs "Celtic Explorer", "Fridtjof Nansen" and "Magnus Heinason" March–April 2005. Target strength used for blue whiting: 21.8 log L – 72.8 dB.

	Age in years (year class)											Num-	Bio-	Mean
Length	1	2	3	4	5	6	7	8	9	10	11	bers	mass	weight
(cm)	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	(10^6)	(10^6 kg)	(g)
14.0 – 15.0	16	0	0	0	0	0	0	0	0	0	0	16	0.2	14.0
15.0 – 16.0	48	0	0	0	0	0	0	0	0	0	0	48	0.8	16.8
16.0 – 17.0	44	0	0	0	0	0	0	0	0	0	0	44	0.9	20.0
17.0 – 18.0	24	0	0	0	0	0	0	0	0	0	0	24	0.7	29.1
18.0 – 19.0	142	1	0	0	0	0	0	0	0	0	0	144	4.4	30.8
19.0 – 20.0	156	71	0	0	0	0	0	0	0	0	0	227	7.7	34.0
20.0 – 21.0	57	591	0	0	0	3	0	0	0	0	0	650	23.4	35.9
21.0 – 22.0	0	113	157	0	0	0	0	0	0	0	0	269	12.8	47.4
22.0 – 23.0	8	99	614	45	0	0	0	0	0	0	0	766	41.0	53.6
23.0 – 24.0	0	612	2880	379	41	0	0	0	0	0	0	3912	237	60.5
24.0 – 25.0	0	127	4593	3268	1646	0	0	0	0	0	0	9633	642	66.7
25.0 – 26.0	0	126	5833	7668	4093	519	0	0	0	0	0	18239	1366	74.9
26.0 – 27.0	0	0	2360	8686	8204	470	29	0	0	0	0	19749	1630	82.5
27.0 – 28.0	0	0	1304	5398	7281	797	22	5	0	0	0	14807	1364	92.1
28.0 – 29.0	0	0	419	2890	4709	1586	311	121	0	0	0	10036	1045	104
29.0 – 30.0	0	0	96	1262	4784	1538	276	22	0	0	0	7978	917	115
30.0 – 31.0	0	0	8	182	1400	1390	27	184	0	0	0	3192	406	127
31.0 – 32.0	0	0	30	48	732	1478	332	15	14	0	0	2649	381	144
32.0 – 33.0	0	0	0	47	30	418	251	98	11	0	0	855	137	160
33.0 – 34.0	0	0	0	0	18	262	166	82	0	0	0	528	93.7	177
34.0 – 35.0	0	0	0	0	6	71	278	16	172	14	0	558	106	190
35.0 – 36.0	0	0	0	0	0	8	23	36	43	0	0	109	23.6	217
36.0 – 37.0	0	0	0	0	15	193	14	0	0	0	0	222	49.7	223
37.0 – 38.0	0	0	0	0	0	2	2	0	2	0	0	6	1.5	243
38.0 – 39.0	0	0	0	0	5	36	5	29	0	0	0	74	20.8	283
39.0 – 40.0	0	0	0	0	0	11	2	0	3	0	0	15	4.0	258
40.0 – 41.0	0	0	0	0	0	3	2	0	0	0	0	5	1.4	279
41.0 – 42.0	0	0	0	0	0	0	0	0	0	0	0	0		
42.0 – 43.0	0	0	0	0	0	0	0	0	0	0	0	0		
43.0 – 44.0	0	0	0	0	0	0	0	0	0	0	2	2	1.0	584
TSN (10^6)	496	1739	18294	29874	32964	8782	1738	610	245	14	2	94757		
TSB (10^6 kg)	15.7	90.8	1332.1	2513	3097	1073.4	253.6	90.7	47.7	2.6	0.9	8517.5		
Avg. length (cm)	18.5	22.3	25.2	26.5	27.5	29.7	31.5	31.6	34.5	34.5	43.5	26.9		
Avg. weight (g)	31.7	52.2	72.8	84.1	93.9	122	146	149	195	192	604	89.9		
Cond. (g/dm^3)	5.0	4.7	4.5	4.5	4.5	4.7	4.7	4.7	4.7	4.7	7.3	4.6		
% of SSB	0	1	16	30	36	13	3	1	1	0	0	100		

Table 3.2.2.1: Average zooplankton biomass [g dry weight m^{-2}].

Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	Mean
Total area	8.2	13.4	10.6	14.2	11.6	13.1	12.4	9.2	9.2	11.3
Region W of 2°W	9.1	13.4	13.5	15.7	11.4	13.7	14.6	9.8	10.7	12.4
Region E of 2°W	7.5	14.4	10.2	11.8	8.7	13.6	9.0	8.0	8.2	10.2

Table 3.2.3.1: Age- and length-stratified abundance estimate of Norwegian spring-spawning herring in May-June 2005. Data from RVs "G.O. Sars", "Dana", "Magnus Heinason" and "Arni Fridriksson", May-June 2005. Target strength used for herring: 20 log(L) – 71.9 dB.

Length	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Number	Biomass	Weight
17		19														19	0.8	42
18		8														8	0.3	37
19		218	27													245	12.9	52.5
20		346	94													440	26.5	60.2
21		427	569													996	69.4	69.7
22		216	1659													1875	146.2	78
23		59	2842	29												2930	257.9	88
24			2389	0												2389	249	104.2
25			3685	48	24	24										3781	454.1	120.1
26			3695	225	0	23										3943	527.1	133.7
27			2934	279	74	37	19									3343	500.3	149.7
28			1355	258	113	81	0									1807	297.3	164.6
29			317	328	180	127	42									994	180	181
30			62	112	385	223	74	37								893	187.3	209.6
31			29	59	521	1660	530	20	10							2829	642.4	227.1
32			8	8	386	2398	1722	40	8							4570	1113.4	243.6
33			14	7	63	1378	1945	147	28		7	14	21			3624	955.1	263.6
34					13	240	843	240	110	13	32	52	26	39		1608	466.9	290.5
35					6		174	141	152	62	118	180	242	79	12	1166	372.4	319.8
36							22	22	67	50	83	211	467	167	48	1137	390.6	344.8
37						4		4	13	4	22	69	195	69	25	405	150.1	369.3
38						10				10			52	10	10	92	37.1	396.3
39															20	20	8	400.6
40																	0.2	436
41																		
42																		
43																		
44																		
45																		
Number 10^6	0	1293	19679	1353	1765	6205	5371	651	388	139	262	526	1003	364	115	39114		
Biomass 10^3 t		85.1	2356.6	222.6	380.3	1494.3	1386.8	184.7	119.9	46.5	85.7	174.6	343.7	123.6	40.8		7045.2	
Length cm		21.1	25.5	28.3	31	32.3	33.1	34.1	35.1	36.1	35.8	36	36.4	36.3	38			28.7
Weight g		65.9	119.7	164.5	215.5	240.8	258.2	283.7	309.4	333.2	326.7	331.9	343.1	339.7	360			180.1

Table 3.2.4.1: Age- and length-stratified abundance estimate of blue whiting in the Norwegian Sea in May-June 2005. Data from RVs "Dana", "Magnus Heinason", "Arni Fridriksson", "Johan Hjort" and "G. O. Sars". Target strength used for blue whiting: 21.8 log L – 72.8 dB.

	Age in years (year class)											Num-	Bio-	Mean
Length	1	2	3	4	5	6	7	8	9	10	11	bers	mass	weight
(cm)	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	(10^6)	(10^6 kg)	(g)
14.0 – 15.0	186											186	2.8	14.8
15.0 – 16.0	2416											2416	41.6	17.3
16.0 – 17.0	10571											10571	223	21.3
17.0 – 18.0	19465	87										19552	499	25.7
18.0 – 19.0	16751											16751	516	31.0
19.0 – 20.0	8741	331										9073	338	37.6
20.0 – 21.0	2351	2938	321									5610	260	46.6
21.0 – 22.0	703	6916	1133									8752	469	54.6
22.0 – 23.0	497	7772	1916	35								10221	631	62.9
23.0 – 24.0	91	4720	4085	212								9107	648	72.6
24.0 – 25.0		1332	4684	712	46							6774	570	84.4
25.0 – 26.0	18	350	3976	1509	387							6240	584	94.6
26.0 – 27.0		56	2266	2225	584	28						5158	527	104
27.0 – 28.0		13	672	1863	811	63	25					3447	388	114
28.0 – 29.0			245	1289	908	110	37					2590	320	124
29.0 – 30.0			26	764	817	105	13					1727	231	134
30.0 – 31.0				148	557	272	74	25		12		1089	161	148
31.0 – 32.0				14	252	196	56	28	14			559	86.2	157
32.0 – 33.0					37	135	25	37				233	40.2	173
33.0 – 34.0					46	46	46	15				153	26.8	184
34.0 – 35.0					27		27	27	27			108	21.5	200
35.0 – 36.0							11					11	2.6	238
36.0 – 37.0								10				10	2.0	199
37.0 – 38.0												0	0	
38.0 – 39.0											11	11	2.4	222
TSN (10^6)	61791	24514	19325	8772	4471	956	314	142	41	12	11	120349		
TSB (10^6 kg)	1792	1489	1591	941	553	139	49.0	24.4	7.5	1.8	2.4	6590		
Mean length (cm)	18	22.3	24.5	26.9	28.5	30.5	31.3	32.7	33.5	30.5	38.5	21.1		
Mean weight (g)	29.2	61.7	83.4	108	125	147	158	173	185	148	222	55.3		
Condition	5.0	5.6	5.7	5.6	5.4	5.2	5.2	5.0	4.9	5.2	3.9	5.9		

Table 3.2.4.2: Estimated stock biomass, numbers, length and weight at age for blue whiting in the standard survey area (between 8°W-20°E and north of 63°N) in the international surveys 2000–2005.

Age	1	2	3	4	5	6	7	8	9	10	11	Total
Numbers (10^6)												
2000	48927	3133	3580	1668	201	5						57514
2001	85772	25110	7533	3020	2066							123501
2002	15251	46656	14672	4357	513	445		15		6		81915
2003	35688	21487	35372	4354	639	201	43	3				97787
2004	49254	22086	13292	8290	1495	533	83	39				95072
2005	54660	19904	13828	4714	1886	326	103	43	8	3	11	95486
Biomass (10^6 kg)												
2000	1795	260	335	193	25	1						2608
2001	2735	1776	763	418	322							6014
2002	651	2640	1289	526	76	64		3		2		5250
2003	1475	1539	2897	497	88	31	11	1				6538
2004	1643	1437	1188	886	193	77	13	6				5442
2005	1558	1204	1124	502	233	49	16	8	2	1	2	4699
Length (cm)												
2000	19.2	24.7	25.6	27.3	27.7	33.2						20.2
2001	18.2	23.4	26.3	28.8	29.8							20.2
2002	20.1	21.9	25.1	27.9	30.1	30.2		34.5		37.5		22.5
2003	20.1	23.5	24.5	27	28.9	29.9	34.5	33.5				22.8
2004	18.7	22.5	24.8	26.5	28.6	30.1	31.4	30.9				21.4
2005	17.9	22.3	24.3	26.5	28	30.3	31	32.7	32.7	30.5	38.5	20.4
Weight (g)												
2000	36.7	83	93.5	116	122	225						45.3
2001	31.9	70.7	101	138	156							48.7
2002	42.7	56.6	87.8	121	147	145		210		269		64.1
2003	41.3	71.6	81.9	114	138	153	256	219				66.9
2004	33.4	65	89.4	107	129	144	162	160				57.2
2005	28.8	61.7	82.7	108	126	155	164	197.3	189.5	157.7	222	49.9

Table 3.2.4.3: Age stratified abundance estimate of blue whiting in the Icelandic waters west of 15°W. Data from RV "Bjarni Sæmundsson", May 2005. Target strength used for blue whiting: 21.8 log L – 72.8 dB.

		N Age								
Length	Weight (gr)	1	2	3	4	5	6	Numbers	Biomass	Total
18	34.7	46138						46138	1599	
19	39.9	76896						76896	3071	
20	50.7	153792						153792	7797	
21	55.5	138413						138413	7679	
22	65.0	123034	92275					215309	13985	
23	74.6		569031	30758				599790	44759	
24	85.2		630548	215309				845857	72032	
25	95.0		246068	399860	46138	15379		707444	67208	
26	108.5		123034	353722	76896			553652	60082	
27	120.2		46138	276826	246068			569031	68425	
28	131.4			199930	261447			461377	60627	
29	146.8			30758	92275	46138	15379	184551	27097	
30	172.9				15379	46138		61517	10637	
	Total N (´000)	538273	1707094	1507164	738203	107655	15379	4613768		
	Total B ('000 t)	28	144	161	93	16	2		445	
	Average L (cm)	20.4	23.9	25.9	27.4	28.9	29.0			24.9
	Average W (gr)	52.3	84.6	106.9	125.8	150.6	146.8			96.4
	% N	11.7	37.0	32.7	16.0	2.3	0.3			100.0

Table 3.3.3.1: Age- and length-stratified abundance estimate of young Norwegian spring-spawning herring in the Norwegian Sea in June 2005. Data from RVs "Fritjof Nansen", June 2005. Target strength used for herring: 20 log(L) – 71.9 dB.

	Age												N Tot	Biomass	Mean w
	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990			
Length	4	5	6	7	8	9	10	11	12	13	14	15	10^6 sp.	10^3 t	g
27	0,4												0,40	0,075	188,2
28	46,4	1,0											47,33	9,682	204,6
29	155,2	9,4											164,67	37,993	230,7
30	180,6	20,3	7,9										208,76	51,383	246,1
31	32,9	106,9	64,9	45,6	15,5								265,86	70,941	266,8
32	6,7	53,0	180,9	219,5	8,9								468,94	133,256	284,2
33	6,0	52,8	368,0	759,0	43,5			6,5				6,5	1242,32	372,356	299,7
34	6,4	18,3	221,4	542,3	31,1	12,7		29,8	6,5				868,45	271,115	312,2
35		7,9	41,8	275,1	32,6	26,4	26,4	39,5	24,2	85,8			559,78	192,427	343,8
36		2,9	8,5	116,8	27,1	29,6	9,5	16,6	60,7	229,3	10,5		511,39	188,888	369,4
37			6,5	45,5	12,9	6,5	6,4	3,2	12,9	190,8	15,9		300,72	118,061	392,6
38				4,7		4,7		4,7		47,9	26,7	3,1	91,77	37,699	410,8
39										8,1	9,8		17,89	7,395	413,4
40											0,5		0,53	0,233	439,5
N mill.	434,6	272,4	899,8	2008,5	171,7	79,9	42,4	100,3	104,2	561,8	63,4	9,7	4748,8		
Mean length cm	29,6	31,8	33,0	33,7	34,1	35,6	35,5	34,9	35,8	36,4	37,6	34,6	33,58		
Biomass 1000 t	103,9	76,4	268,9	628,2	55,8	28,8	15,3	34,3	38,0	213,2	25,3	3,3		1491,5	
Mean weight g	239,1	280,6	298,8	312,8	325,0	360,7	361,8	341,9	364,8	379,4	399,2	336,5			314,1

Table 3.3.3.2: Age- and length-stratified abundance estimate of young Norwegian spring-spawning herring in the Norwegian Sea in July 2005. Data from RVs "Fritjof Nansen", July 2005. Target strength used for herring: 20 log(L) – 71.9 dB.

	Age														N Tot	Biomass	Mean w
	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990			
Length	2	3	4	5	6	7	8	9	10	11	12	13	14	15	10^{6} sp.	10^{3} t	g
23	12,8														12,85	1,386	107,9
24		16,0													16,04	1,924	120,0
25		98,8													98,82	14,280	144,5
26		348,3													348,30	56,912	163,4
27		799,3													799,34	139,805	174,9
28		973,0													973,04	184,785	189,9
29		440,8	46,6	21,2											508,60	105,644	207,7
30		265,6	125,2	62,0											452,76	104,584	231,0
31		59,9	123,3	213,4	138,4		15,1								550,14	142,741	259,5
32		12,8	14,8	172,4	640,8	321,9	12,8		12,8						1188,21	332,579	279,9
33				33,5	633,3	998,2	31,2	10,1							1706,34	522,255	306,1
34				16,5	148,5	765,1									930,21	302,479	325,2
35					8,0	238,3	8,0		34,3	4,9	6,5	4,9			304,98	108,569	356,0
36						75,6	21,0		63,4		11,3	80,4			251,77	96,082	381,6
37						16,1	15,0		79,5	4,2	1,2	118,0	4,2		238,19	94,522	396,8
38							1,5				1,5	28,5	6,1		37,60	16,408	436,4
39												1,3	1,1	1,1	3,45	1,525	442,0
40												0,1			0,13	0,060	457,2
N mill.	12,85	3014,7	309,9	519,0	1569,0	2415,2	104,6	10,1	190,0	9,1	20,5	233,4	11,3	1,1	8420,8		
Mean length cm	23,0	27,8	30,3	31,4	32,5	33,5	34,0	33,0	36,0	35,9	35,9	36,7	37,7	39,0	31,09		
Biomass 1000 t	1,4	569,5	74,9	138,0	462,8	762,4	34,4	3,1	71,6	3,4	7,8	91,8	4,9	0,5		2225,2	
Mean weight g	107,9	188,9	241,8	266,0	295,0	315,7	329,2	304,4	376,7	369,9	383,4	393,3	428,8	443,9			264,4

Table 3.3.4.1: Length stratified abundance estimate of blue whiting in the Norwegian Sea in the June-July 2005. Data from RV "Fridjof Nansen", 06.06–23.07.2005. Target strength used for blue whiting: 21.8 log L – 72.8 dB.

Length, cm	June			July		
	Number (10^6)	Biomass (10^3 kg)	Mean weight (g)	Number (10^6)	Biomass (10^3 kg)	Mean weight (g)
15	3,4	0,1	17,1			
16	81,7	1,7	20,9			
17	45,9	1,2	25,1			
18	893,1	26,7	29,8	209,4	5,6	26,7
19	2157,8	75,9	35,2	1209,4	38,8	32,1
20	2324,5	95,6	41,1	1661,8	63,1	38,0
21	1599,3	76,3	47,7	1510,8	70,8	46,9
22	3133,7	172,3	55,0	1538,7	81,3	52,8
23	10213,6	643,0	63,0	3425,7	210,9	61,6
24	8507,9	609,7	71,7	3772,5	266,9	70,7
25	5140,4	417,1	81,1	4397,9	358,6	81,5
26	3669,8	335,6	91,4	3135,5	295,3	94,2
27	2646,8	271,5	102,6	2038,6	222,8	109,3
28	1390,0	159,3	114,6	1338,8	167,4	125,0
29	876,3	111,8	127,5	1023,6	142,4	139,2
30	579,7	82,0	141,4	644,6	101,4	157,4
31	302,2	47,2	156,3	440,9	75,4	171,0
32	192,5	33,1	172,1	702,2	129,9	184,9
33	64,9	12,3	189,1	381,8	76,9	201,5
34	42,5	8,8	207,1	25,5	5,5	217,5
35	16,8	3,8	226,2	25,5	6,0	234,3
36	4,5	1,1	246,5			
37						
38						
39	3,4	1,1	314,5			
40				32,2	11,0	341,9
Total	43890,6	3187,0		27515,4	2330,0	
Average			72,6			84,7

Table 3.4.3.1: Age- and length-stratified abundance estimate of Herring in the Norwegian Sea in August 2005. Data from RV "Johan Hjort". Target strength used for herring: 20 log(L) – 71.9 dB.

Length	1	2	3	4	5	6	7	8	9	10	11	12	13	14+	Number	Biomass	Weight
15															0		
16															0		
17															0		
18	150	0	0	0	0	0	0	0	0	0	0	0	0		150	6	42
19	169	0	0	0	0	0	0	0	0	0	0	0	0		169	8	47
20	0	116	0	0	0	0	0	0	0	0	0	0	0		116	7	60
21	180	180	0	0	0	0	0	0	0	0	0	0	0		360	29	80
22	0	454	182	0	0	0	0	0	0	0	0	0	0		636	59	93
23	0	844	94	0	0	0	0	0	0	0	0	0	0		938	101	107
24	0	715	1123	0	0	0	0	0	0	0	0	0	0		1838	223	121
25	0	473	2958	0	0	0	0	0	0	0	0	0	0		3431	462	135
26	0	94	3741	0	0	0	0	0	0	0	0	0	0		3835	586	153
27	0	75	1053	75	0	0	0	0	0	0	0	0	0		1203	215	179
28	0	0	1689	0	0	0	0	0	0	0	0	0	0		1689	329	195
29	0	0	727	66	0	0	0	0	0	0	0	0	0		793	177	223
30	0	0	894	447	0	64	0	0	0	0	0	0	0		1405	346	247
31	0	0	180	360	240	0	0	0	0	0	0	0	0		780	200	256
32	0	0	129	64	451	258	64	0	0	0	0	0	0		966	292	302
33	0	0	0	0	128	447	383	0	0	0	0	0	0		958	311	325
34	0	0	64	0	0	0	255	64	0	0	0	0	0		383	133	347
35	0	0	0	0	64	0	128	64	0	0	0	0	64		320	119	372
36	0	0	0	0	0	0	0	0	0	0	0	0	64		64	27	415
37	0	0	0	0	0	0	0	0	0	0	0	0	64		64	25	392
38															0		
Number 10^6	499	2951	12834	1012	883	769	830	128	0	0	0	0	192	0	20098	3654	
Biomass 10^3 t	28.6	332.3	2140.2	249.9	263	238.8	280.1	45.9	0	0	0	0	75.3		.	3654.1	.
Length cm	19.9	23.9	27	30.7	32.6	32.9	34	35	.	.	.	.	36.5		.	27.4	.
Weight g	57.3	112.6	166.8	246.9	298.1	310.7	337.1	359.4	.	.	.	.	392.9		.	181.8	

Table 3.4.4.1: Age- and length-stratified abundance estimate of Blue whiting in the Norwegian Sea in August 2005. Data from RV "Johan Hjort". Target strength used for blue whiting: 21.8 log L – 72.8 dB.

Length	1	2	3	4	5	6	7	8	9	10	11	12+	Number	Biomass	Weight
10													0		
11													0		
12													0		
13													0		
14													0		
15													0		
16													0		
17	107												107	3	26
18	320												320	10	30
19	107												107	4	37
20	0	107											107	4	36
21	373	0	373										746	40	54
22		704	469										1173	69	59
23		1120	1120										2240	150	67
24			1280										1280	104	81
25			1493	747									2240	198	88
26			396	594	198	198							1386	135	97
27			320	160	160								640	68	106
28			178		356								534	68	128
Number 10^6	907	1931	5629	1501	714	198	0	0	0	0	0	0	10880	852	
Biomass 10^3 t	36.3	120.2	453.5	140.8	81.9	19.3								852	
Length cm	19.7	23	24.6	26.1	27.7	26.5								24.4	
Weight g	40.1	62.3	80.6	93.8	114.7	97.3								78	

Table 3.5.2.1: Age- and length-stratified abundance estimate of young Norwegian spring-spawning herring in the Barents Sea in May-June 2005. Data from RVs "Fritjof Nansen" and "Johan Hjort ". Target strength used for herring: 20 log(L) – 71.9 dB.

Length	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	N Tot	Biomass	Mean w
5																0		
6																0		
7																0		
8	528															528	2	4
9	3272															3272	15	5
10	8102															8102	50	6
11	7721															7721	64	8
12	2431															2431	26	11
13	1272	42														1314	18	13
14	434	118														552	9	16
15	107	1110														1217	26	21
16	30	1006														1036	28	27
17		1185														1185	37	32
18		676	60													736	27	36
19		281	141													422	18	44
20		39	236													275	14	52
21		0	320													320	19	59
22		78	466													544	39	72
23			888													888	69	78
24			297													297	36	121
25			97													97	13	138
26			0	47												47	6	129
27			33	11												44	6	148
28			0	11	11											22	4	162
29			0	30	0	7										37	7	182
30			13	64	52	0										129	26	198
31				107	145	184	48									484	104	215
32				67	51	328	118	8								572	131	229
33				36	72	45	72									225	55	245
34				6	0	6	18									30	8	253
35				9	14								27			50	10	288
N mill.	23897	4535	2551	388	345	570	256	8	0	0	0	0	27	0	0	32577	866	
N mill.	23898	4537	2548	388	345	571	257	8								32579		
Biomass 1000 t	183,3	135	198,2	78,9	76,6	128,6	59,7	1,9					7,7			869,9		
Mean length cm	11,1	17,1	22,7	30,9	32	32,2	32,7	32,5					35,5			26,7		
Mean weight g	7,7	29,8	77,8	203,1	222,2	225,1	232,5	228,6					288,2					

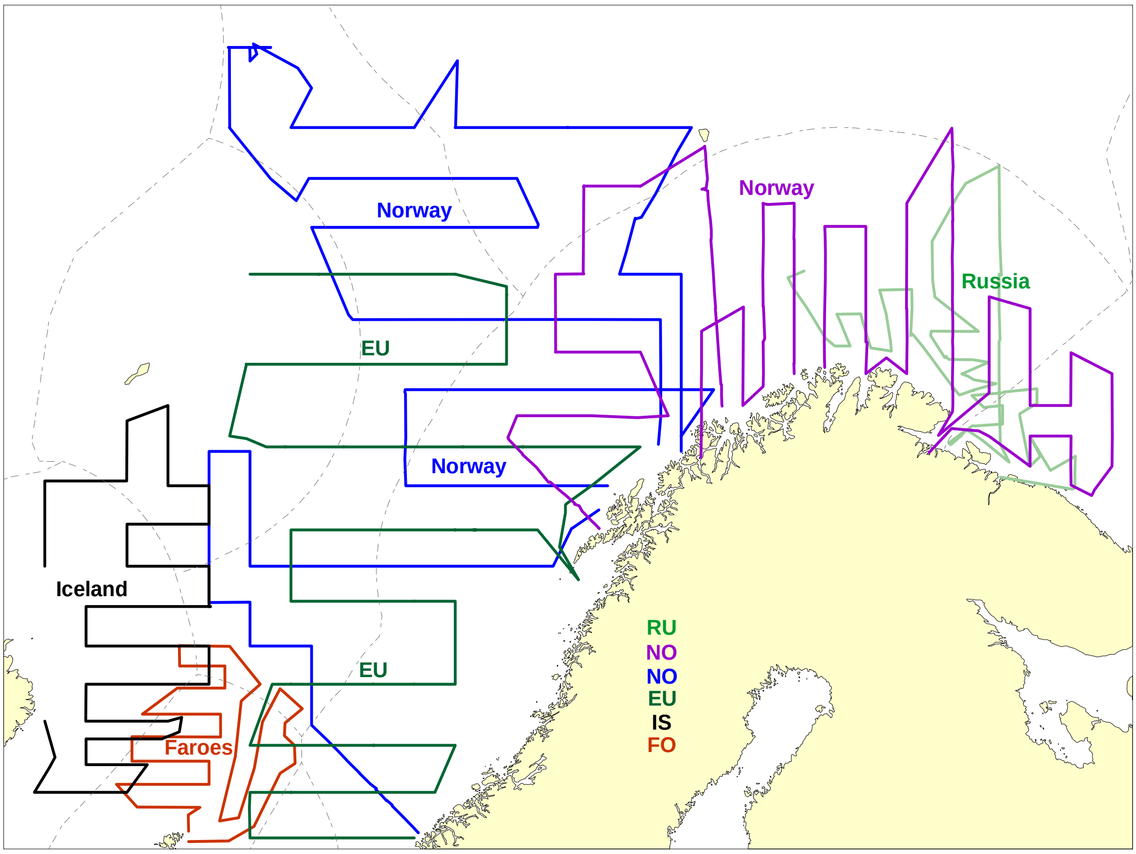


Figure 2.1: May 2005 cruise tracks.

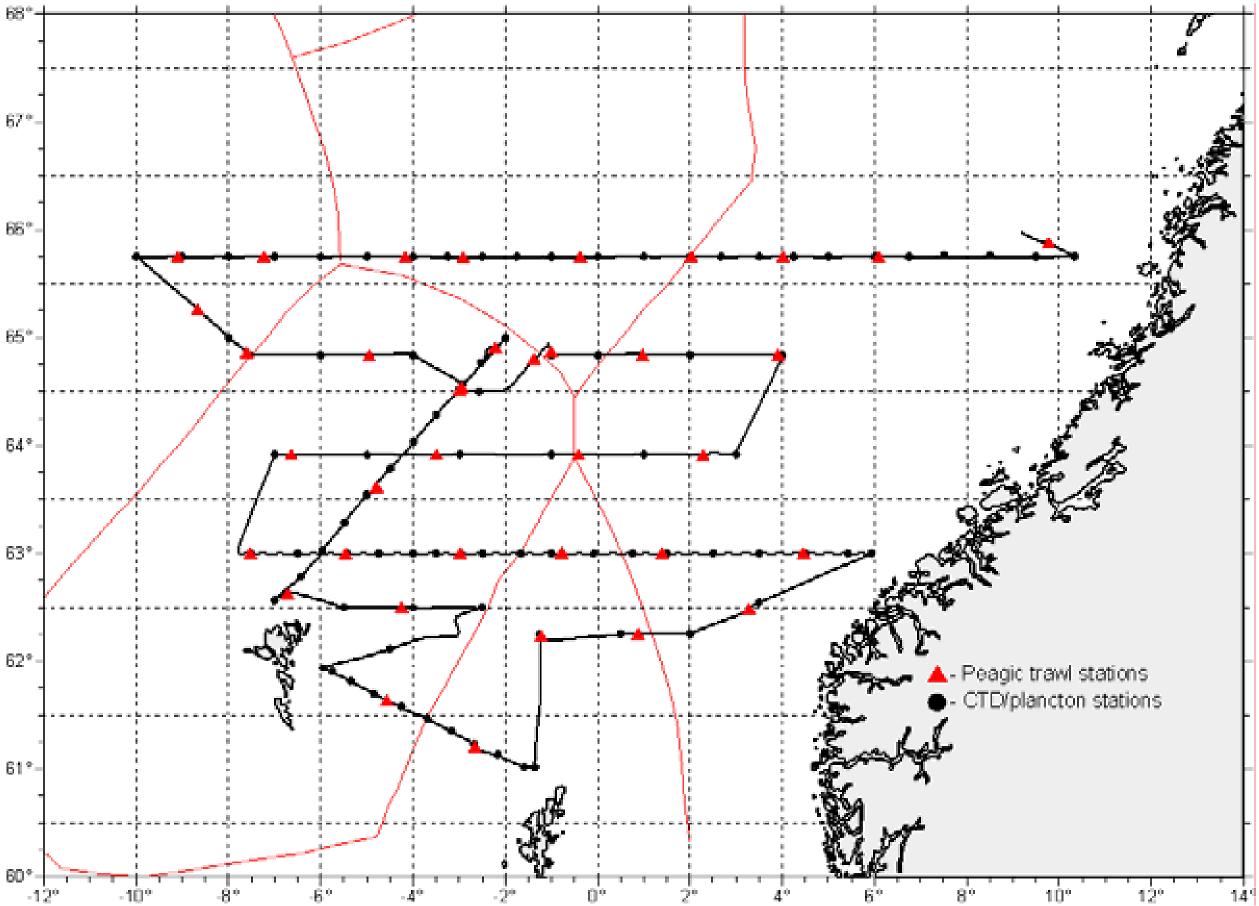


Figure 2.2: Positions of hydrographic (black dots) and pelagic trawl stations (triangles) station in June 2005 by "F. Nansen" in the central Norwegian Sea and Faroese EEZ area.

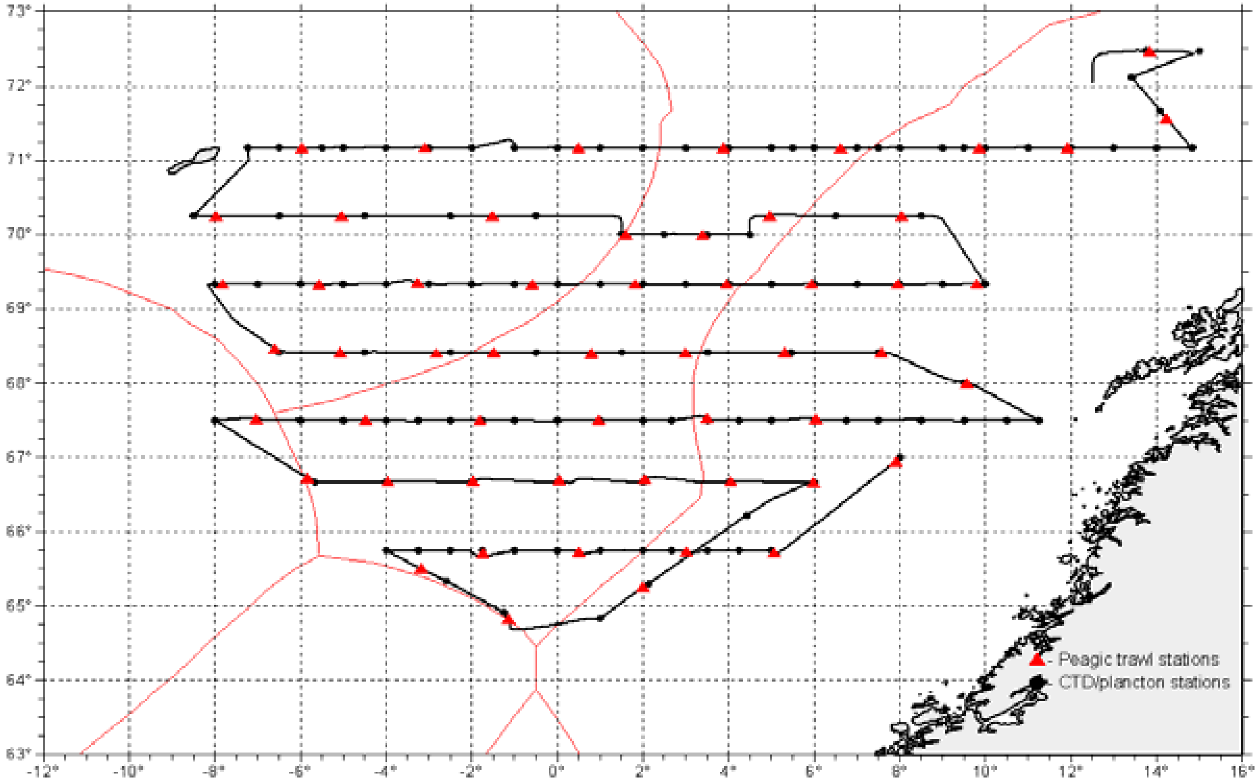


Figure 2.3: Cruise tracks in July 2005 by “F. Nansen” with trawl stations (triangles), and CTD/plankton stations (black dots).

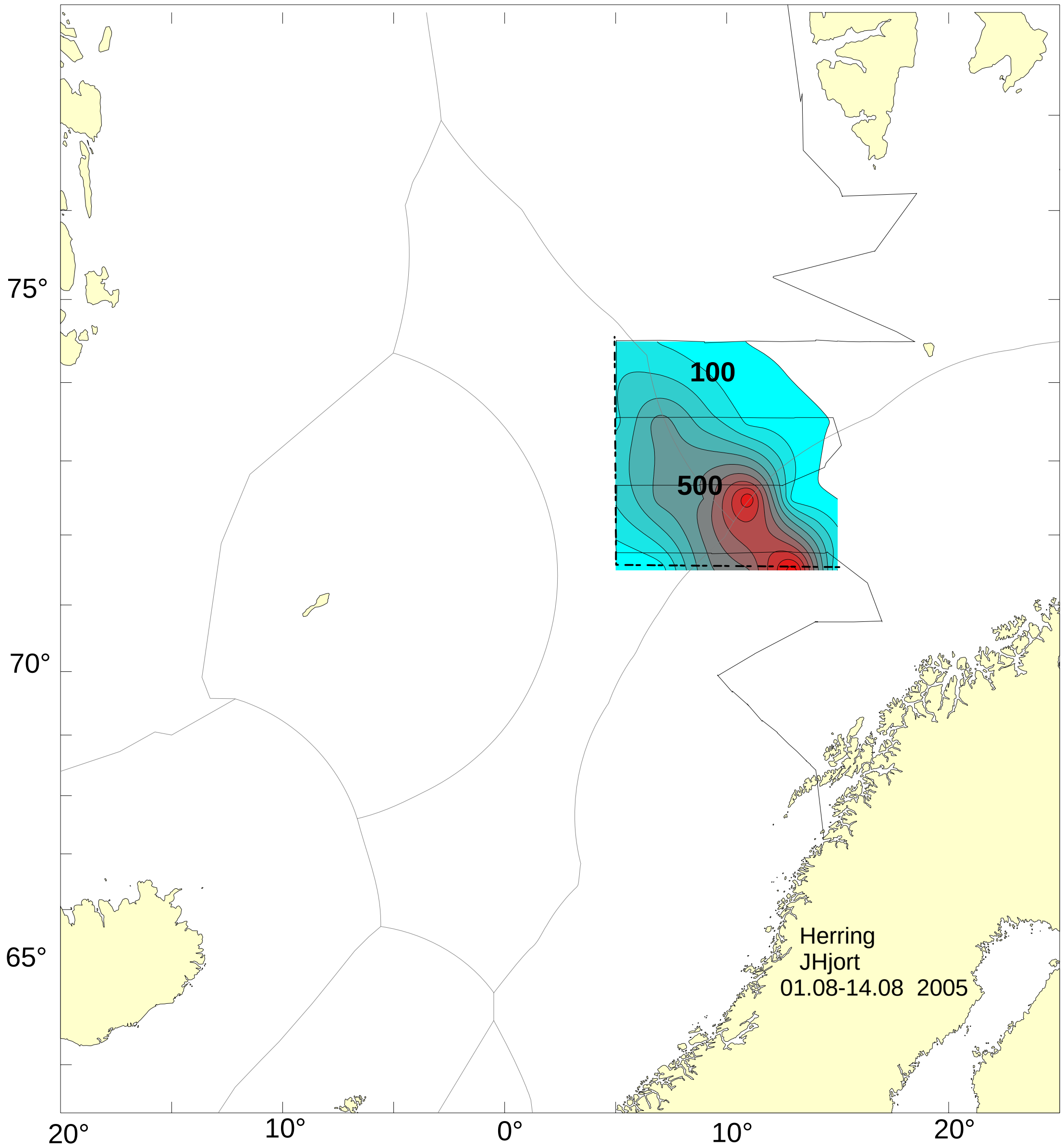


Figure 2.4: Cruise tracks and distribution of Norwegian spring spawning herring in August 2005, RV "J. Hjort".

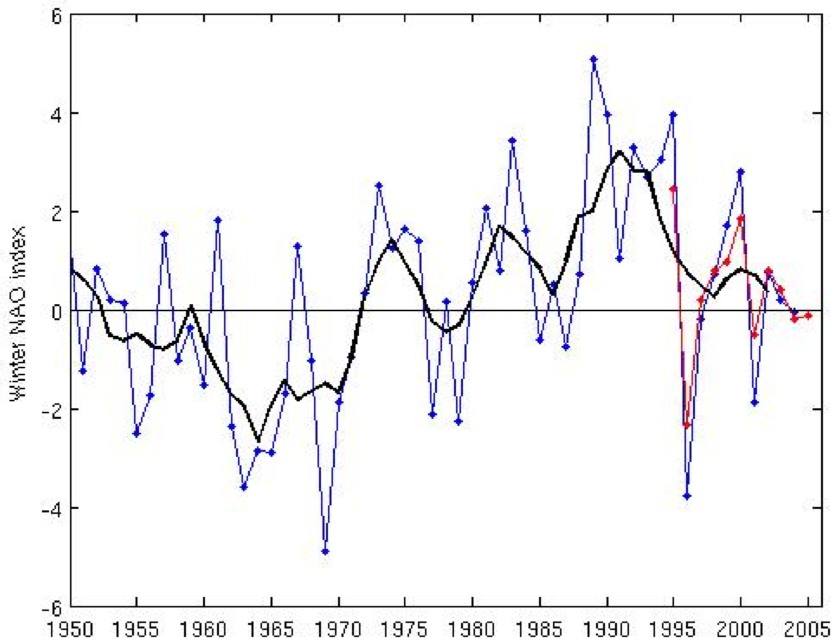


Figure 3.2.1.1: Hurrell's winter NAO index (Lisbon-Stykkisholmur/Reykjavik), from 1950 to 2004 (blue line), and Osborn's winter NAO index (Gibraltar-Southwest Iceland) from 1995 to 2005 (red line). Black line is 5 years moving averages.

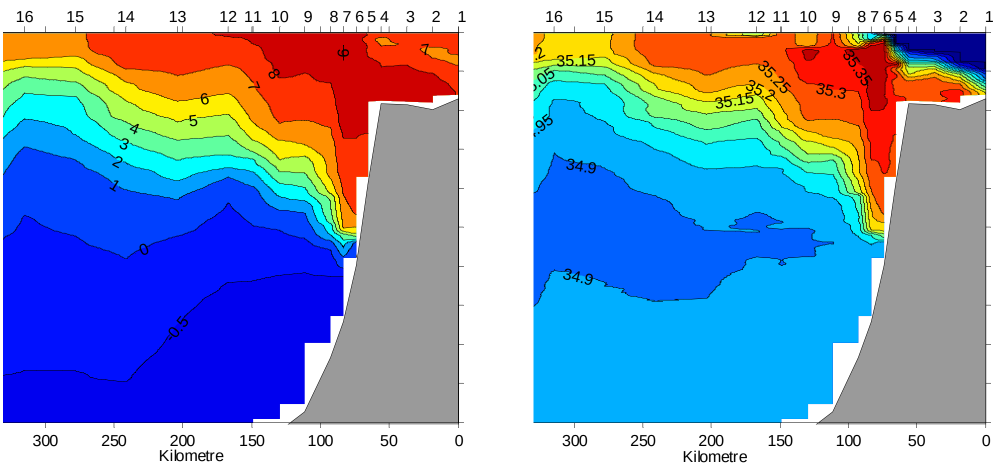


Figure 3.2.1.2: Temperature (left panel) and salinity (right panel) in the Svinøy section, 9 May 2005.

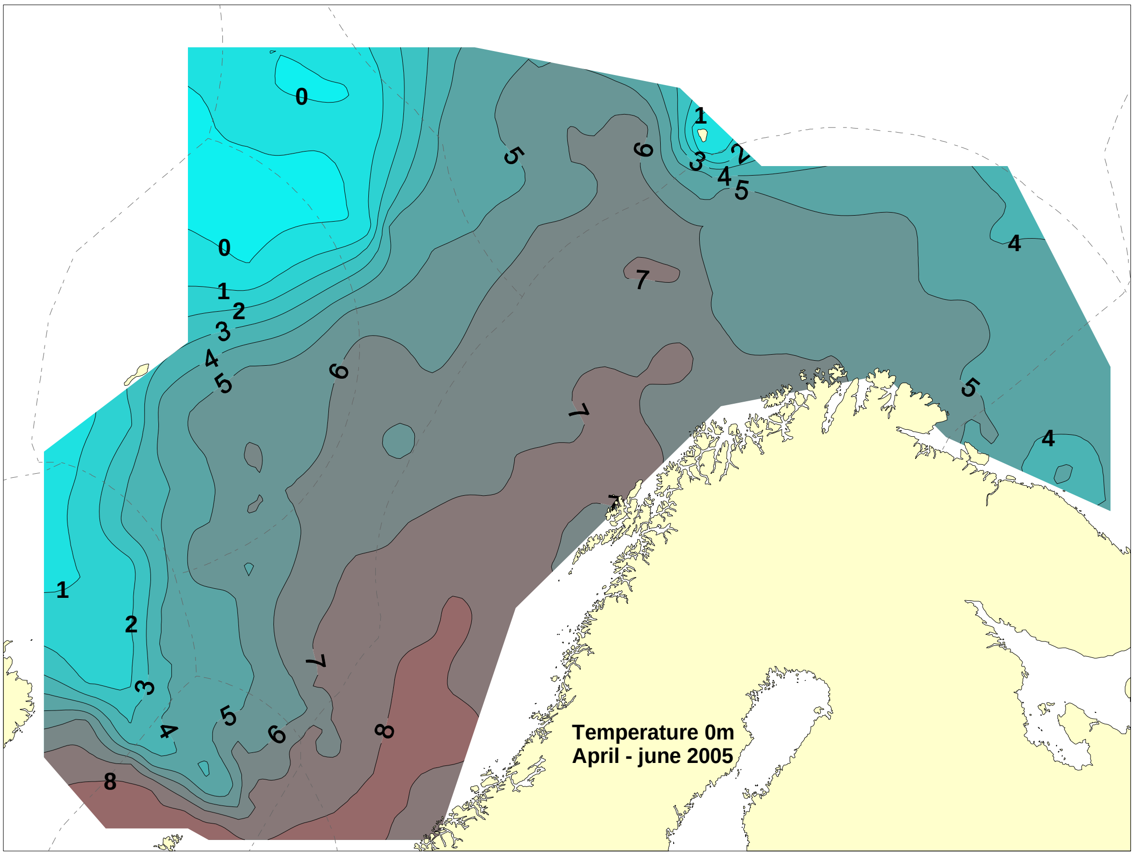


Figure 3.2.1.3: Temperature at surface in May 2005.

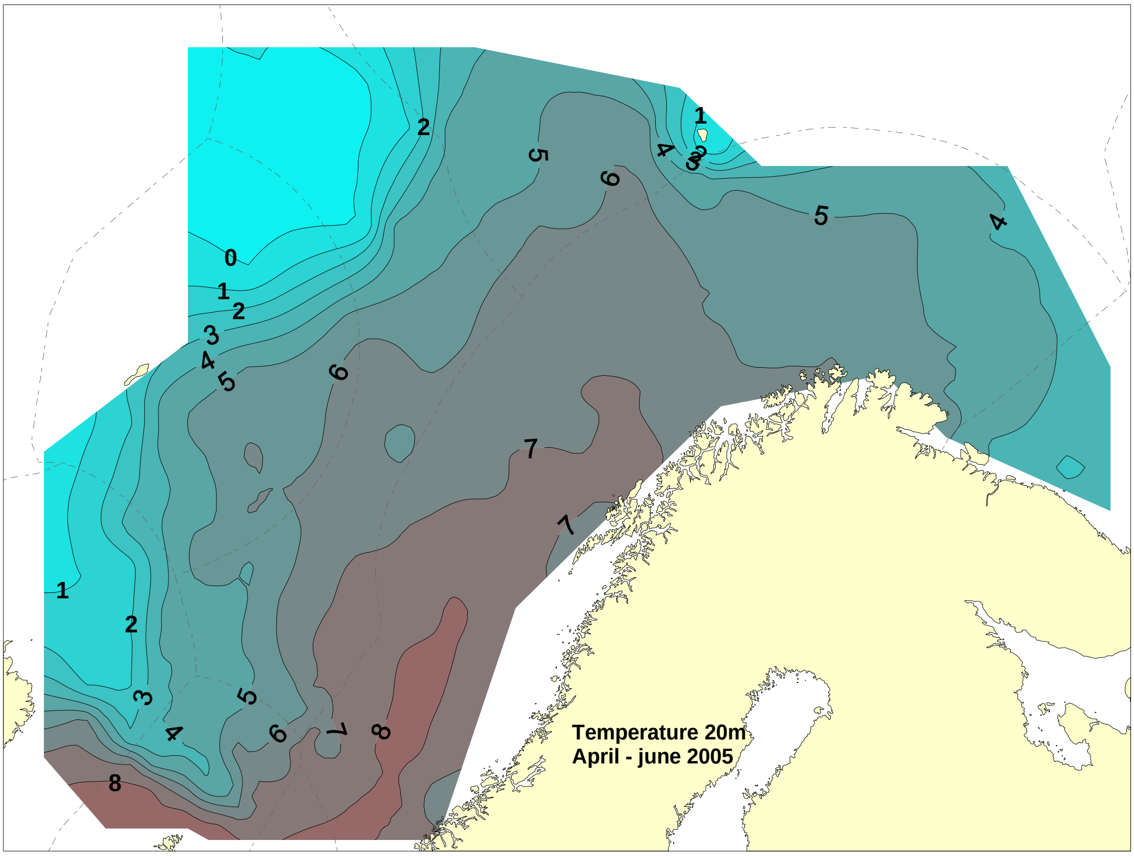


Figure 3.2.1.4: Temperature at 20 m depth in May 2005.

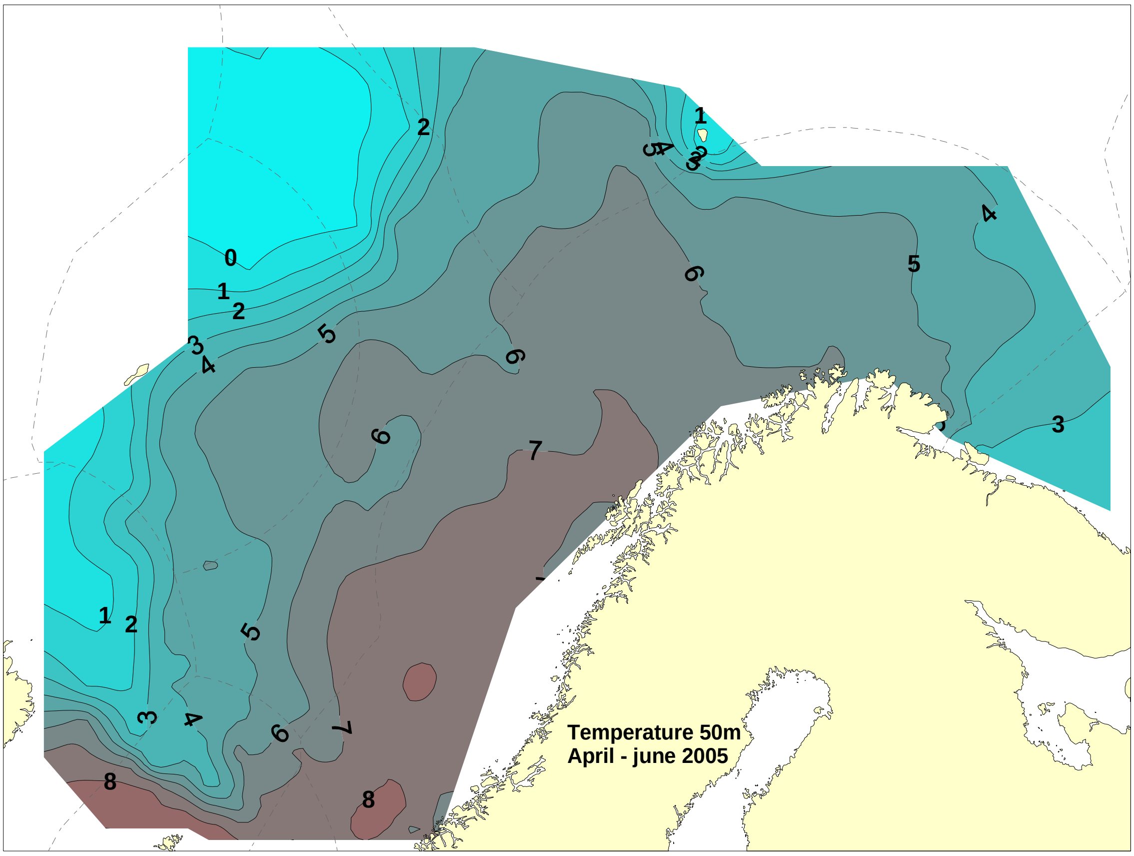


Figure 3.2.1.5: Temperature at 50 m depth in May 2005.

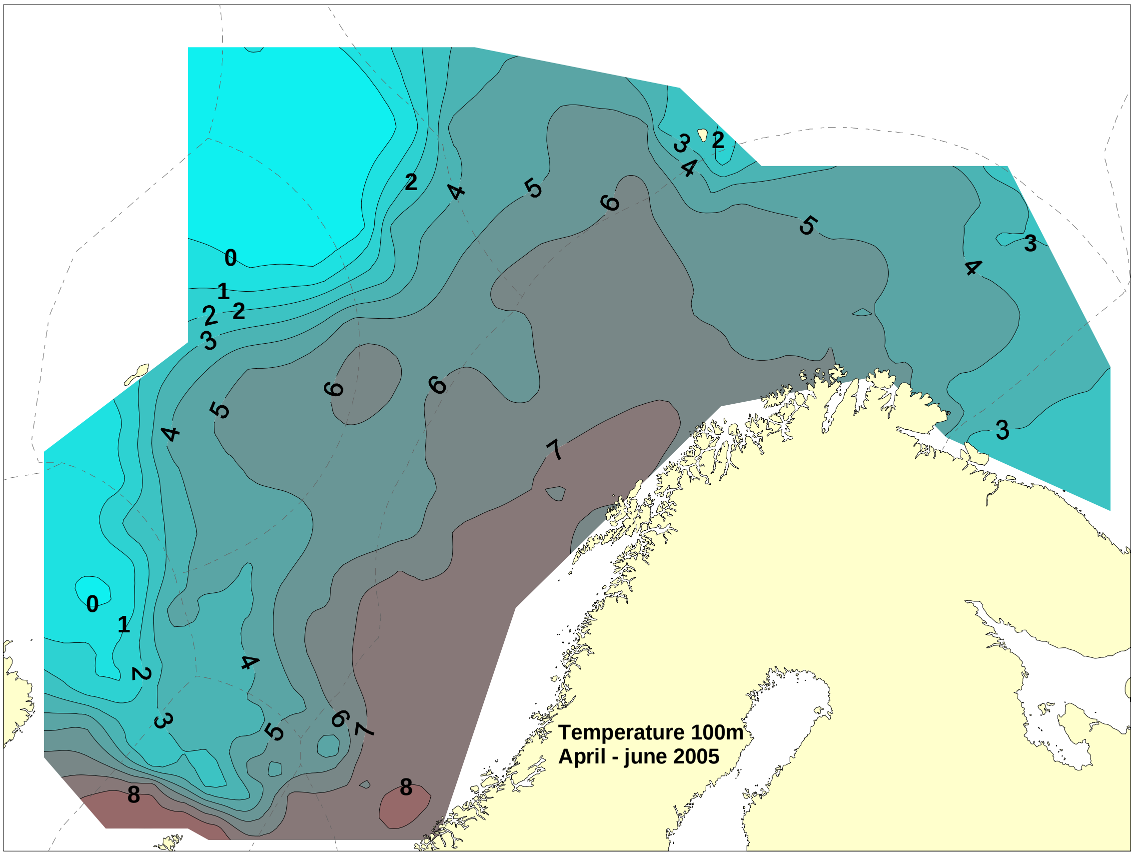


Figure 3.2.1.6: Temperature at 100 m depth in May 2005.

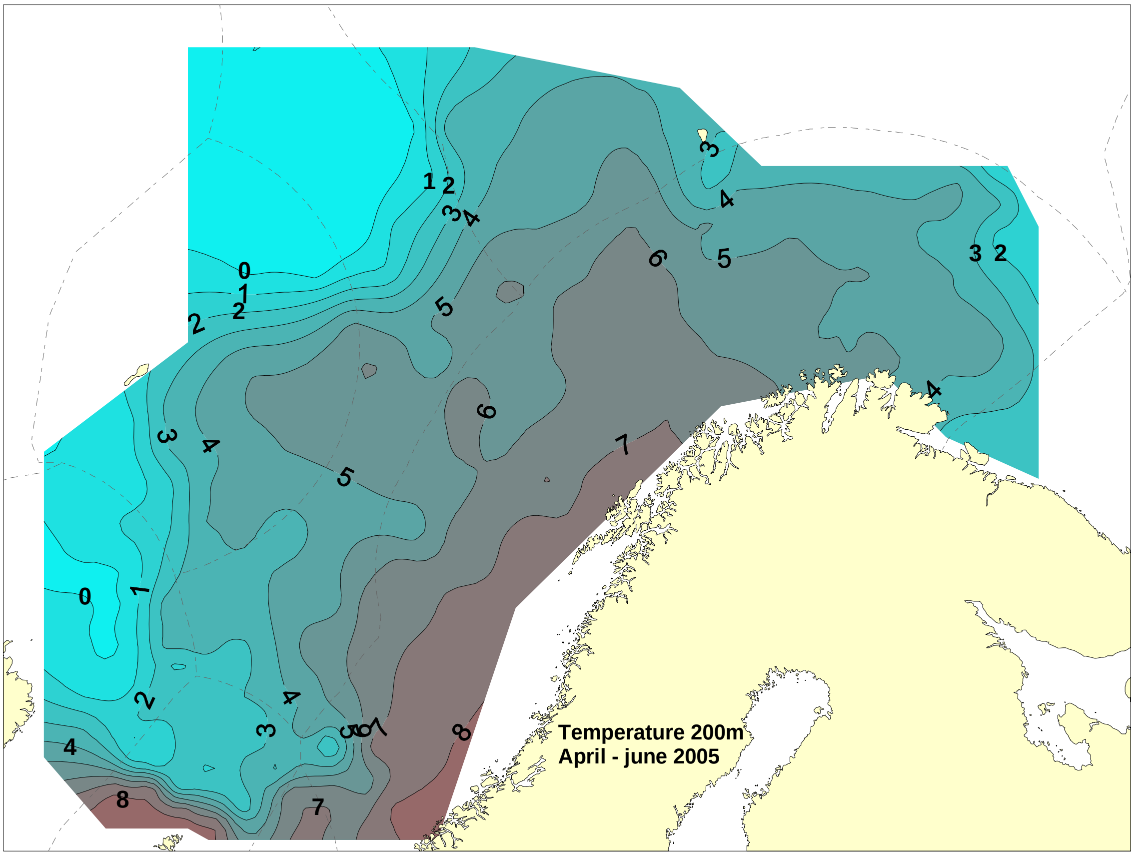


Figure 3.2.1.7: Temperature at 200 m depth in May 2005.

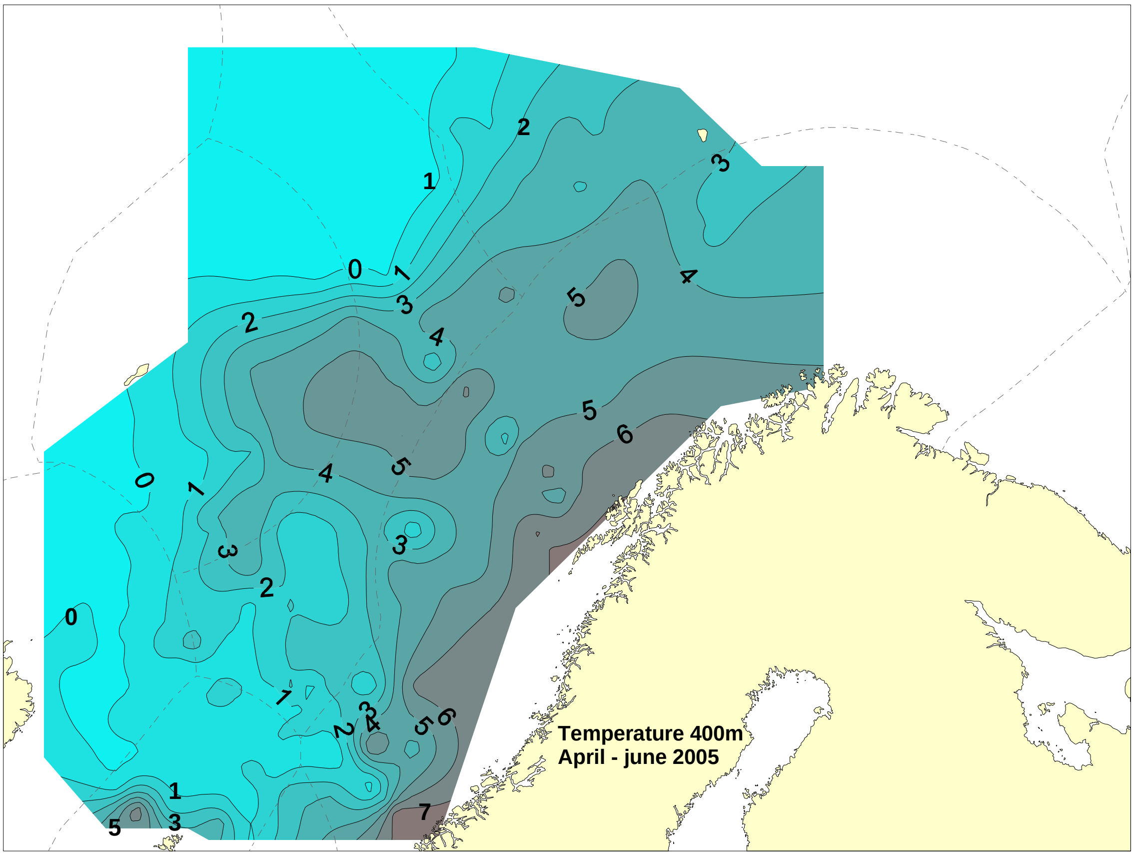


Figure 3.2.1.8: Temperature at 400 m depth in May 2005.

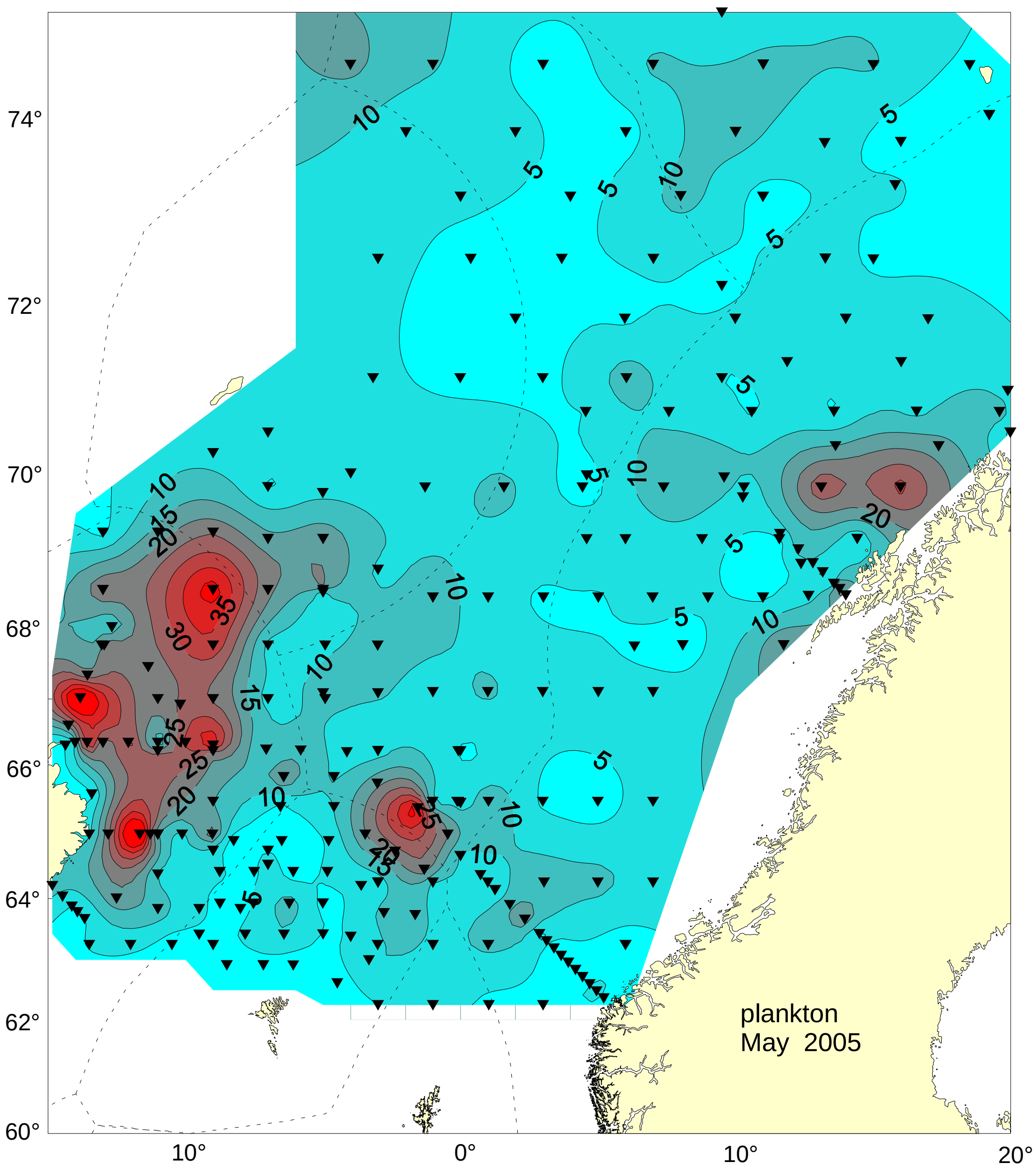


Figure 3.2.2.1: Zooplankton biomass (g dw m^{-2}) (200–0 m) (50–0 m in Icelandic standard sections) in May 2005.

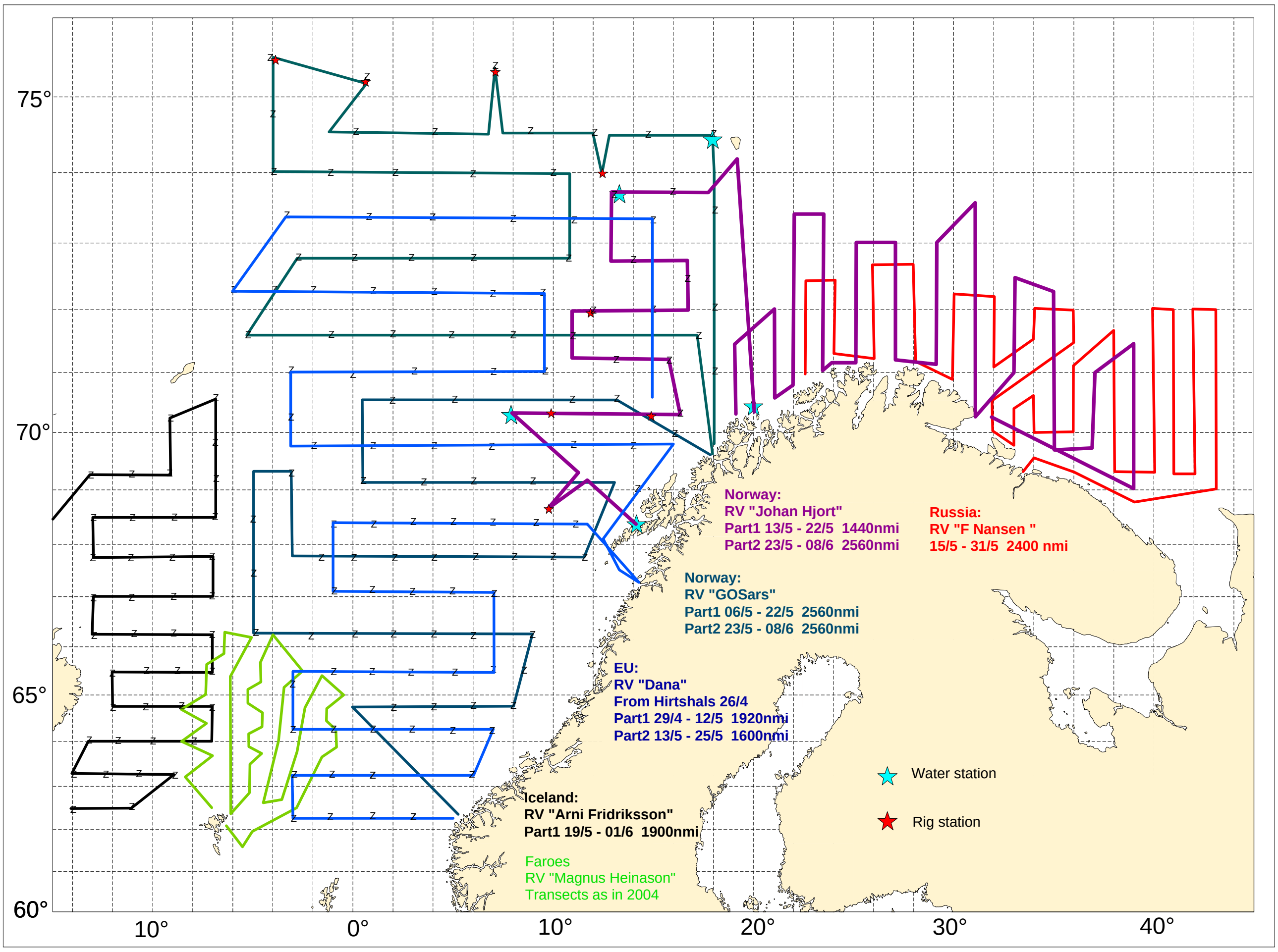


Figure 3.2.3.1: Planned survey for the PGNAPES coordinating area in May 2005.

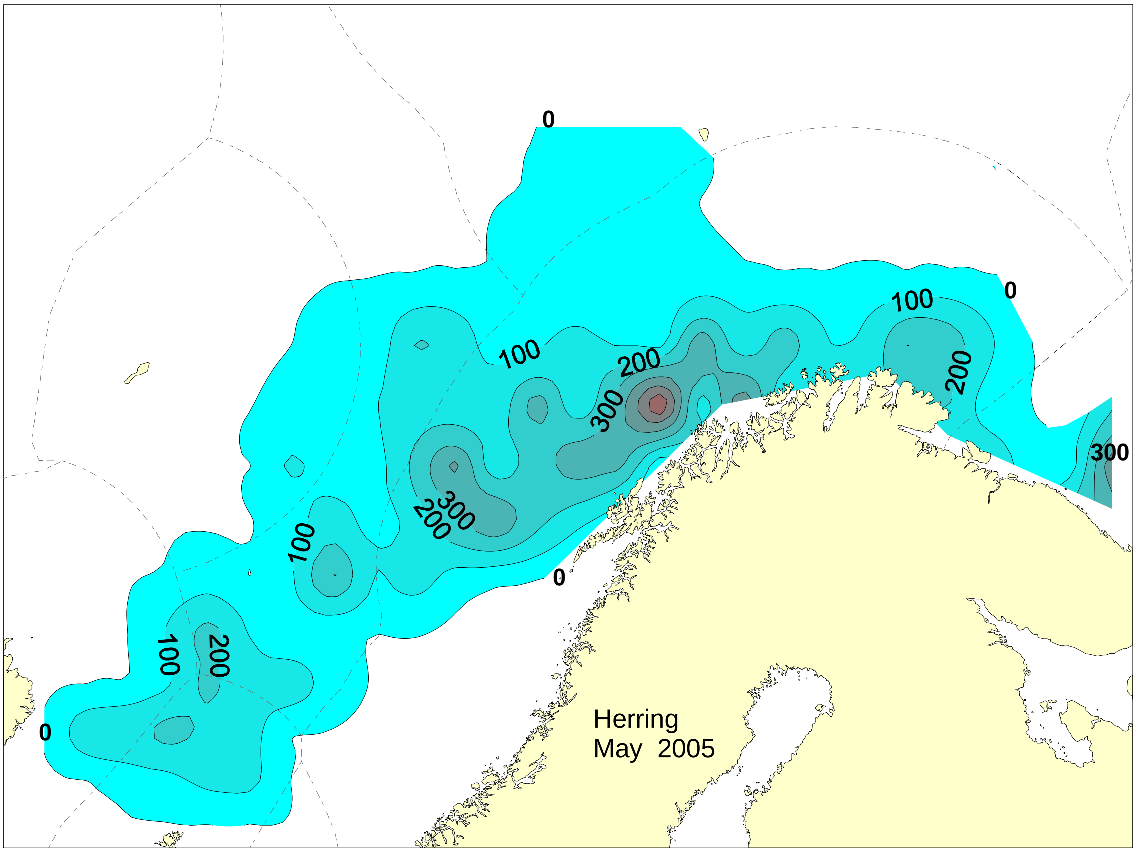


Figure 3.2.3.2: Distribution of Norwegian spring spawning herring in May 2005.

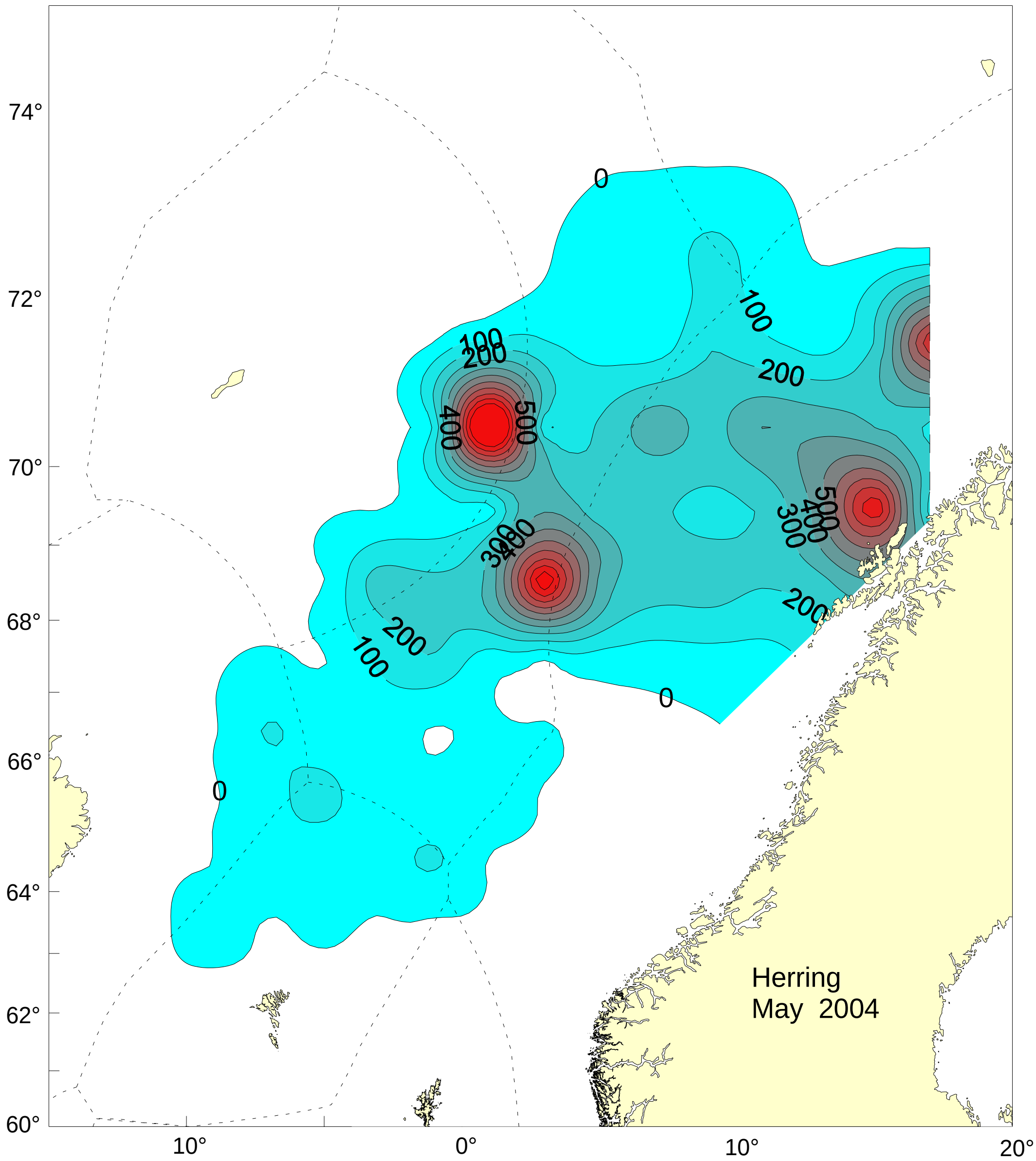


Figure 3.2.3.3: Distribution of Norwegian spring spawning herring in May 2004 (ICES CM 2004/D:07).

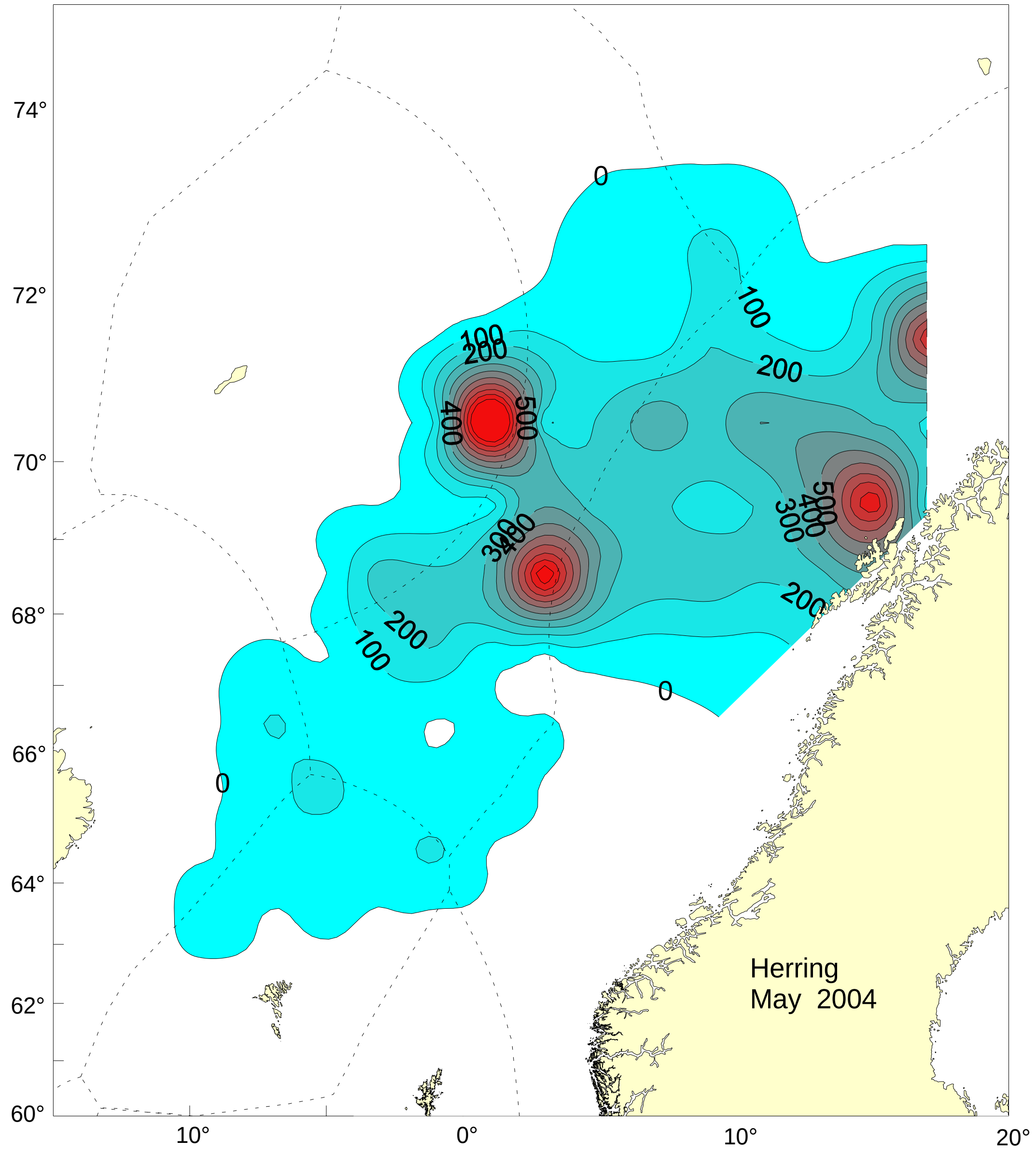


Figure 3.2.3.4: Centre of gravity of herring during the period 1996–2005 derived from acoustic value.

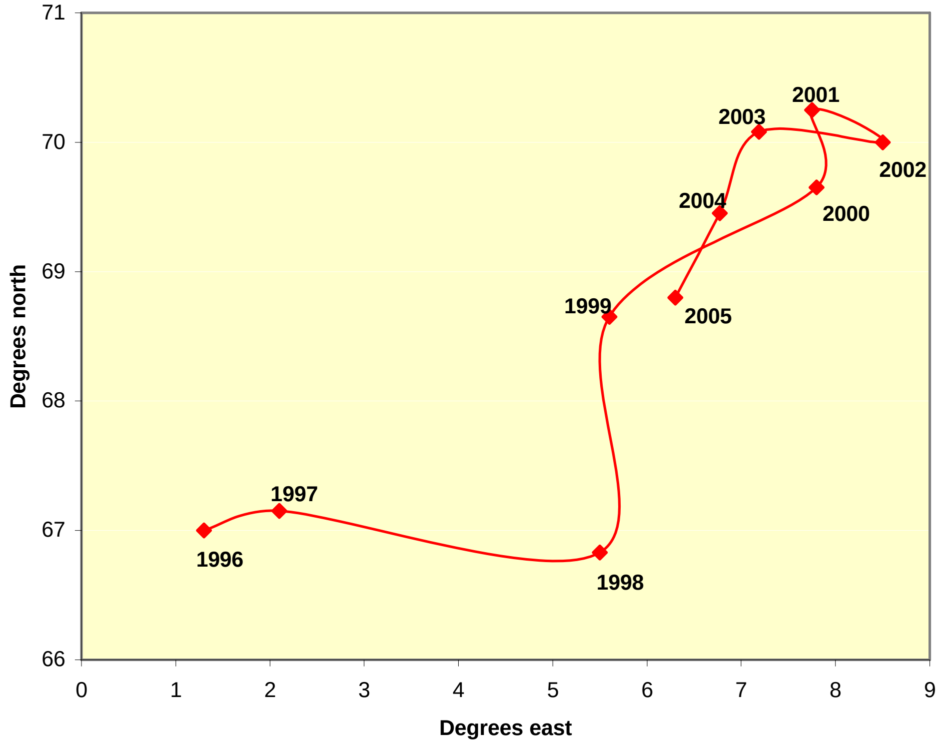


Figure 3.2.3.5: Visualisation of the geographic movement of the centre of gravity of Herring stock in May, during the period 1996–2005 derived from the acoustic values (Figure 3.2.3.3).

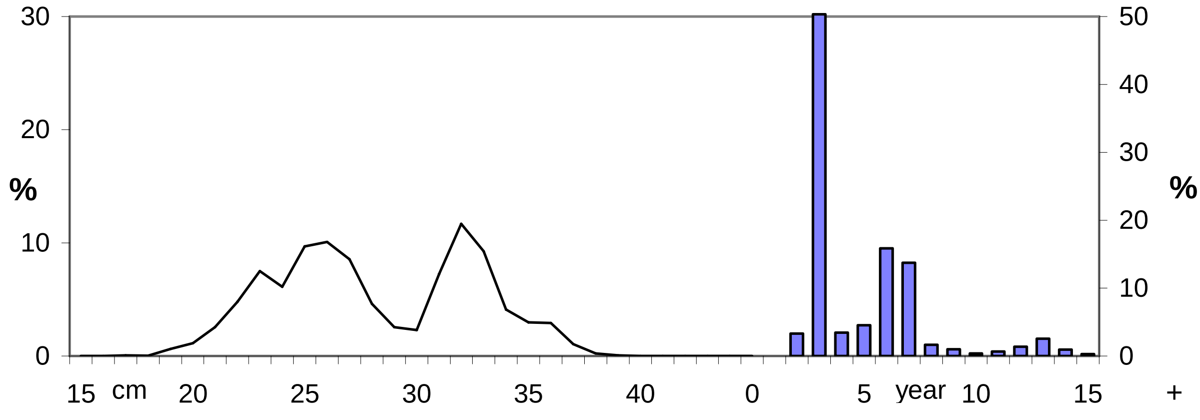


Figure 3.2.3.6: Length and age distribution of Norwegian spring spawning herring in the Norwegian Sea east to 20°E in May 2005.

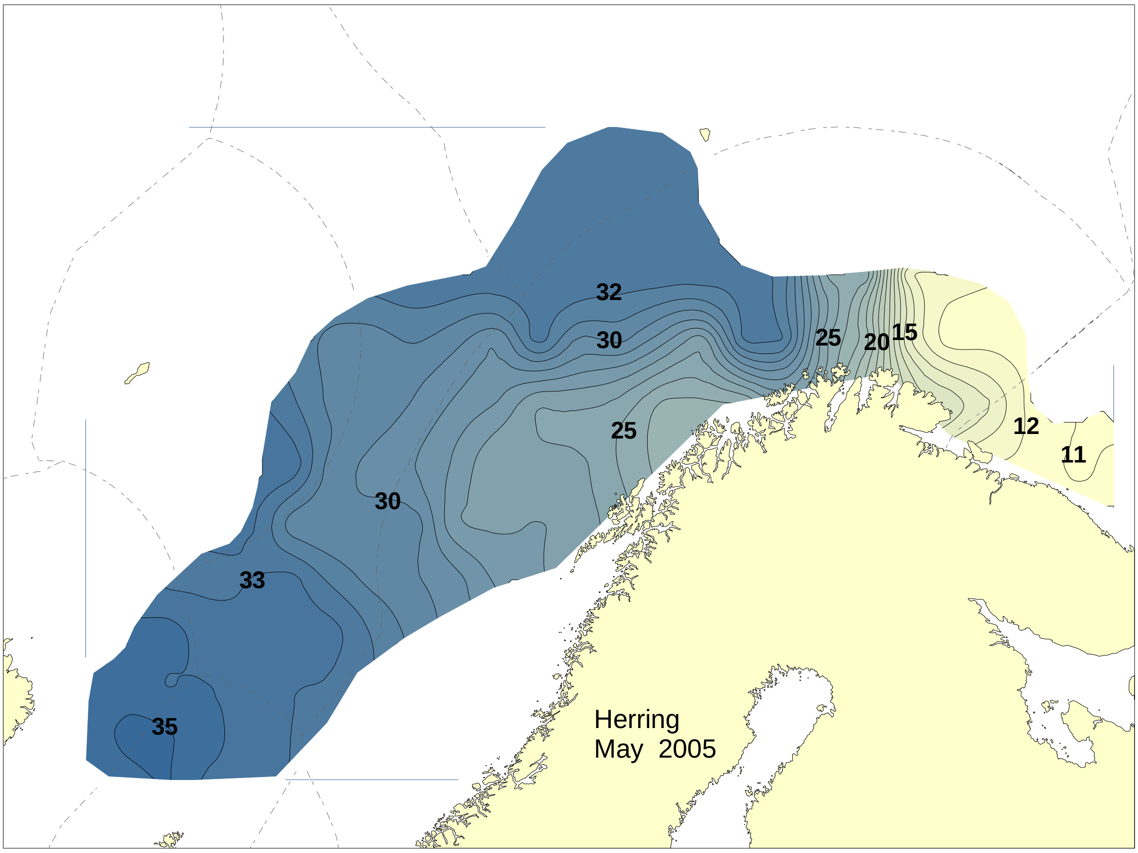


Figure 3.2.3.7: Mean lengths by area of Norwegian spring spawning herring derived from trawl samples in May 2005.

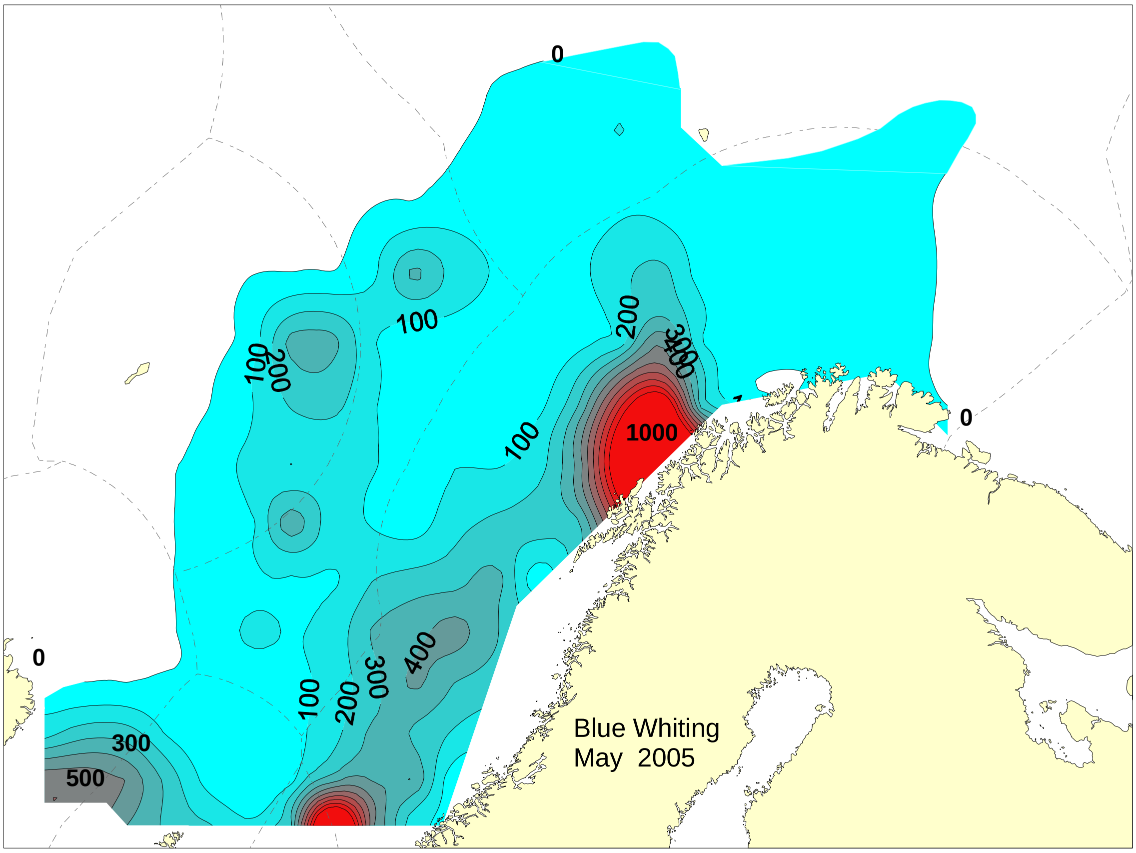


Figure 3.2.4.1: Density of blue whiting in terms of s_A-values (m^2/nm^2) based on combined 5 nm values reported by each of the research vessels "Dana", "Magnus Heinason", "Arni Fridriksson", "Johan Hjort" and "G. O. Sars" in the Norwegian Sea–Faroese EEZ in May 2005.

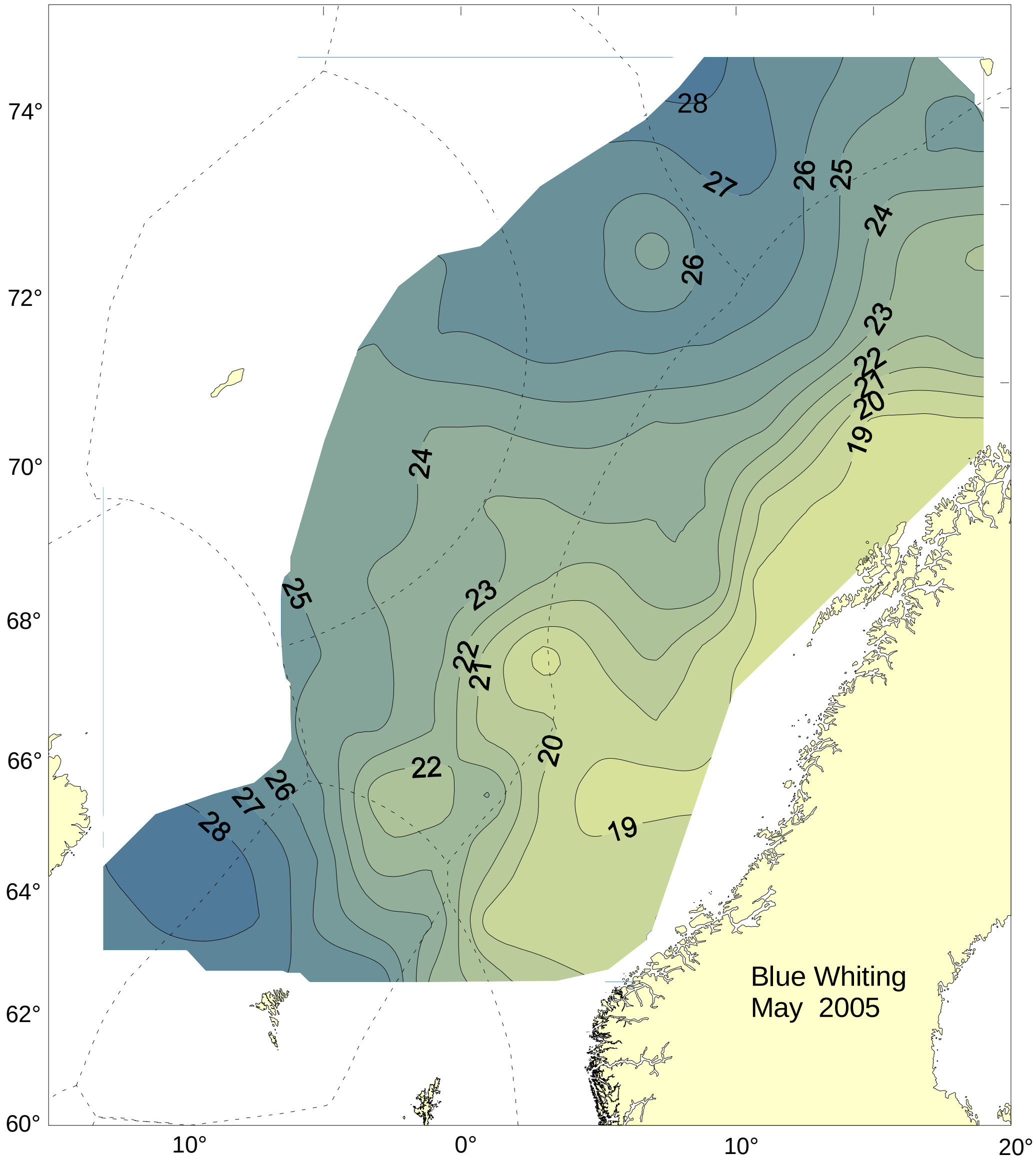


Figure 3.2.4.2: Mean length (cm) of blue whiting in the Norwegian Sea–Faroese EEZ in May 2005. Based on trawl samples from RVs "Dana", "Magnus Heinason", "Arni Fridriksson", "Johan Hjort" and "G. O. Sars".

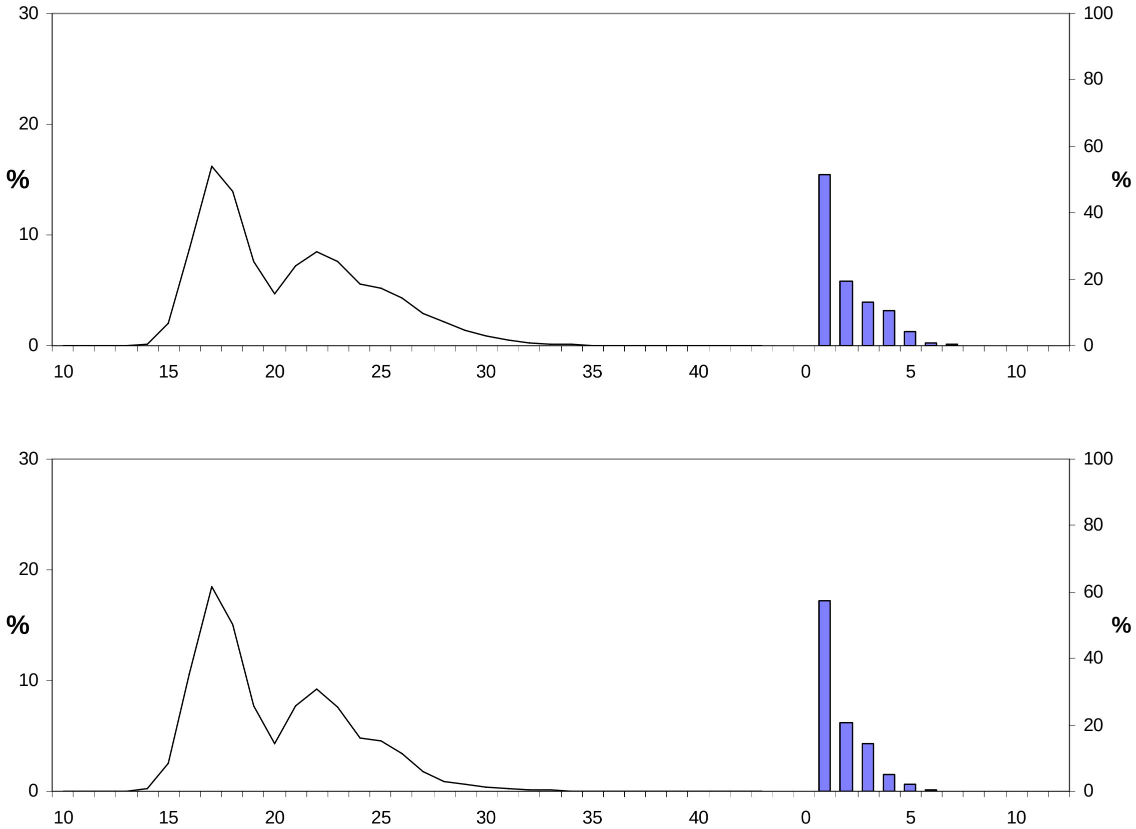


Figure 3.2.4.3: Estimated length and age distributions of blue whiting in the international pelagic survey in May-June 2005. The upper panel is based on the total survey area as shown in Figure 3.2.4.1; the lower panel is based on the standard survey area between 8°W-20°E and north of 63°N.

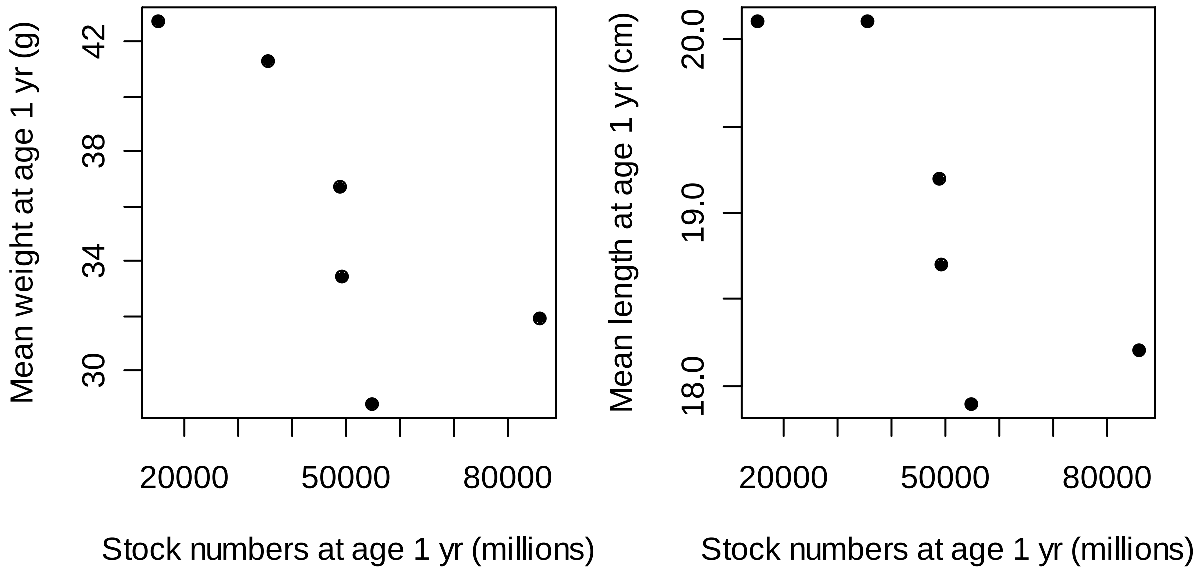


Figure 3.2.4.4: Relationship between size and abundance of blue whiting at age 1 year in the standard survey area. The correlation coefficients are r_p=-0.77 (weight) and r_p=-0.80 (length), which are not statistically significant (respectively p=0.071 and p=0.055).

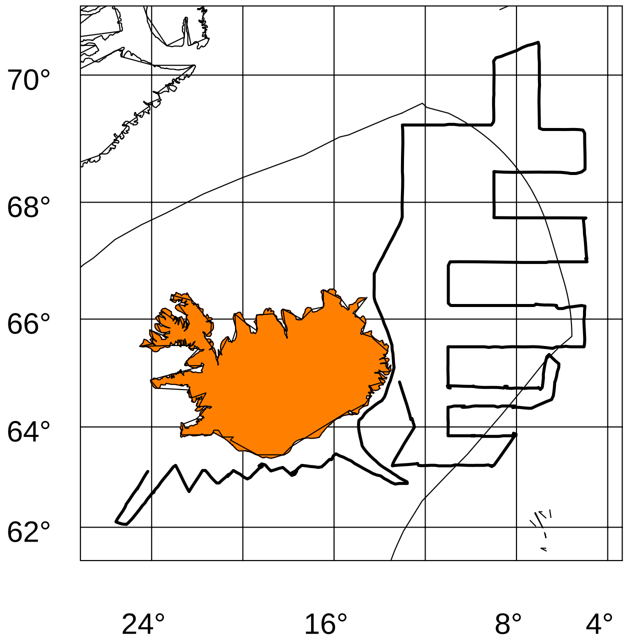


Figure 3.2.4.5: Icelandic survey tracks for the "Arni Fridriksson" in May – June 2005.

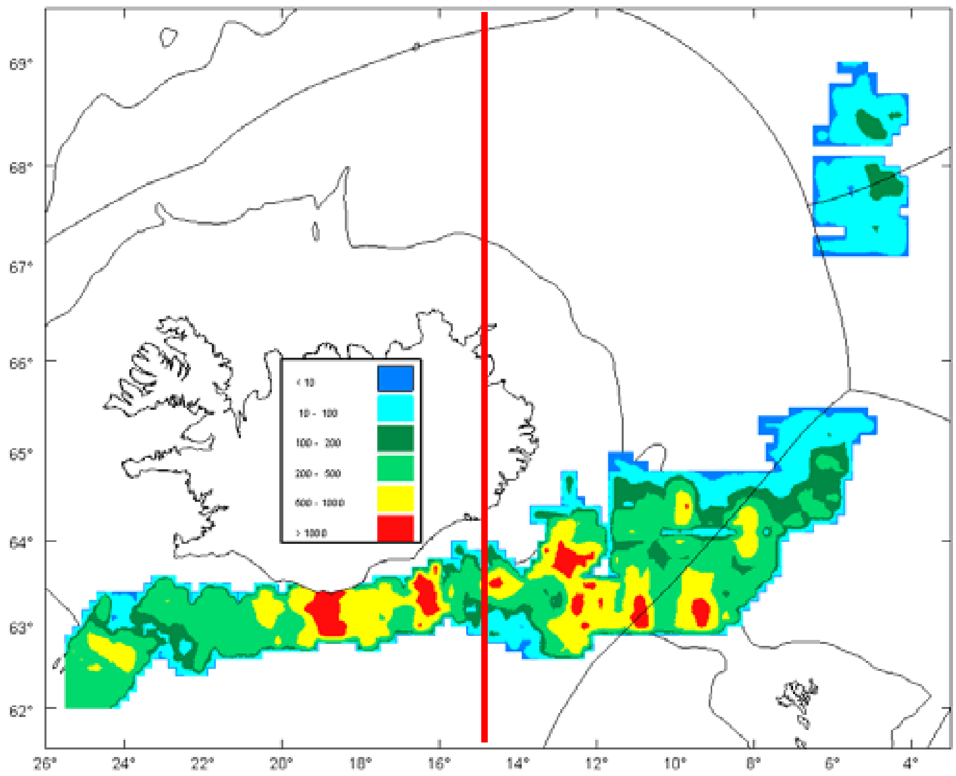


Figure 3.2.4.6: Density of blue whiting in terms of s_A-values (m^2/nm^2) in the Icelandic waters in May - June 2005. The vertical read line demarks the 15th degree longitude where young blue whiting was found (se Section 3.2.4.1 for further explanation).

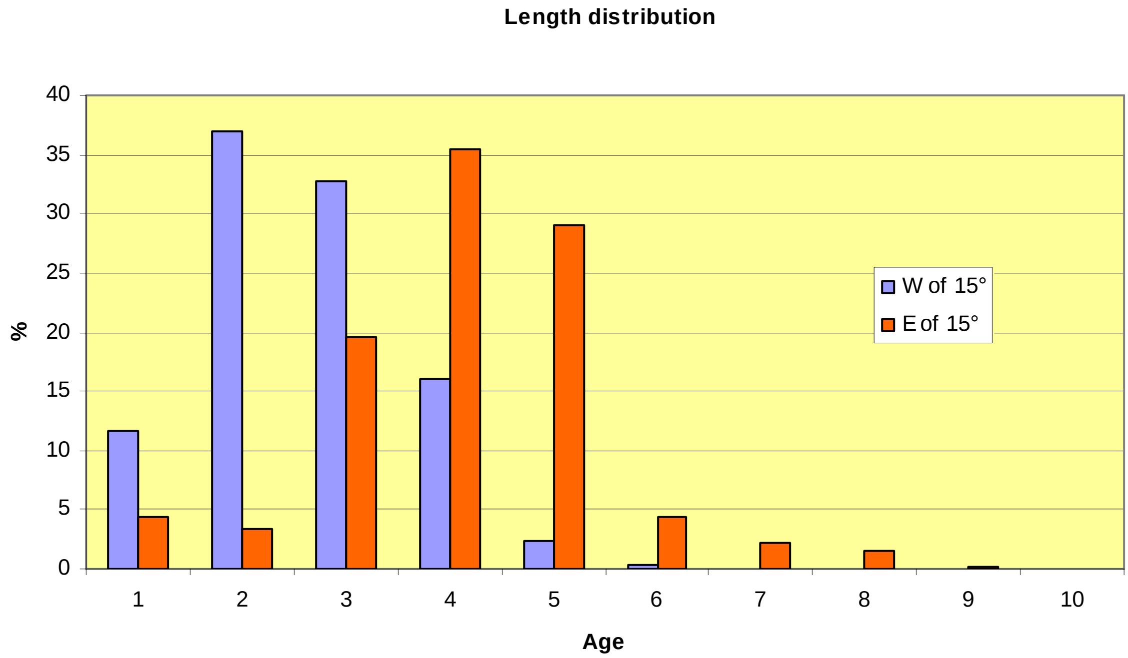


Figure 3.2.4.7: Length distribution of blue whiting in Icelandic area east and west of 15th degree in May – June 2005.

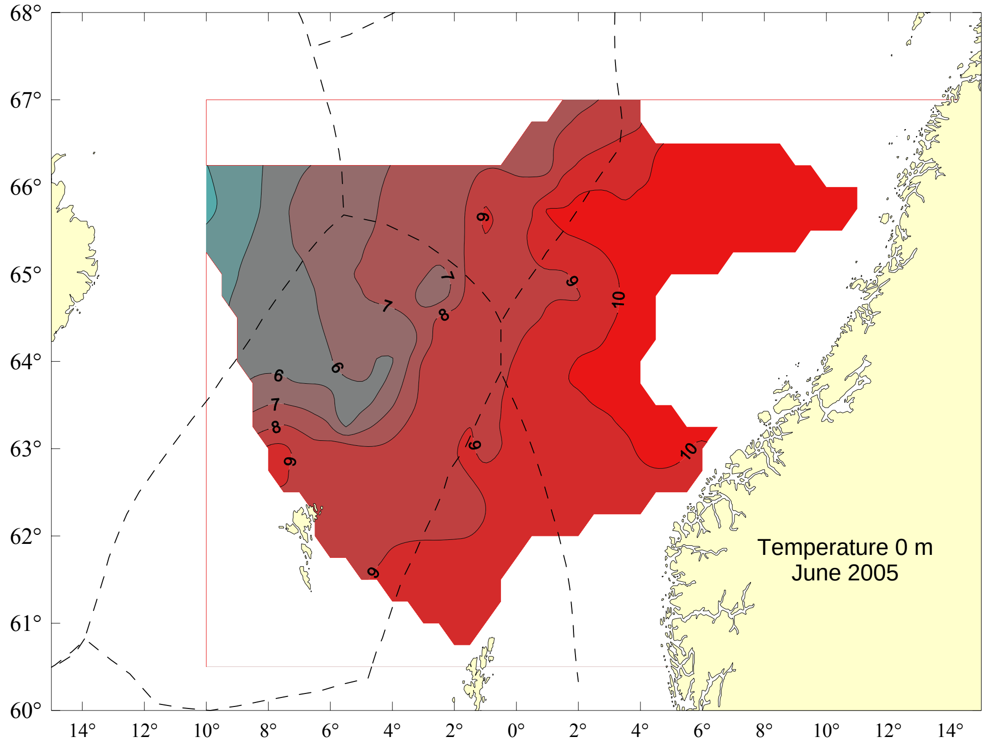


Figure 3.3.1.1: Temperature in the Norwegian Sea at surface in June 2005.

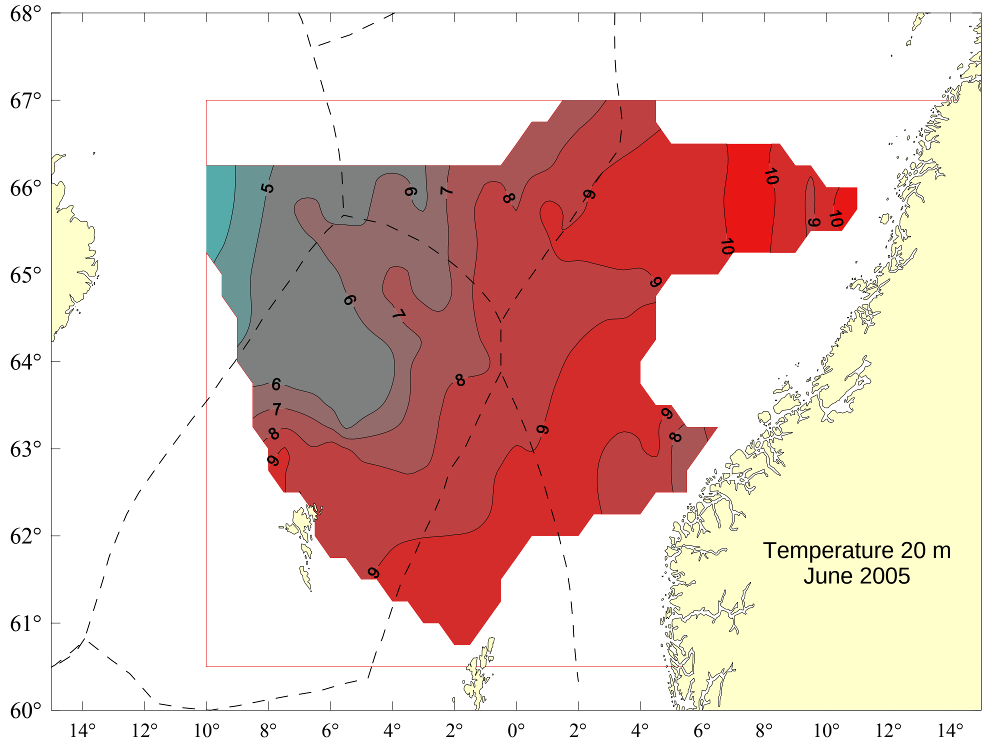


Figure 3.3.1.2: Temperature in the Norwegian Sea at 20 m in June 2005.

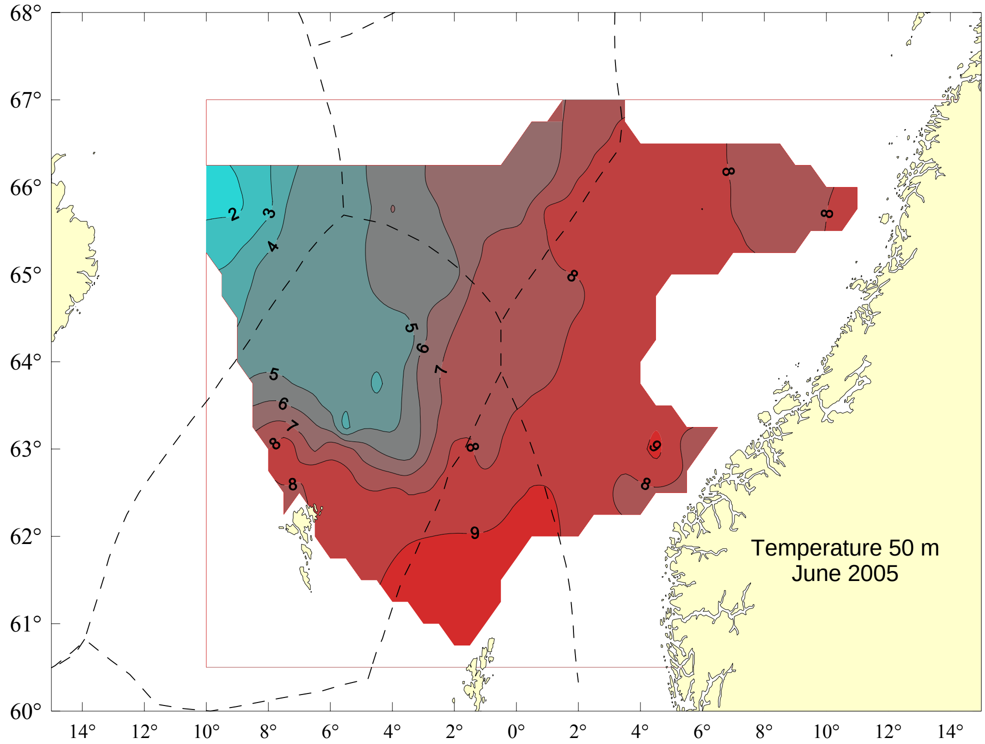


Figure 3.3.1.3: Temperature in the Norwegian Sea at 50 m in June 2005.

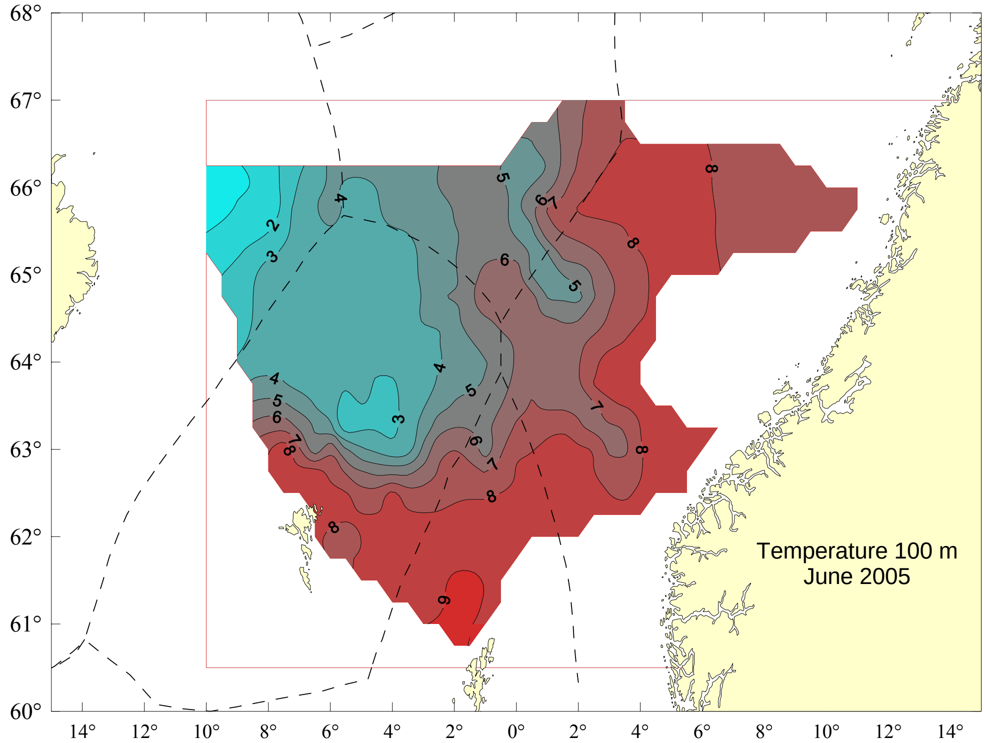


Figure 3.3.1.4: Temperature in the Norwegian Sea at 100 m in June 2005.

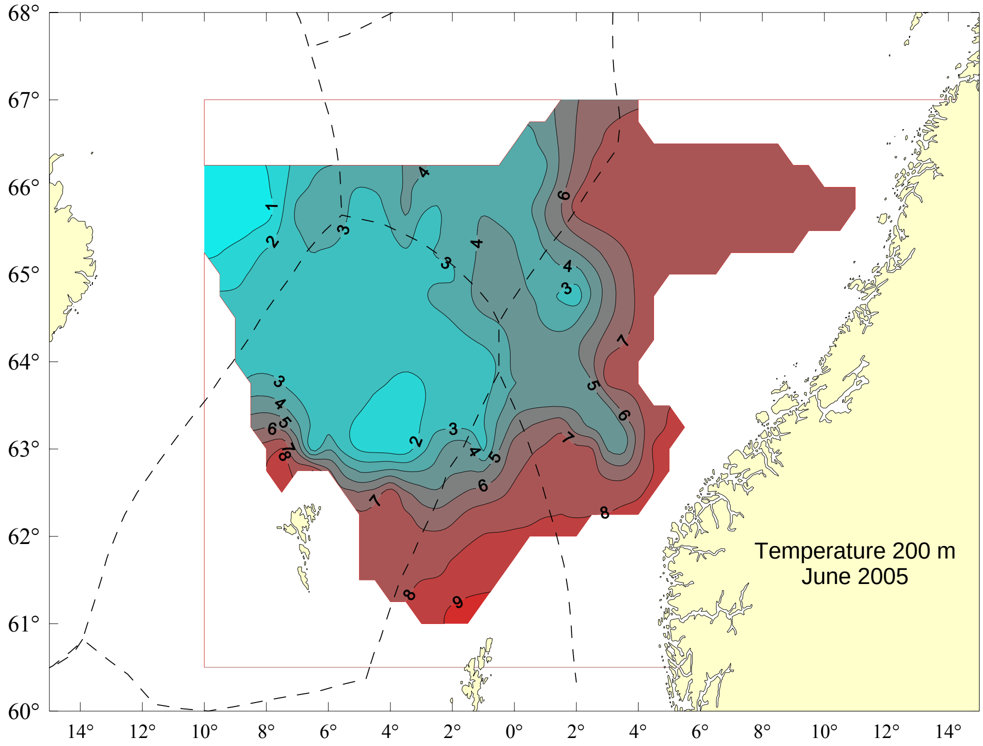


Figure 3.3.1.5: Temperature in the Norwegian Sea at 200 m in June 2005.

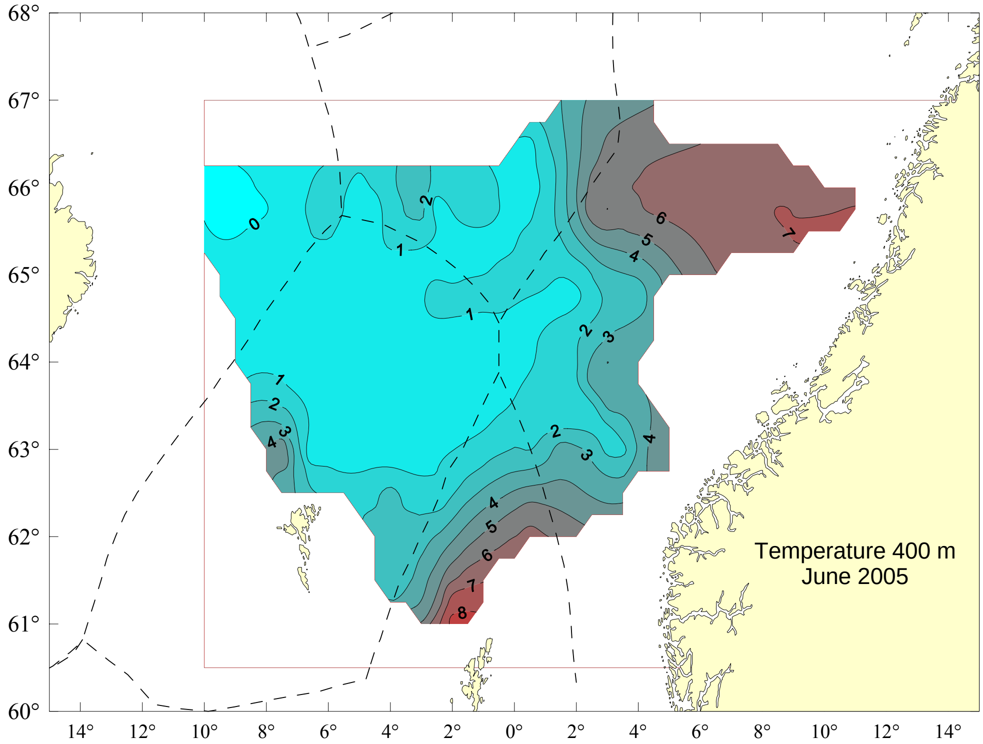


Figure 3.3.1.6: Temperature in the Norwegian Sea at 400 m in June 2005.

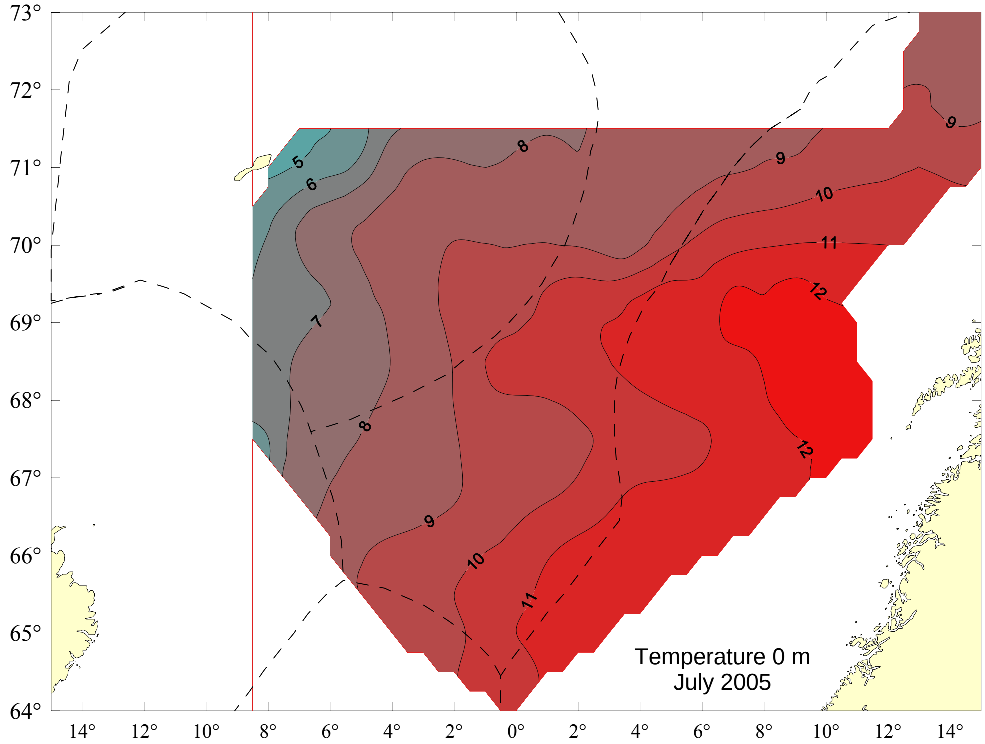


Figure 3.3.1.7: Temperature in the Norwegian Sea at surface in July 2005.

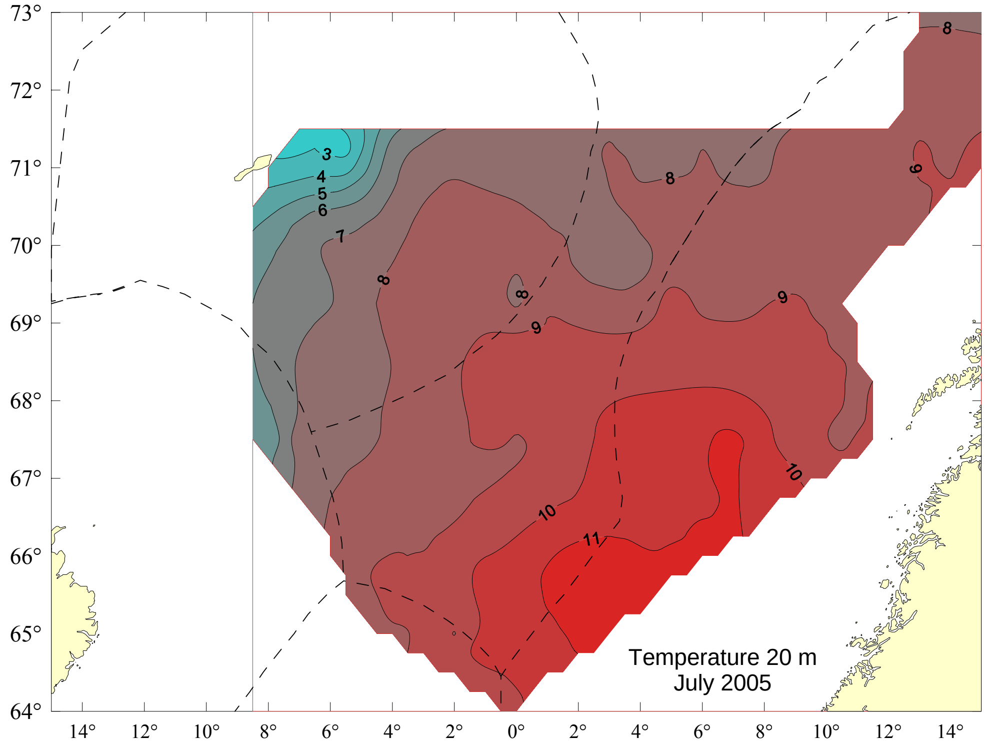


Figure 3.3.1.8: Temperature in the Norwegian Sea at 20 m in July 2005.

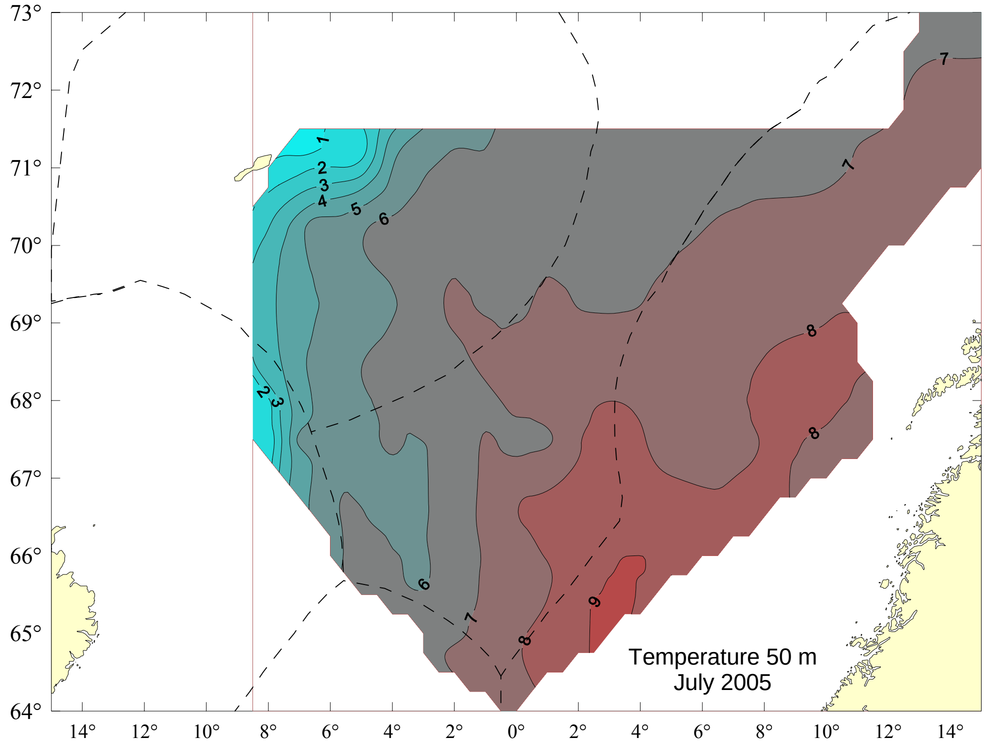


Figure 3.3.1.9: Temperature in the Norwegian Sea at 50 m in July 2005.

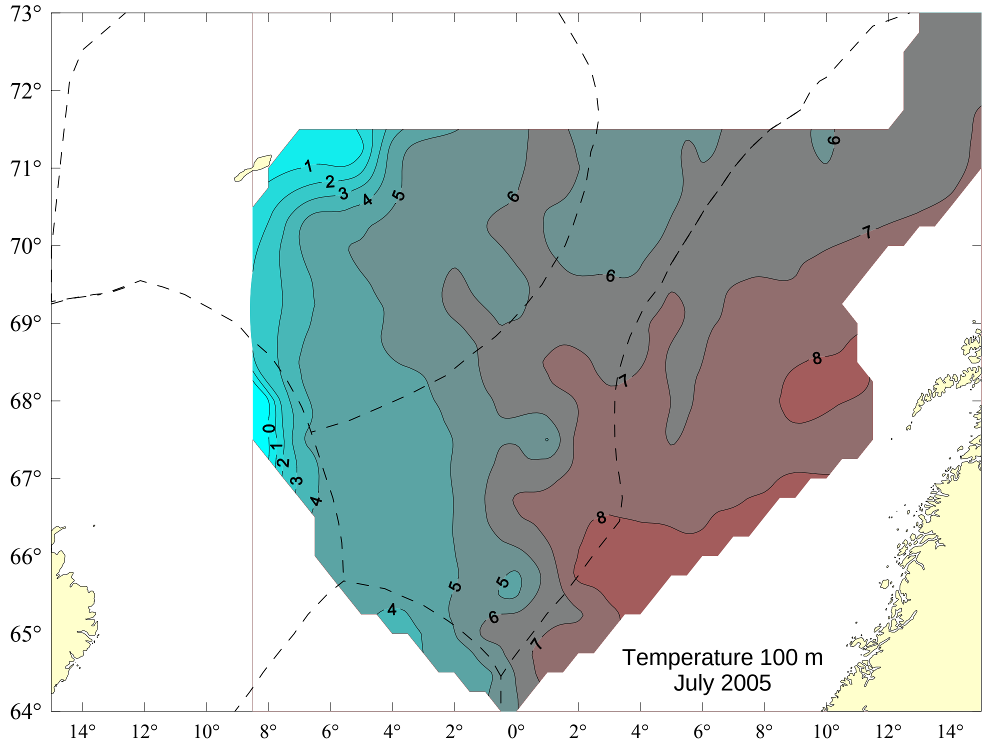


Figure 3.3.1.10: Temperature in the Norwegian Sea at 100 m in July 2005.

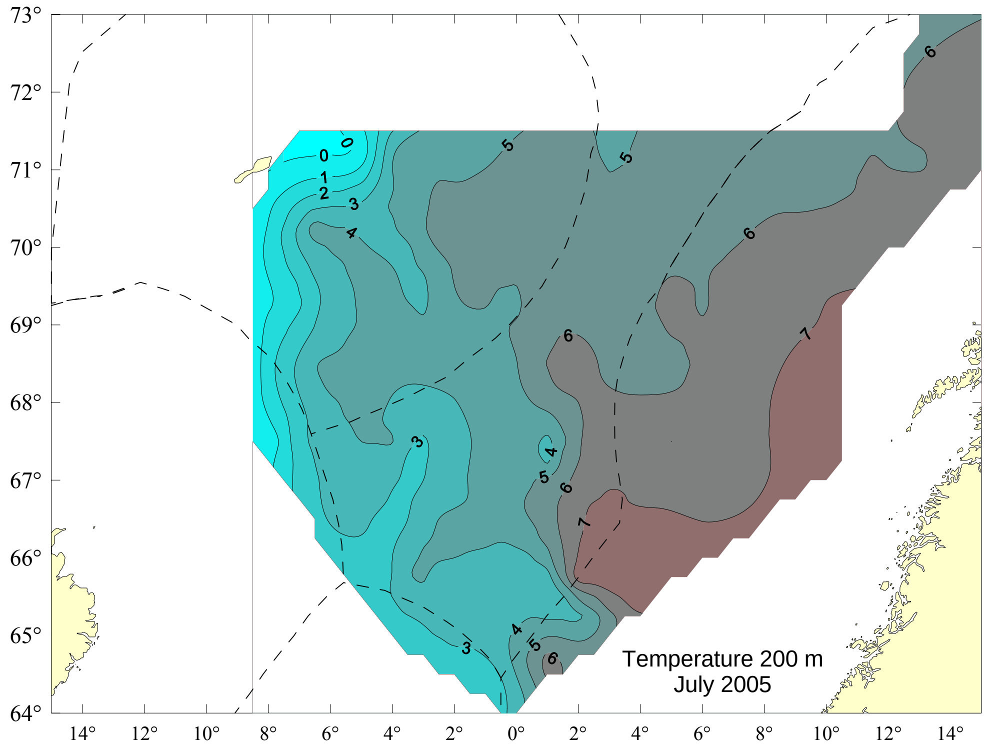


Figure 3.3.1.11: Temperature in the Norwegian Sea at 200 m in July 2005.

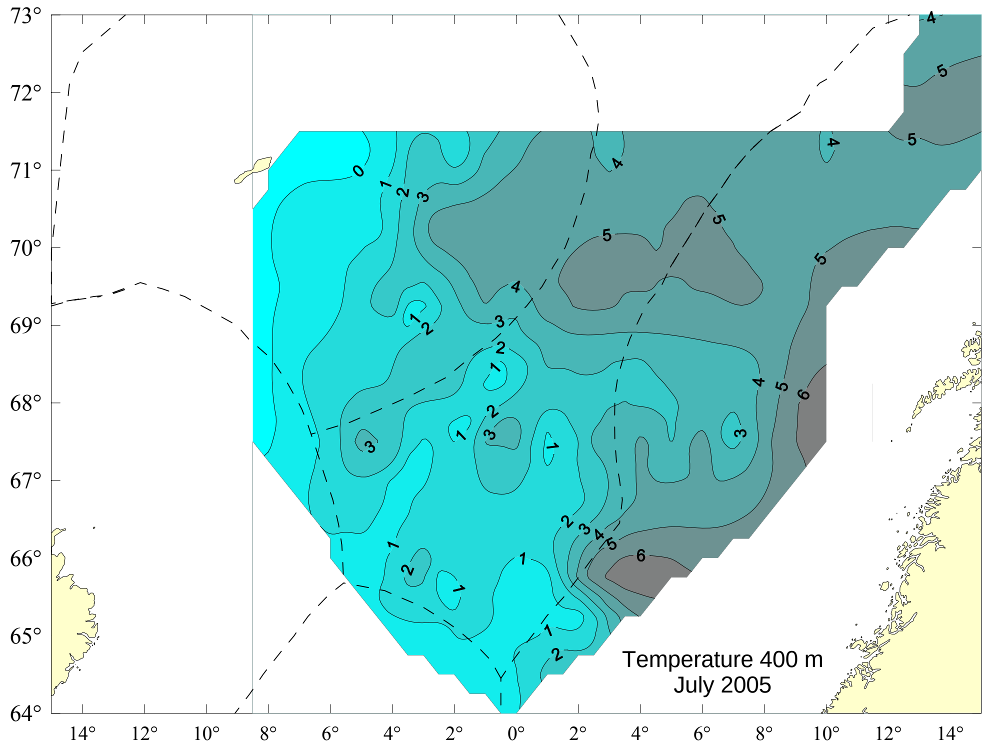


Figure 3.3.1.12: Temperature in the Norwegian Sea at 400 m in July 2005.

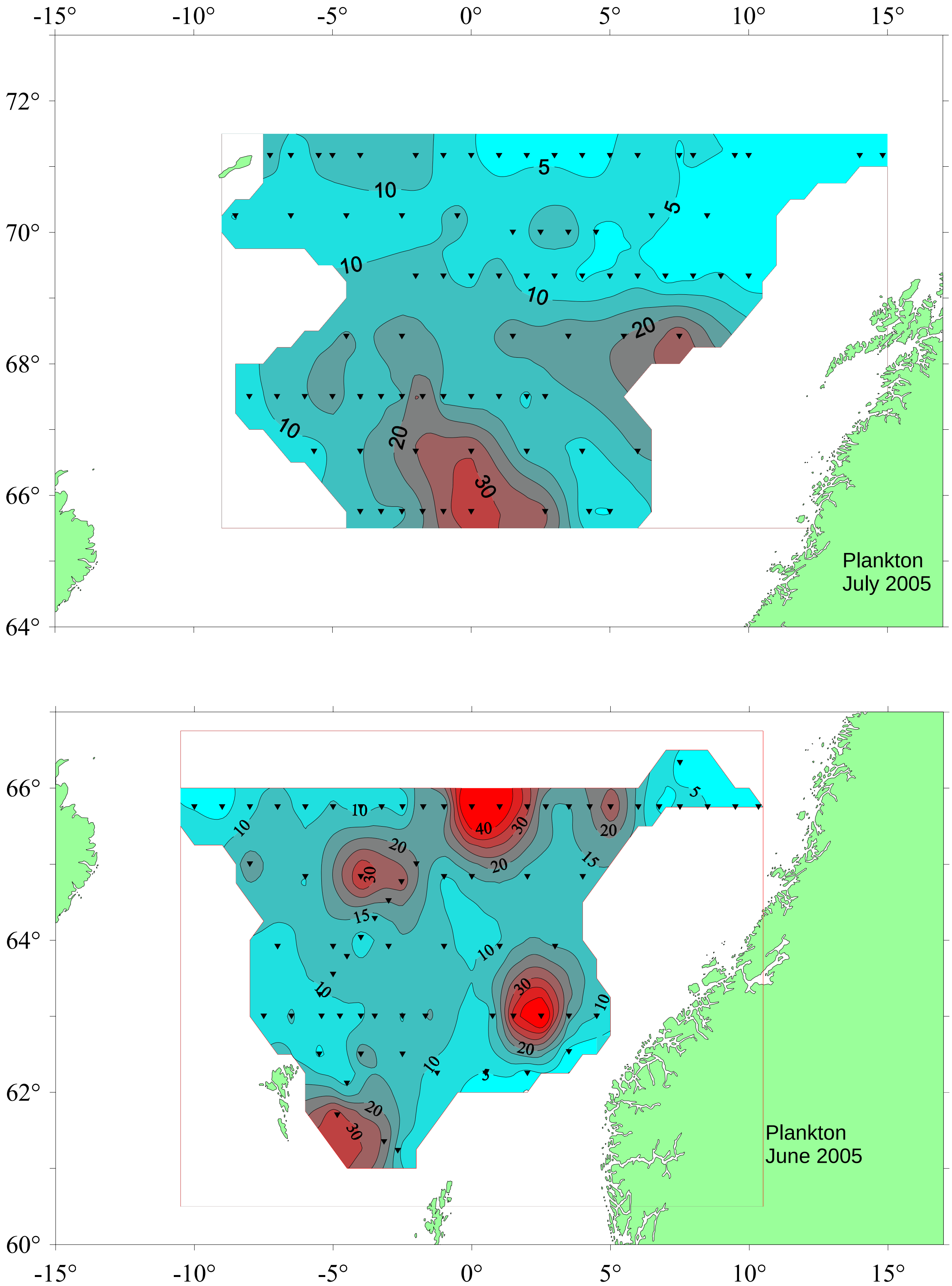


Figure 3.3.2.1: Zooplankton biomass (g dw m^{-2}) (200–0 m) in June (lower panel) and July (upper panel) in 2005. Depth range 50–0 m only in sections along 67°30´N and 66°40´N.

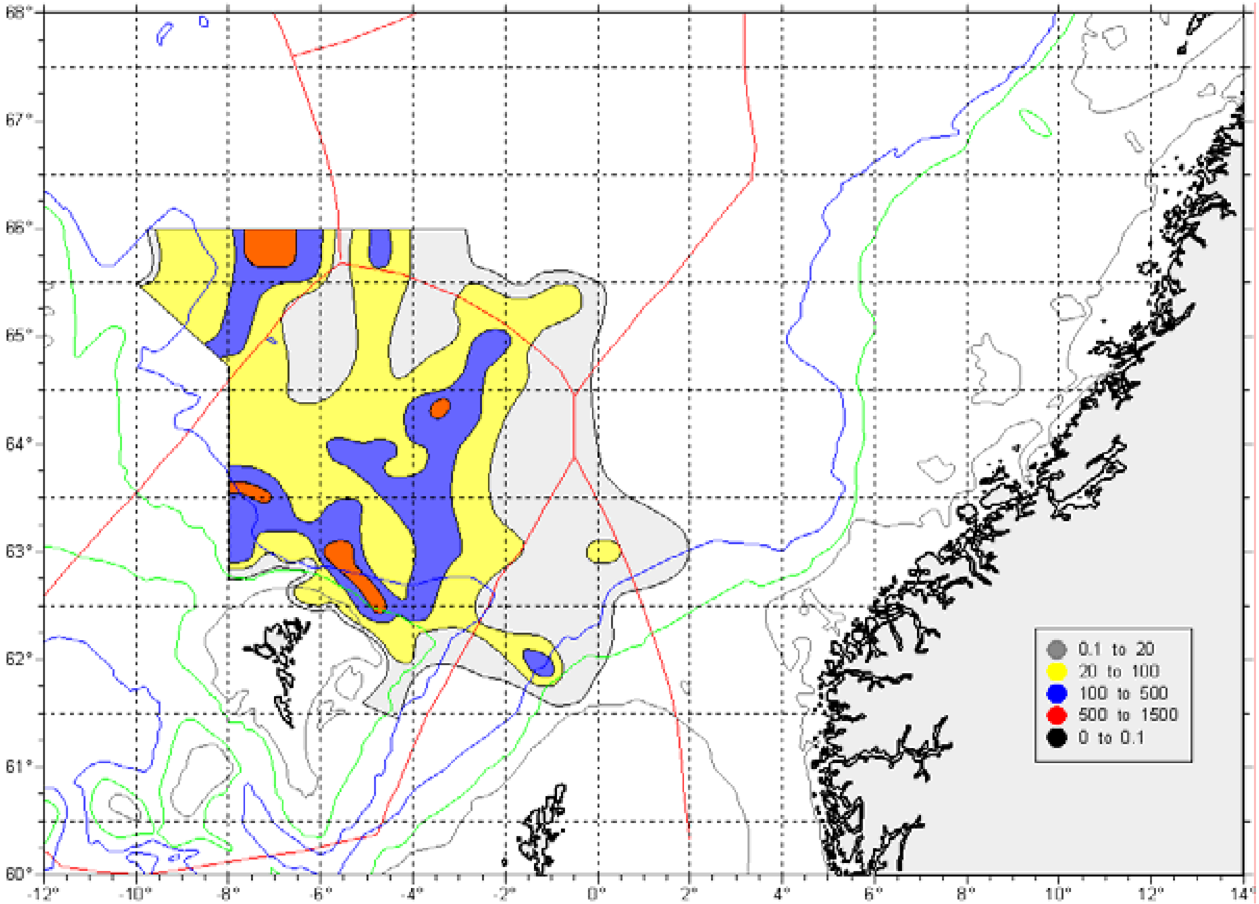


Figure 3.3.3.1: Schematic map of Norwegian spring spawning herring acoustic density (s_A, m^2/nm^2) in June 2005. Some mixing of autumn spawning herring was observed in the southeastern part of the surveyed area, i.e., the eastern part of the Faroese EEZ and in the EU EEZ.

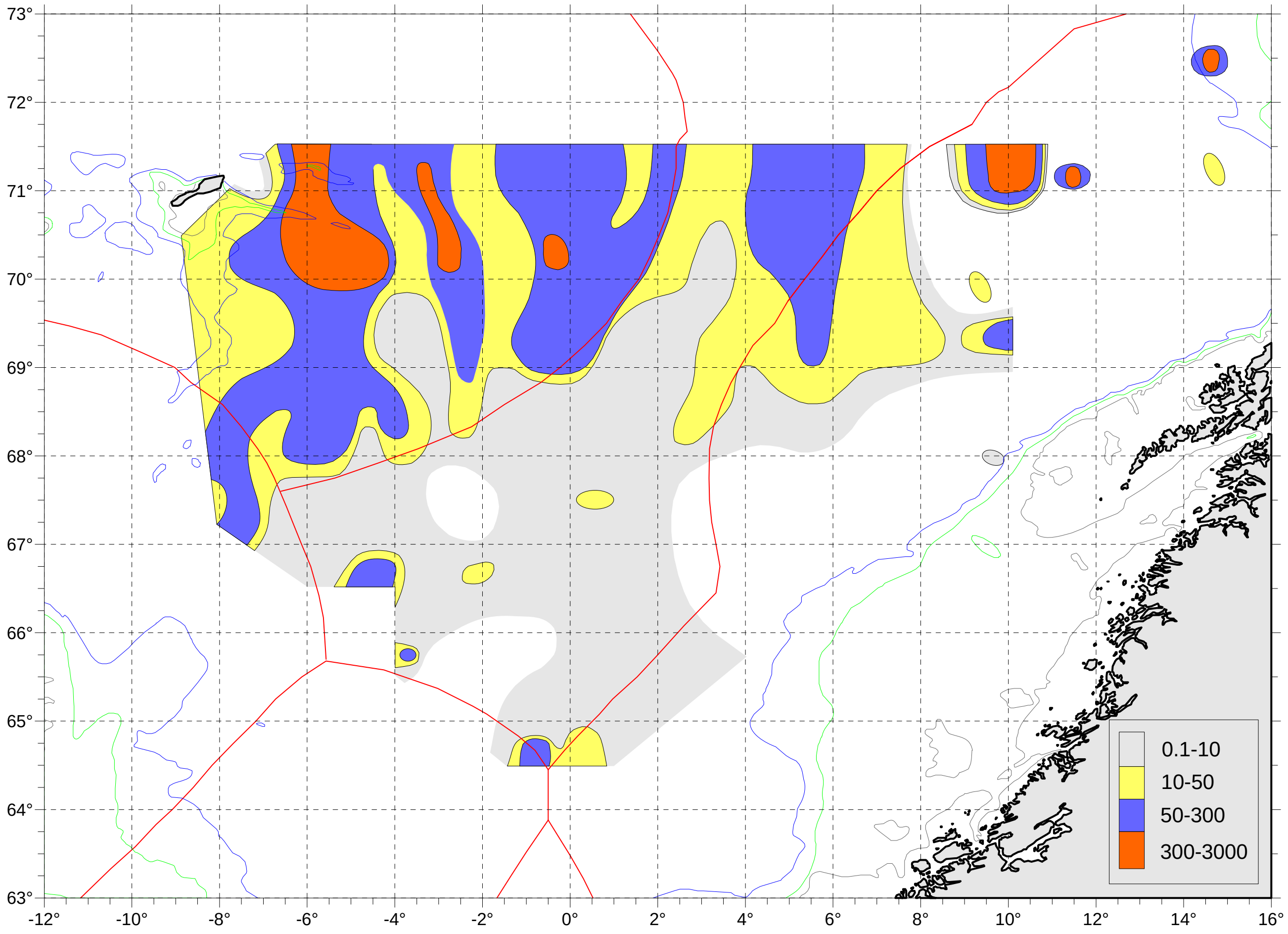


Figure 3.3.3.2: Schematic map of Norwegian spring spawning herring acoustic density (s_A, m^2/nm^2) in July 2005.

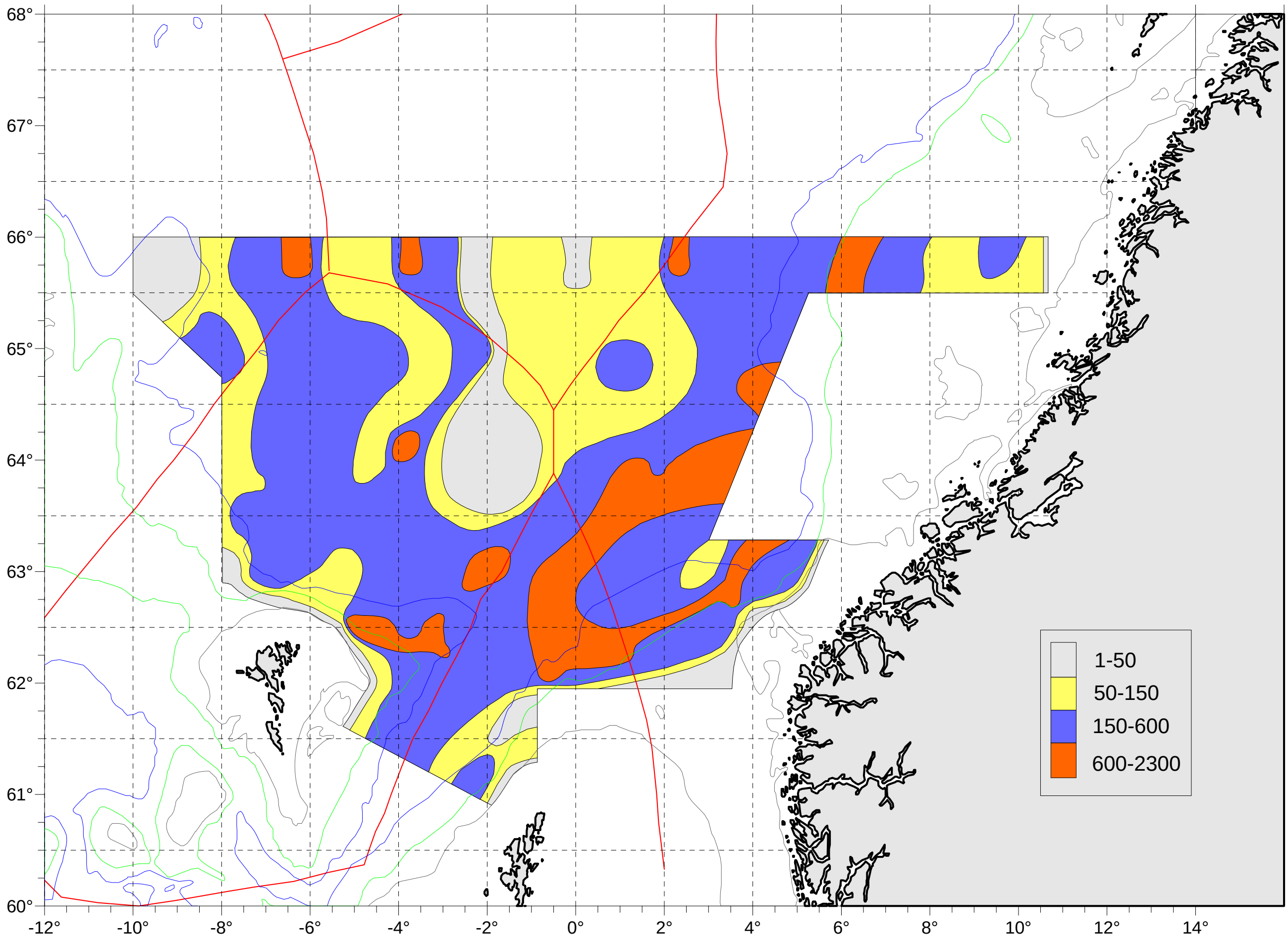


Figure 3.3.4.1: Schematic map of Blue whiting acoustic density (s_A, m^2/nm^2) in June 2005.

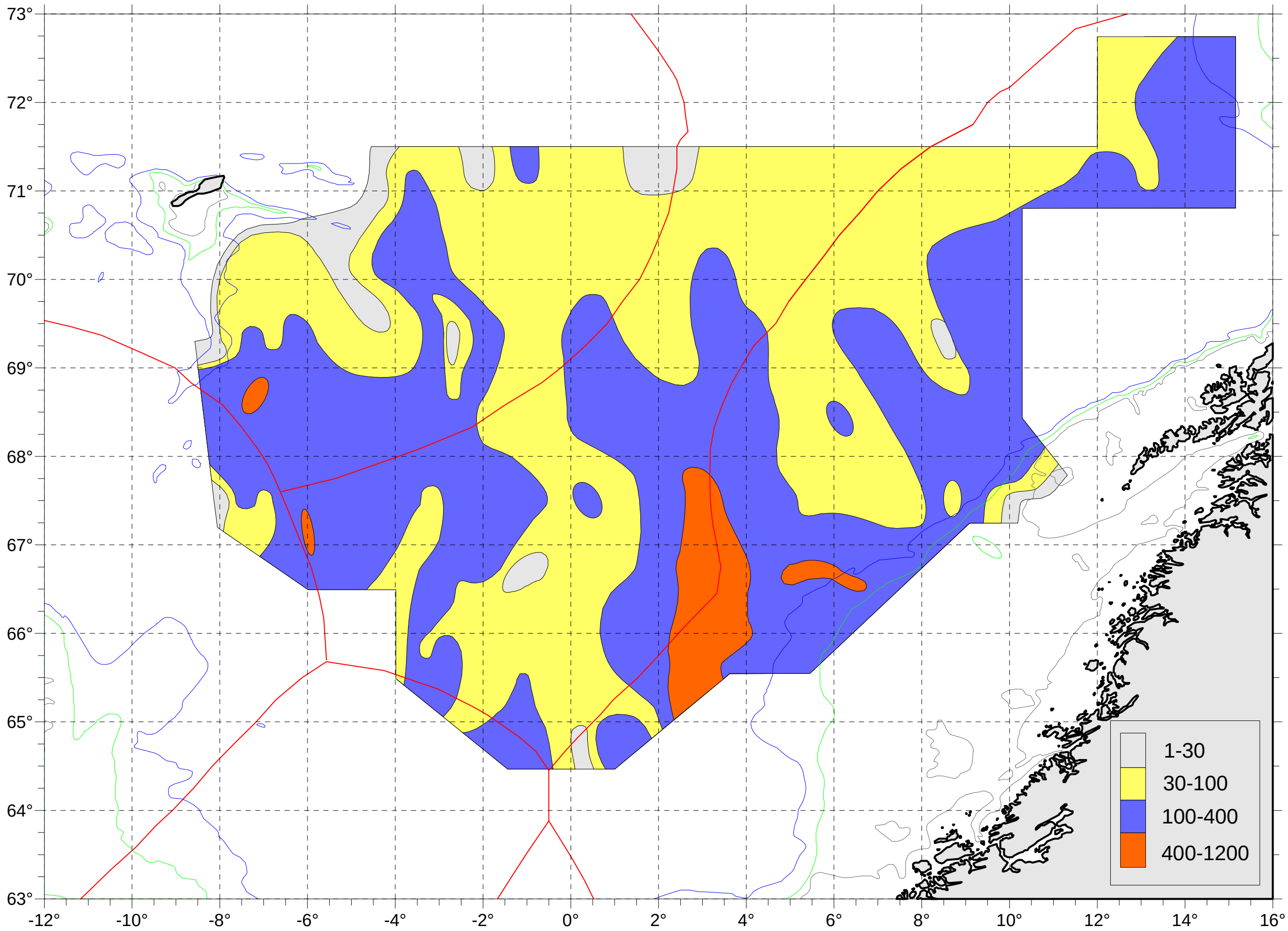


Figure 3.3.4.2: Schematic map of Blue whiting acoustic density (s_A, m^2/nm^2) in July 2005.

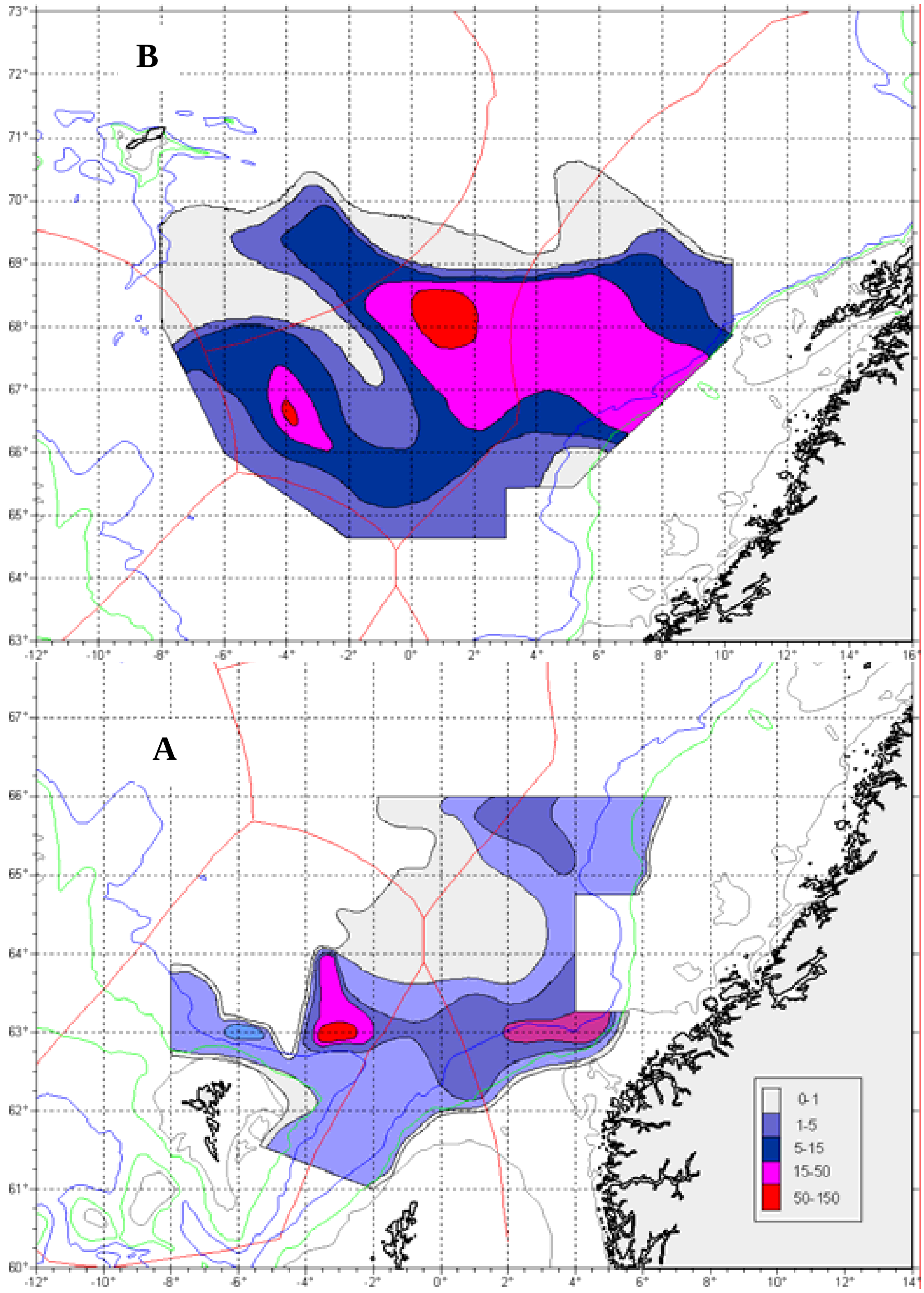


Figure 3.3.5.1: Schematic map of Mackerel distribution in June (lower panel)-July (upper panel) 2005 from pelagic trawl catches of 30 minutes hauls.

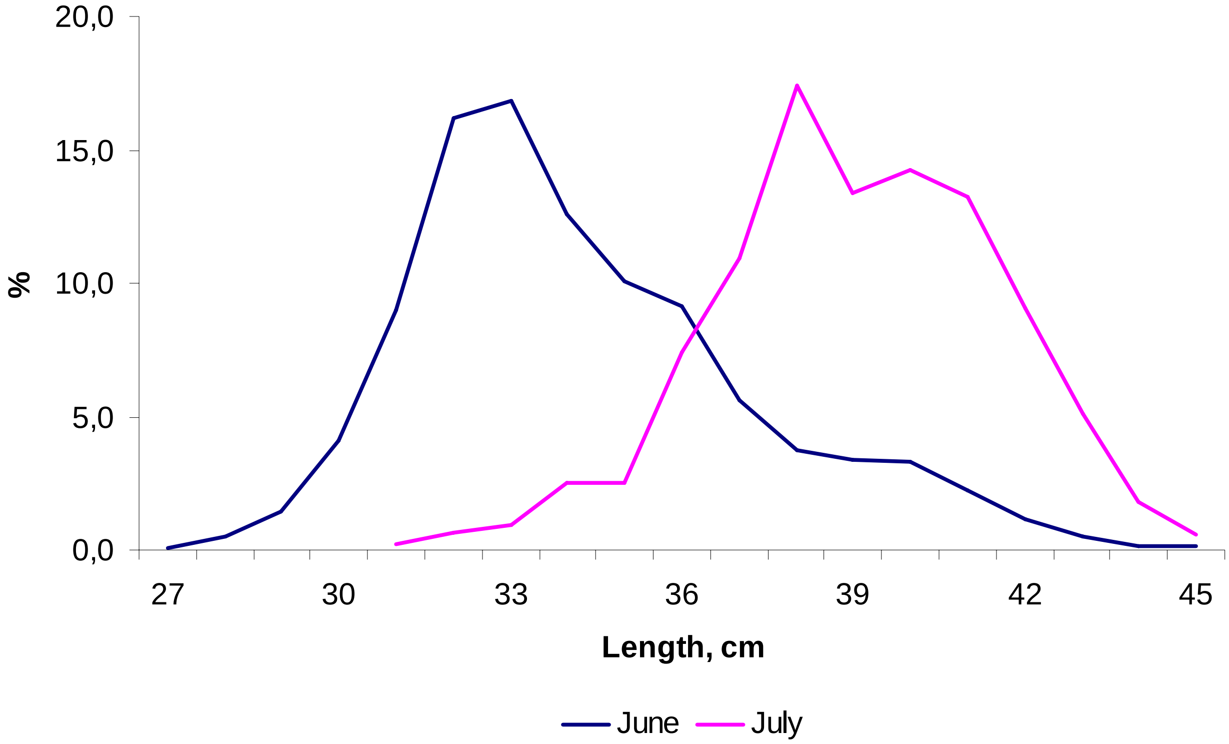


Figure 3.3.5.2: Length composition of Mackerel in the Norwegian Sea in June – July 2005.

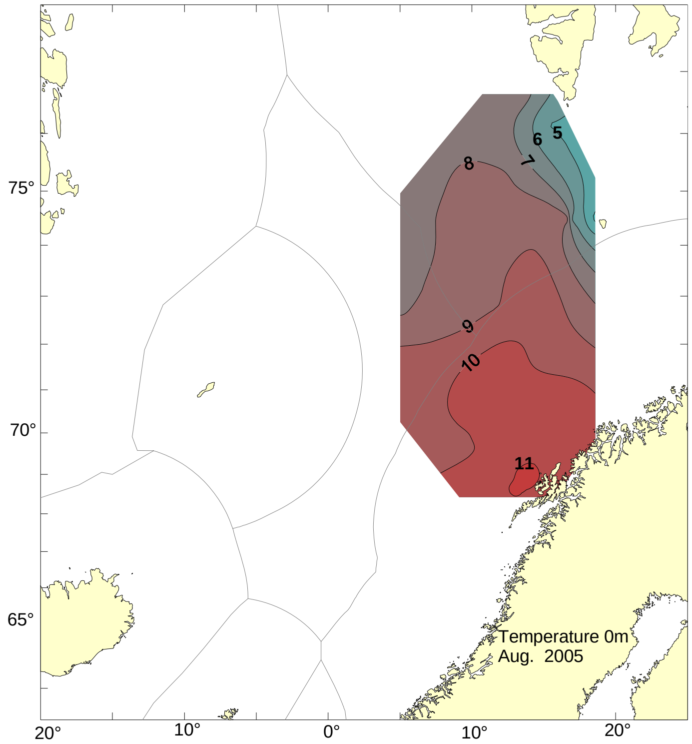


Figure 3.4.1.1: Temperature at surface in August 2005.

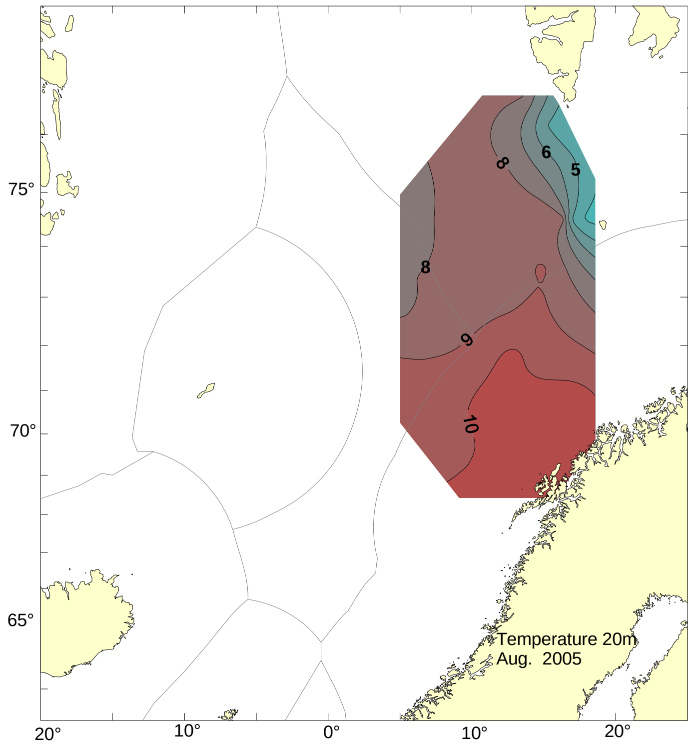


Figure 3.4.1.2: Temperature at 20 m in August 2005.

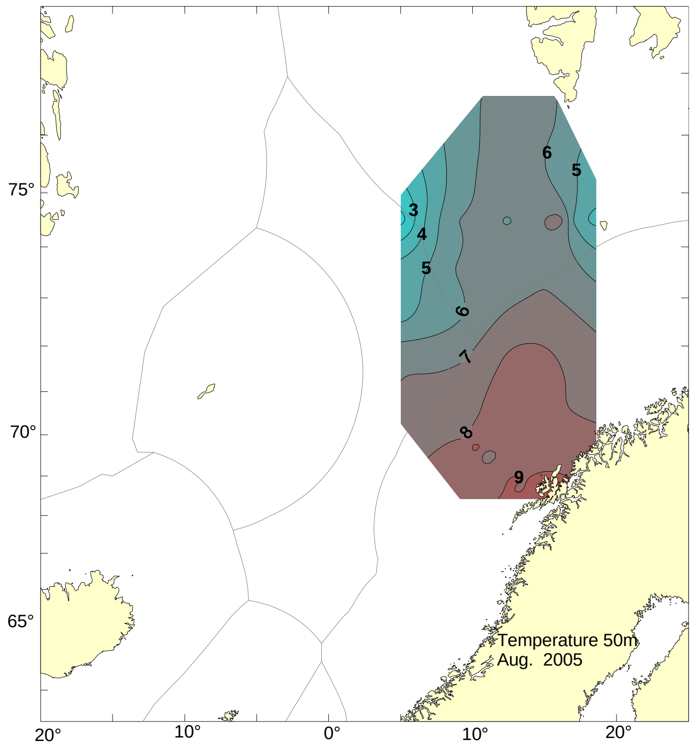


Figure 3.4.1.3: Temperature at 50 m in August 2005.

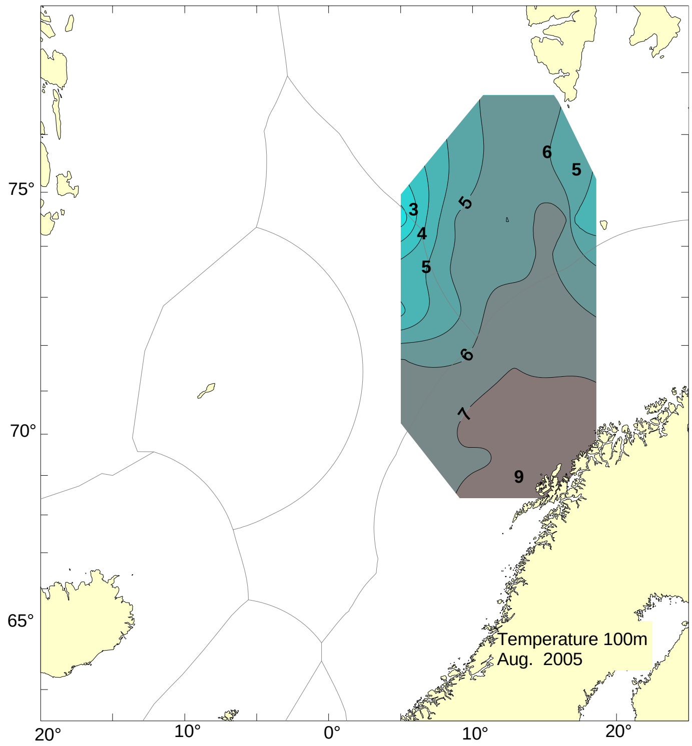


Figure 3.4.1.4: Temperature at 100 m in August 2005.

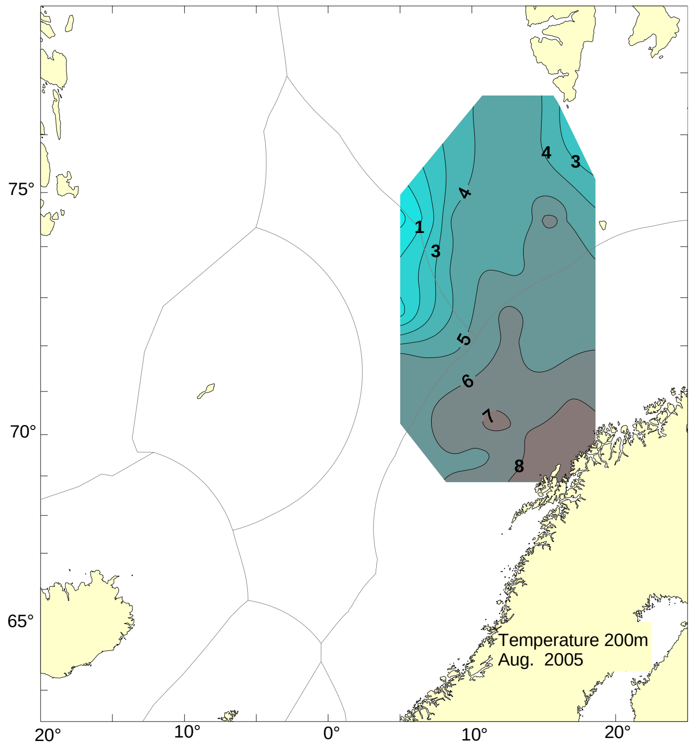


Figure 3.4.1.5: Temperature at 200 m in August 2005.

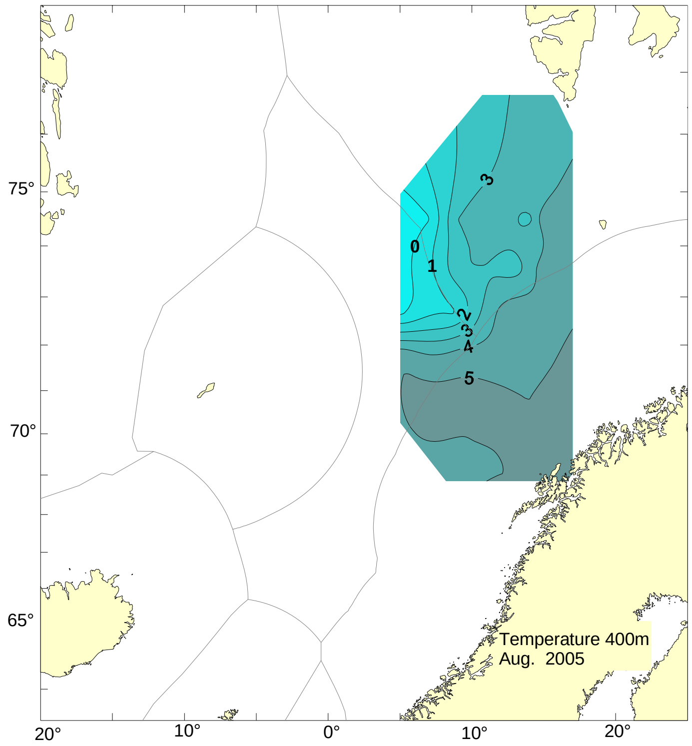


Figure 3.4.1.6: Temperature at 400 m in August 2005.

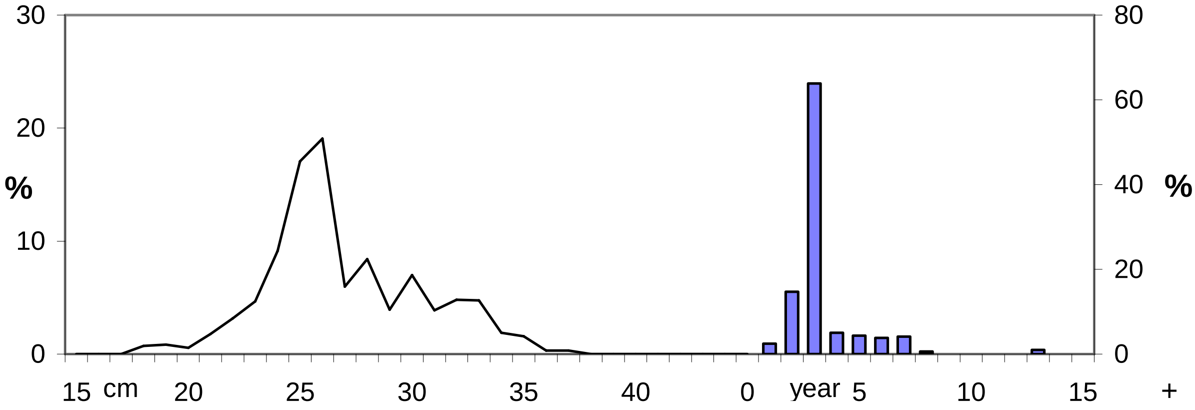


Figure 3.4.3.1: Length and age distribution of Norwegian spring spawning herring in August 2005.

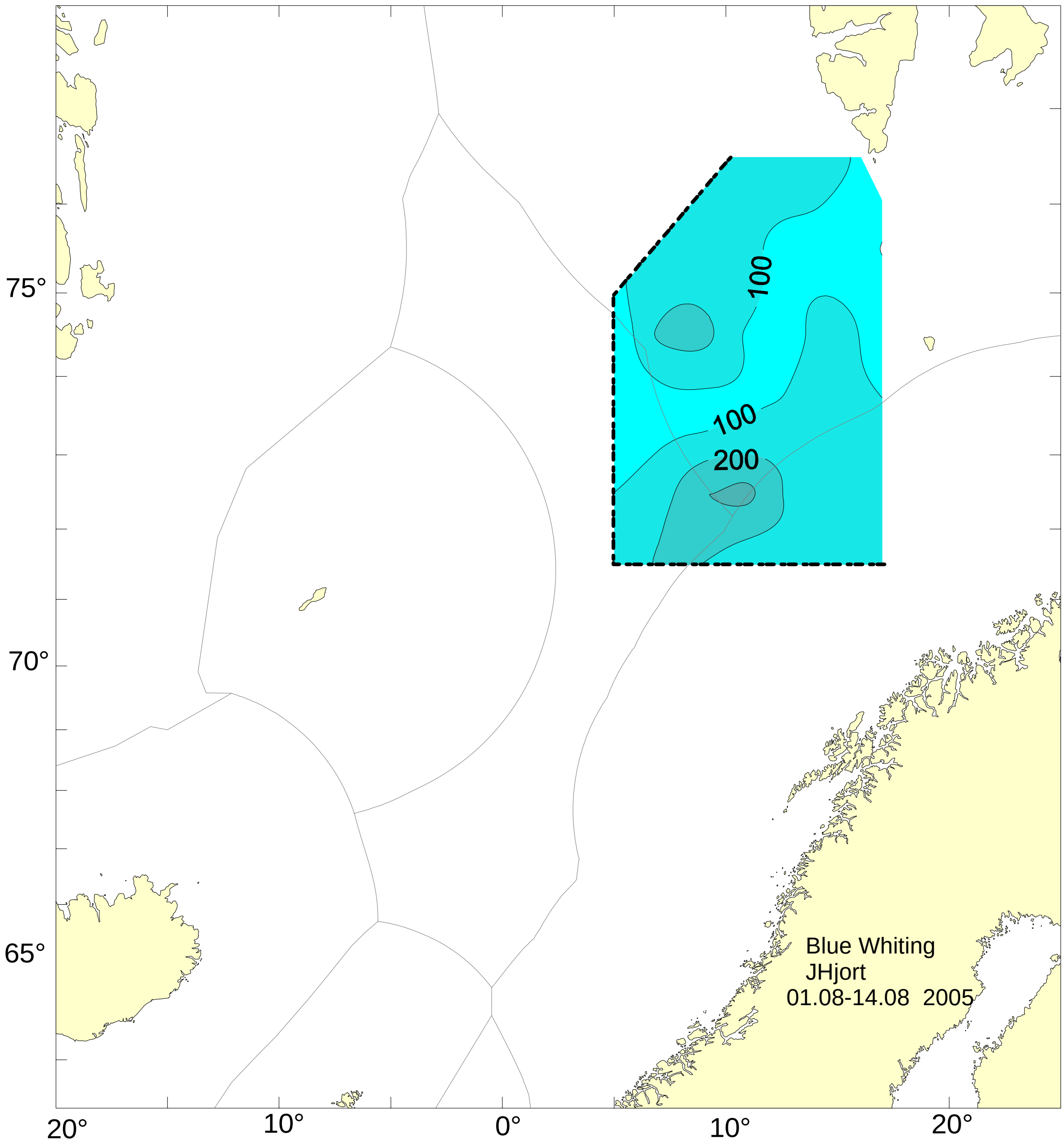


Figure 3.4.4.1: Distribution of blue whiting in August 2005, RV "J. Hjort".

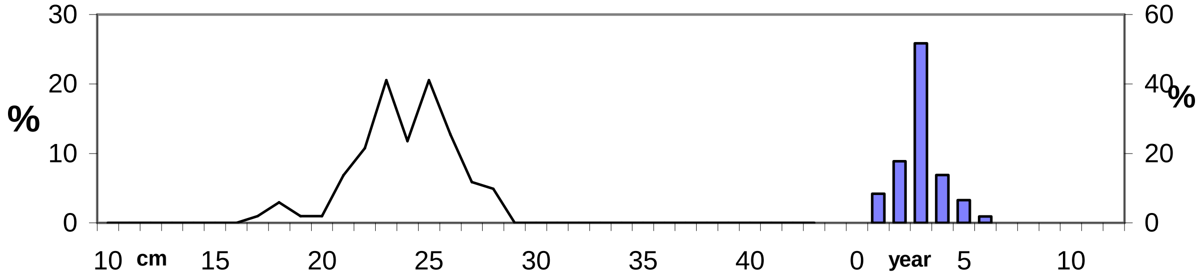


Figure 3.4.4.2: Length and age distribution of blue whiting in August 2005.

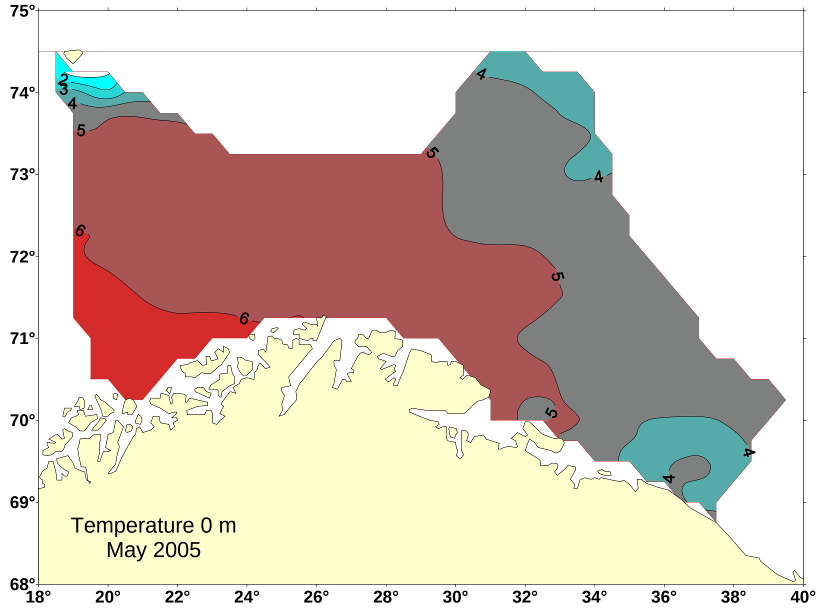


Figure 3.5.1.1: Temperature in the Barents Sea at surface in May 2005.

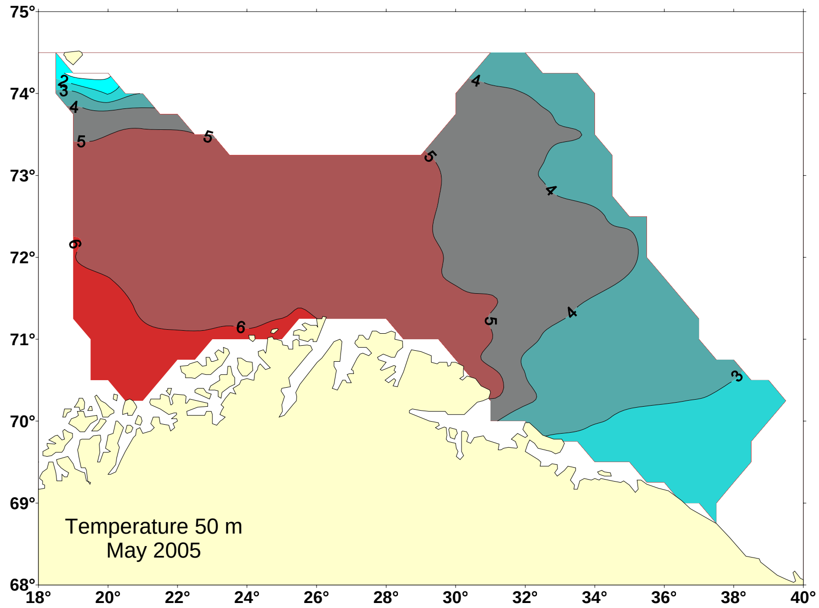


Figure 3.5.1.2: Temperature in the Barents Sea at 50 m in May 2005.

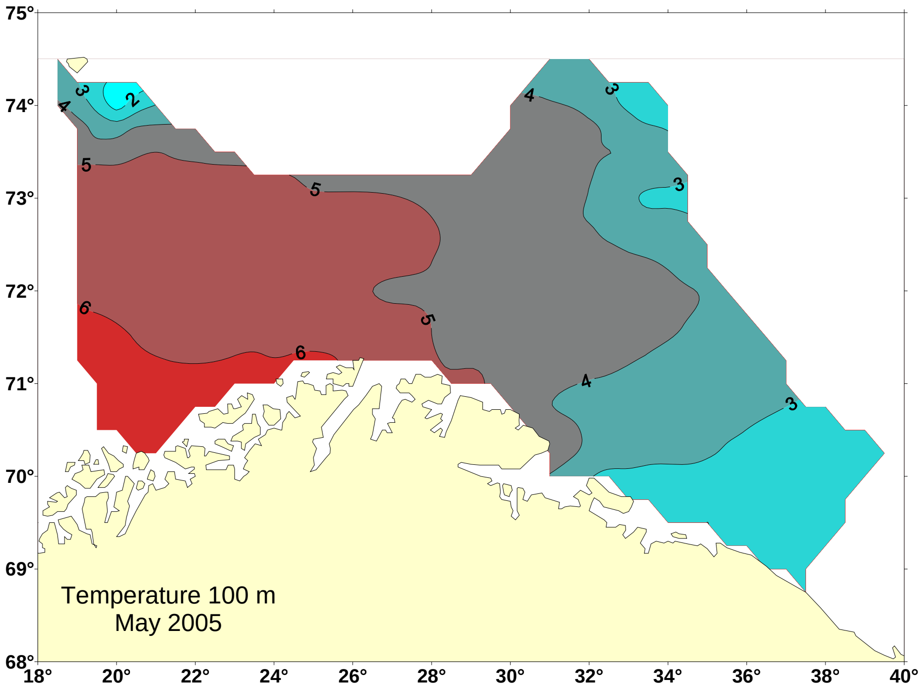


Figure 3.5.1.3: Temperature in the Barents Sea at 100 m in May 2005.

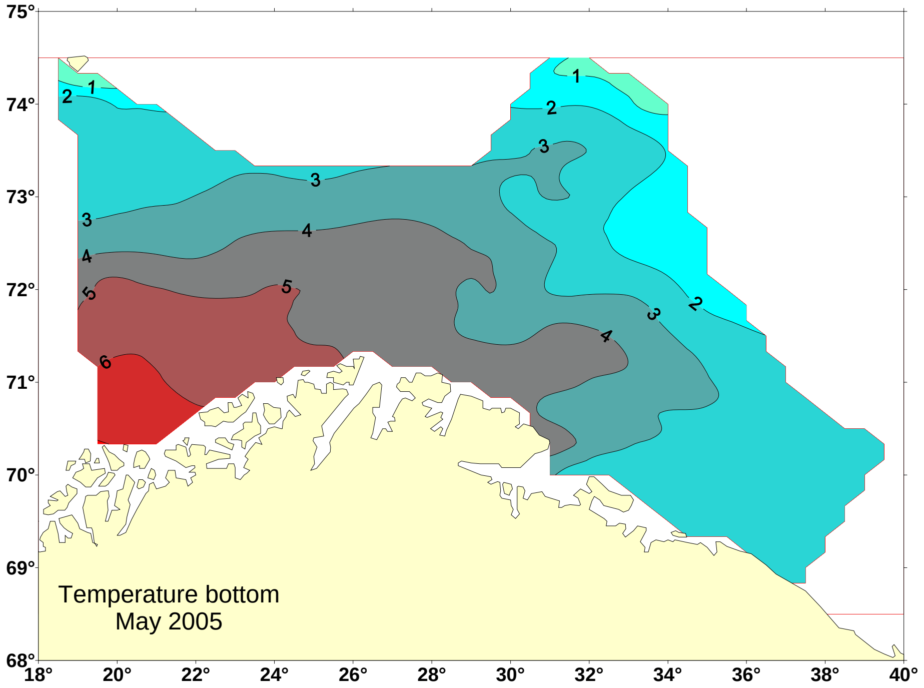


Figure 3.5.1.4: Temperature in the Barents Sea at bottom in May 2005.

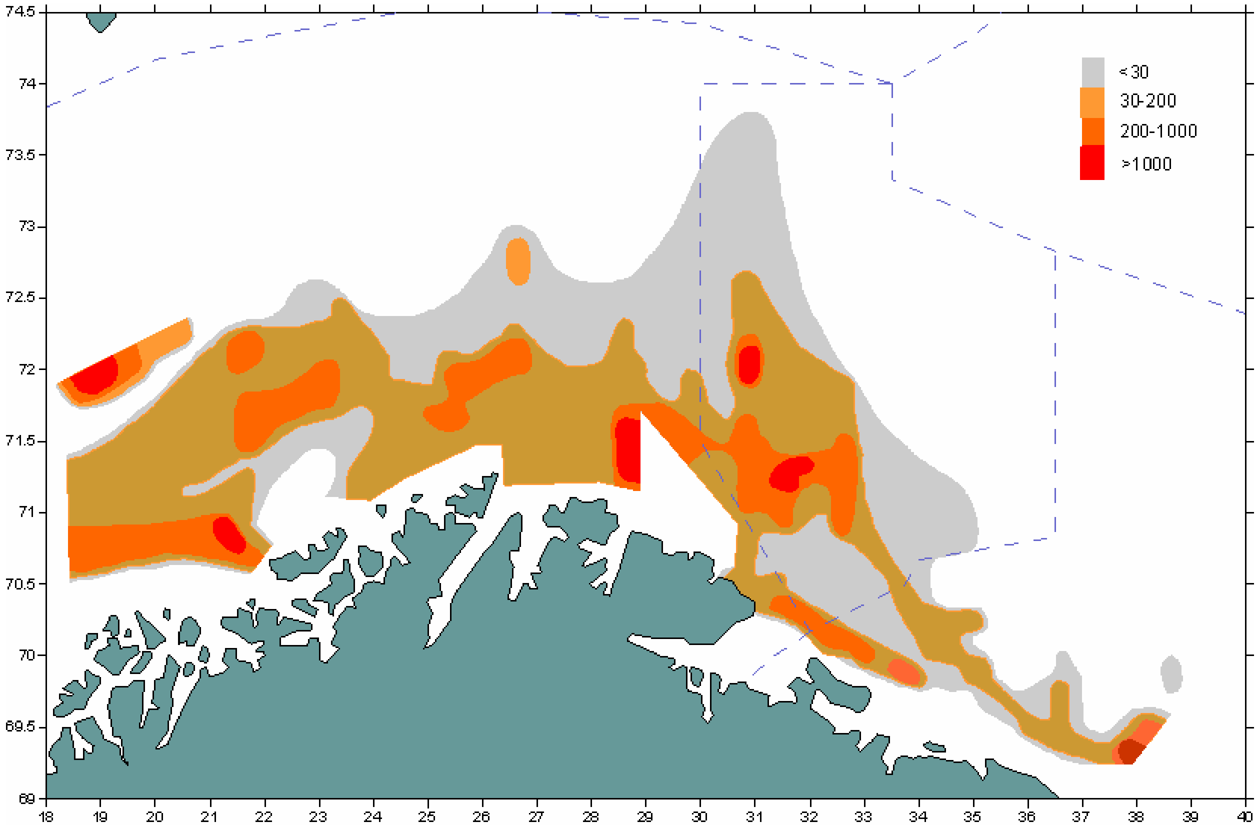


Figure 3.5.2.1: Distribution of young herring in the Barents Sea during the period 21.05–07.06.2005.

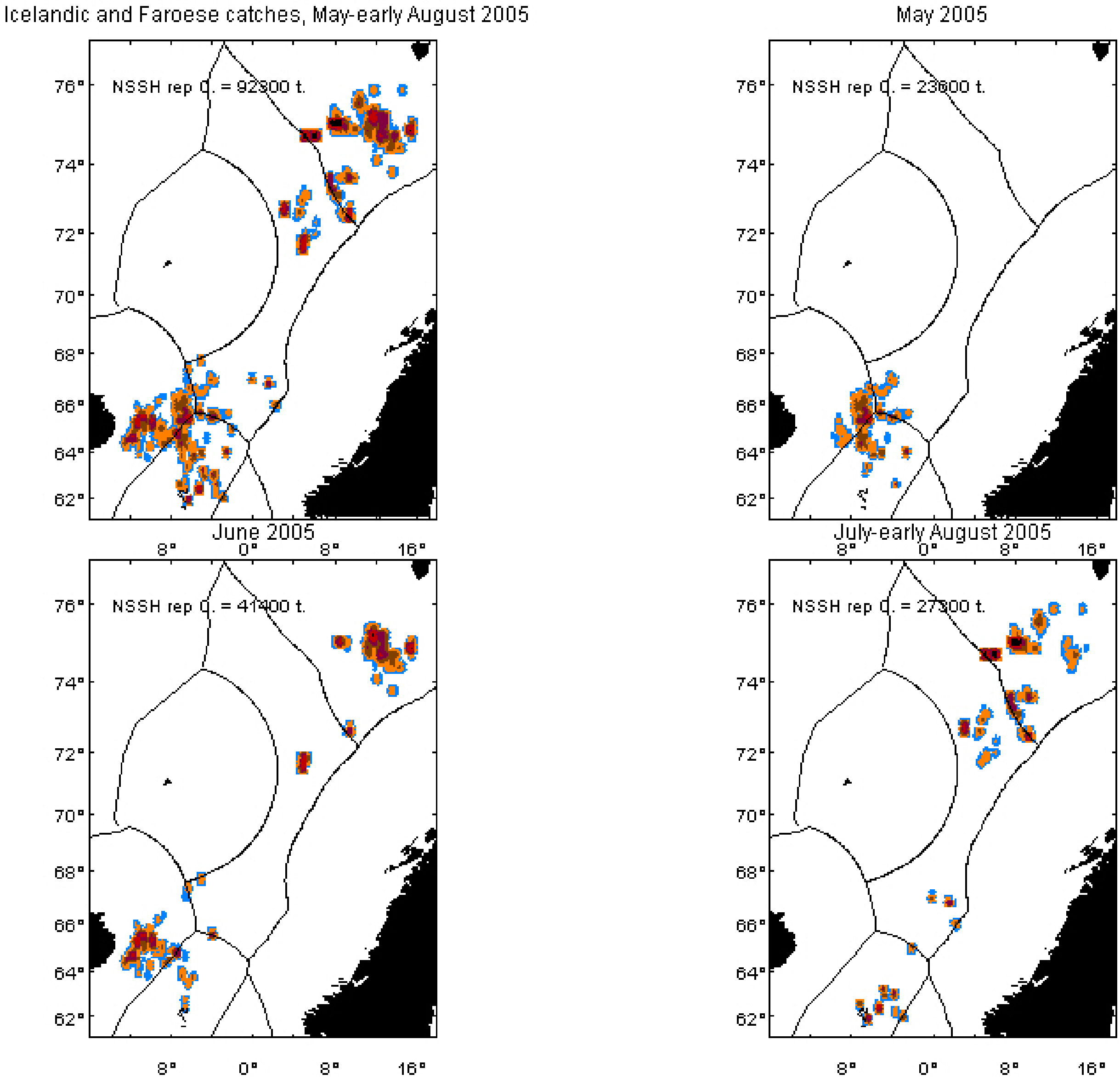


Figure 3.6.1: Icelandic and Faroese NSSH fishery in 2005, for the whole period and also by month.

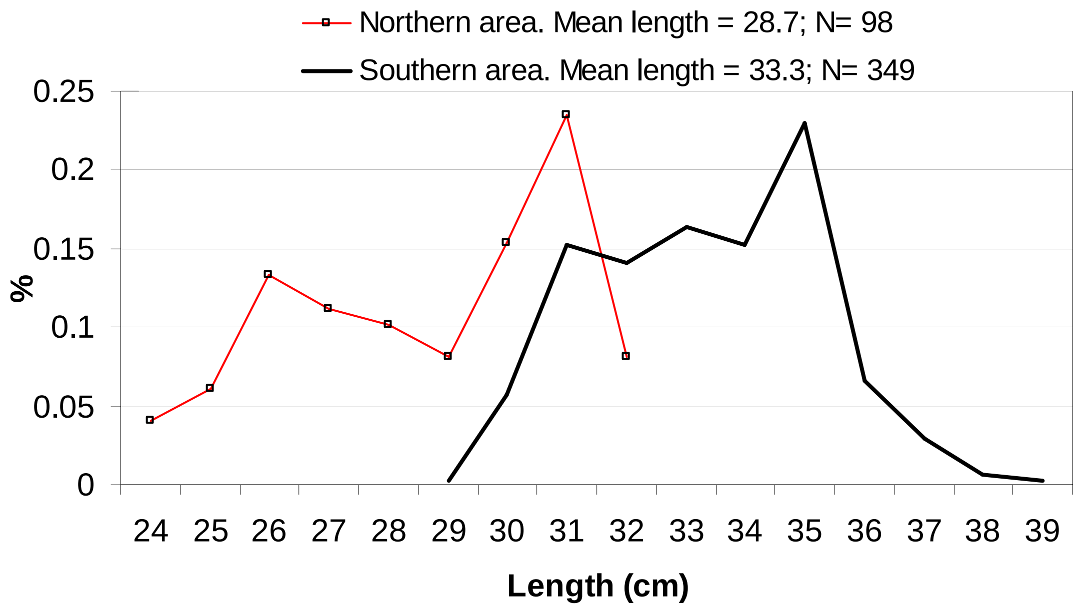


Figure 3.6.2: Length distribution of Icelandic catches of NSSH in May-July 2005 by areas (north and south of 68°N).

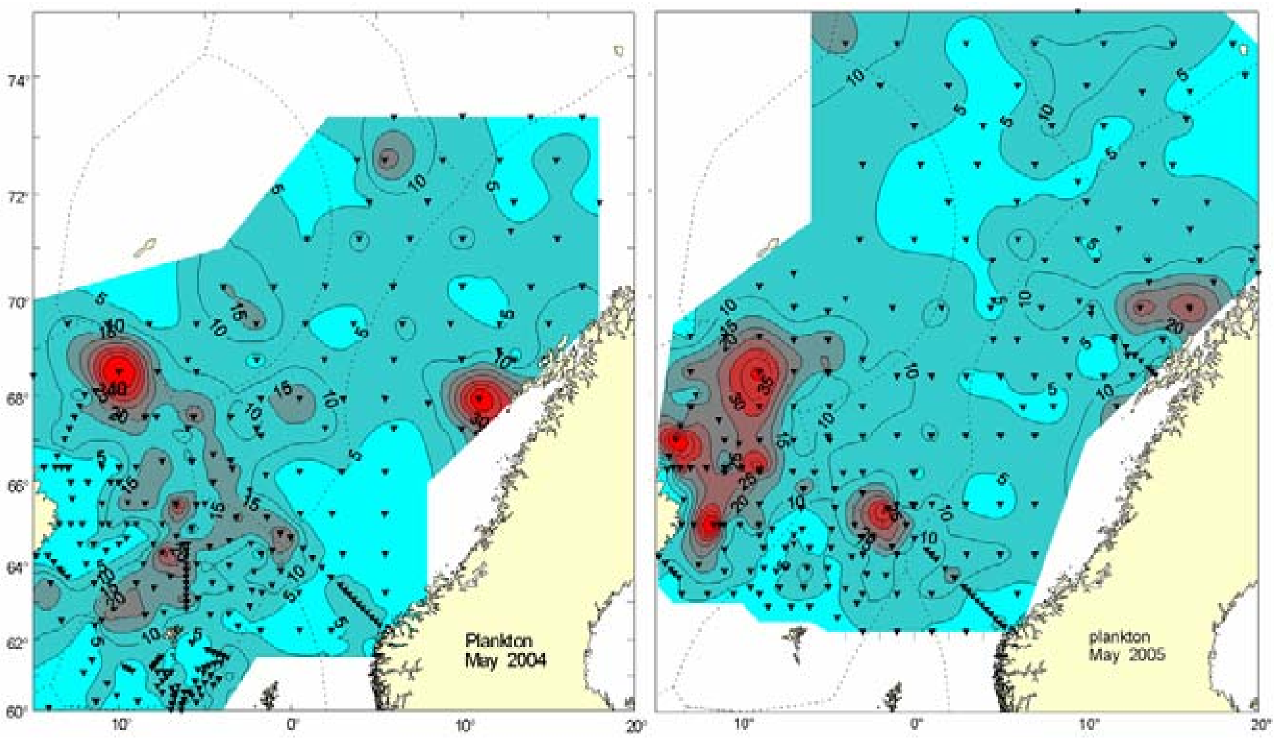


Figure 4.2.1: Comparison of the plankton distribution in the Norwegian Sea in May 2004 (left) and 2005 (right).

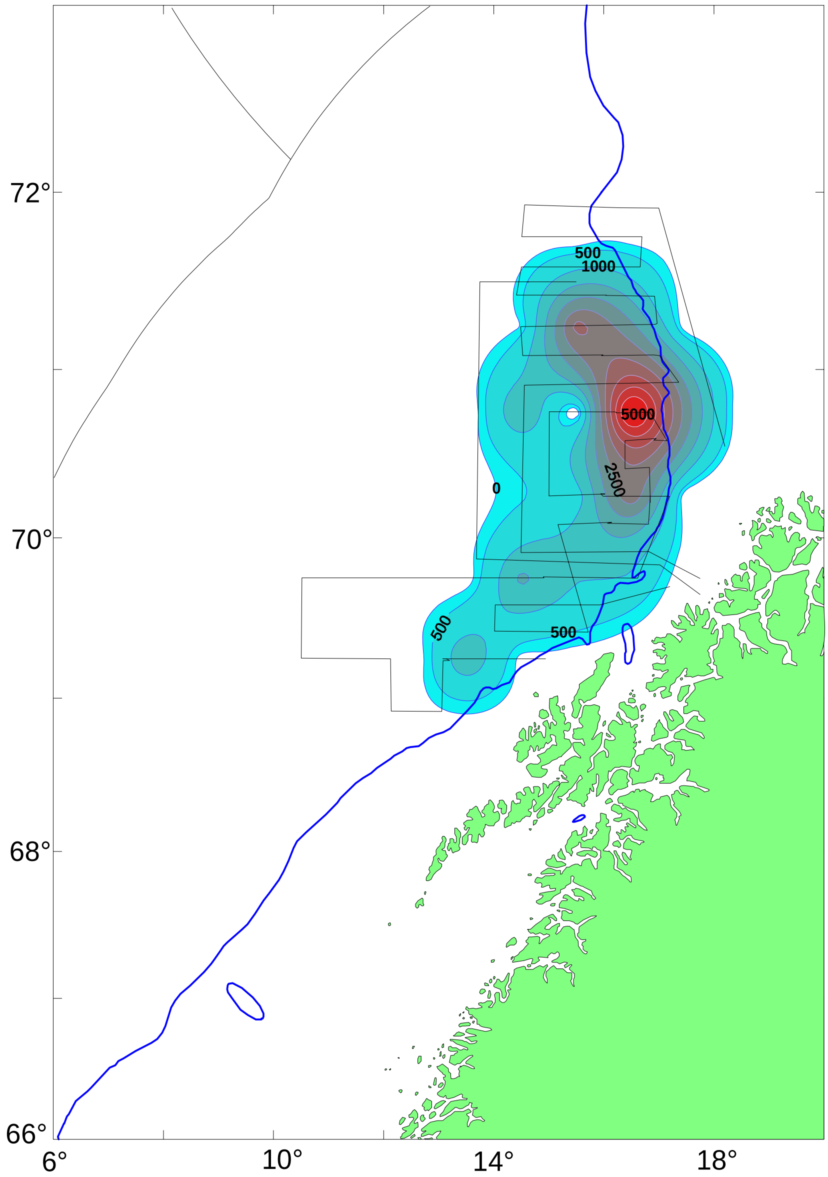


Figure 4.3.1: Oceanic herring distribution in December 2004 (4.4 million tonnes). In addition an estimated 1.2 million tonnes wintered in the Ofotfjord and Tysfjord in 2004/2005 (Holst *et al.* 2005, WD to NPBWWG 2005).

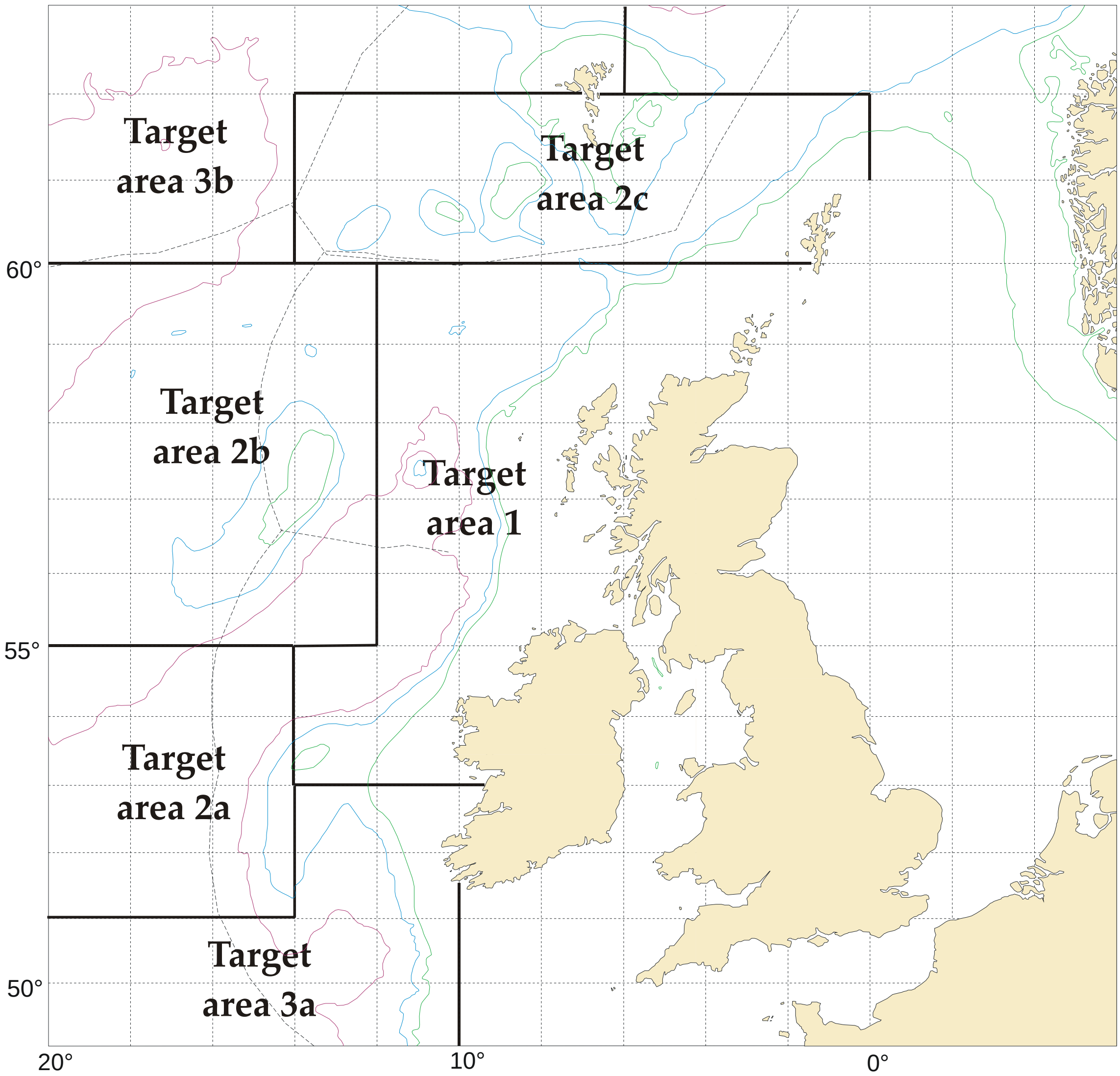


Figure 5.1.1: Planned survey area for the blue whiting spawning survey in March-April 2006.

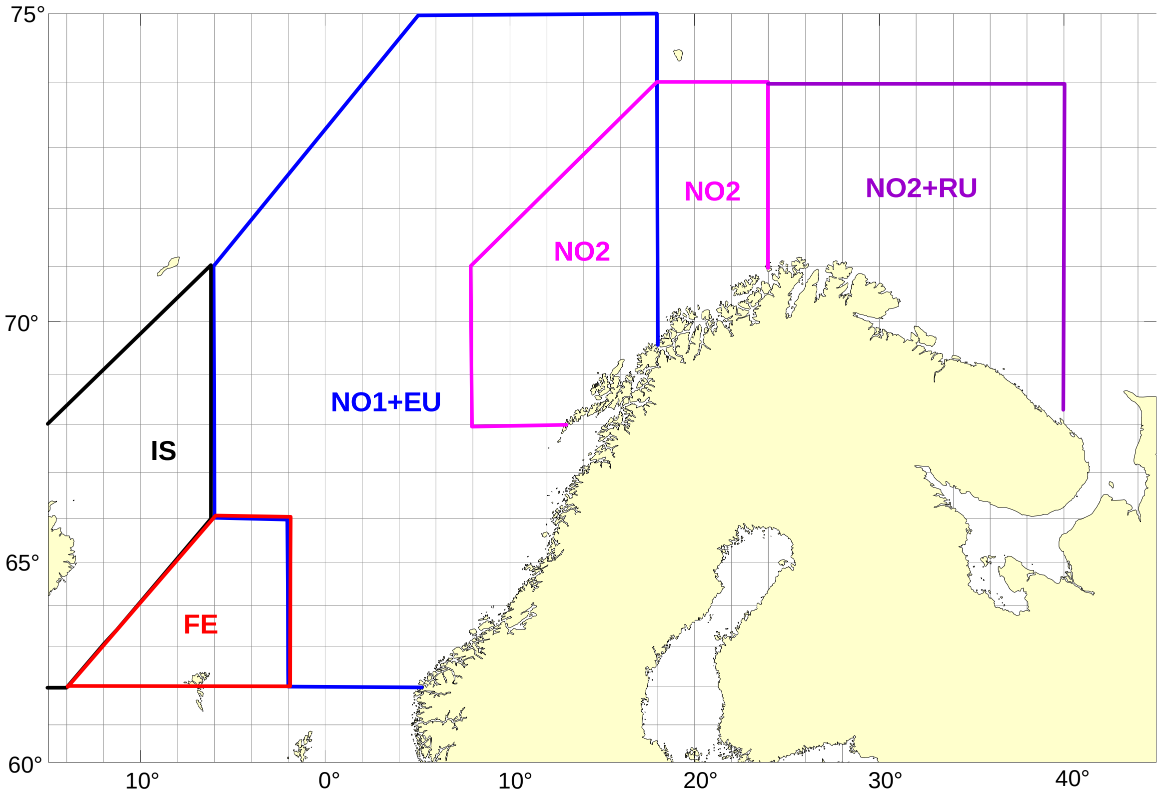


Figure 5.2.1: Planned survey area for surveys in the Norwegian Sea and Barents Sea in May 2005.

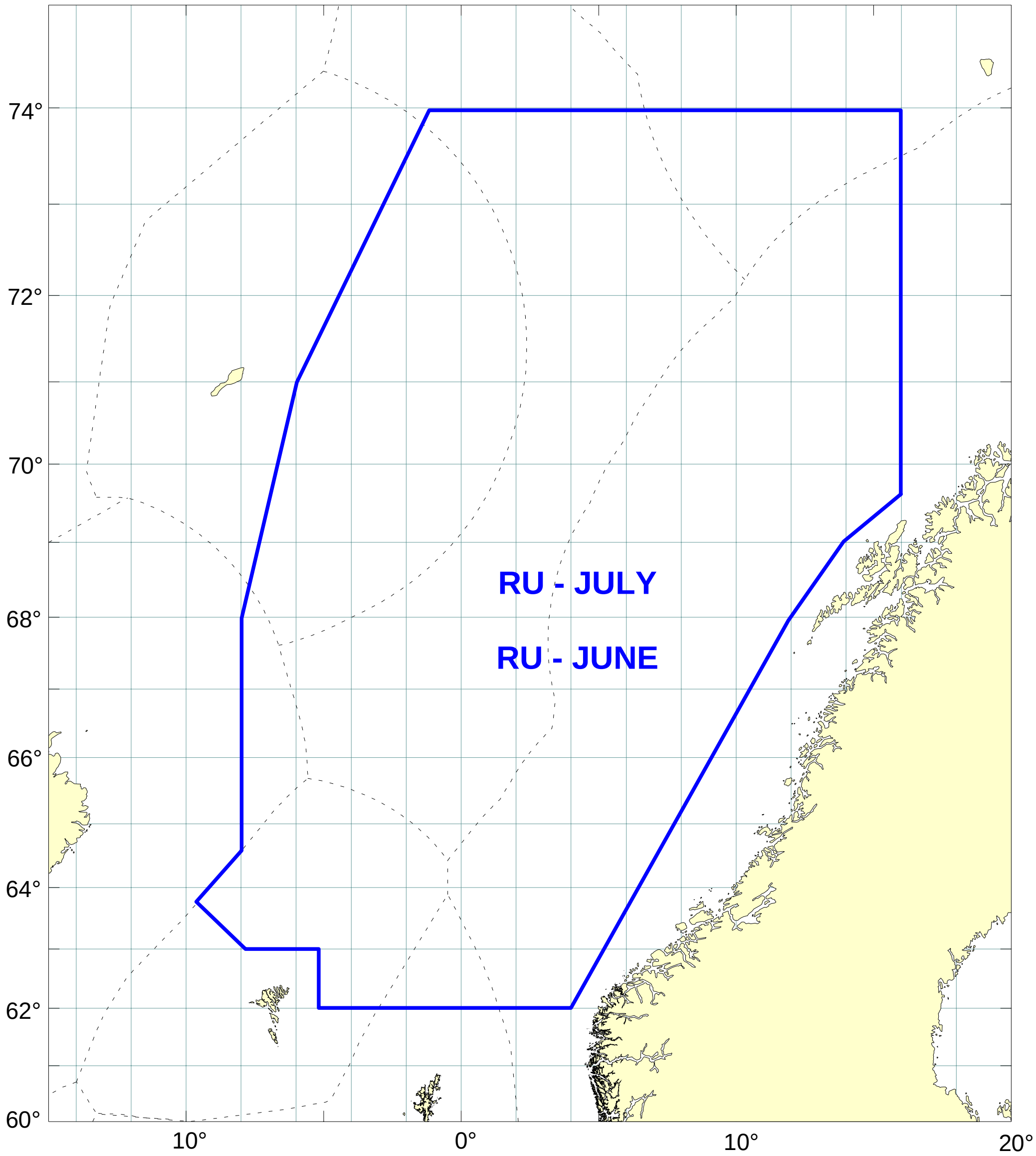


Figure 5.2.2: Planned survey area for the Russian survey in the Norwegian Sea in June-July 2005.

Annex 1: List of participants

NAME	ADDRESS	PHONE/FAX	EMAIL
Maurice Clarke	Marine Institute, GTP Parkmore, Galway, Ireland	+353 91 773 900	maurice.clarke@marine.ie
Ciaron O'Donnell	Marine Institute, GTP Parkmore, Galway, Ireland	+353 91 773 900 (Mobile +353 87 968 1954)	Ciaron.odonnell@marine.ie
Leonie Dransfeld	Marine Institute, GTP Parkmore, Galway, Ireland	+353 91 773 900	Leonie.dransfeld@marine.ie
Jørgen Dalskov	Danish Institute for Fisheries Research, Charlottenlund Slot, DK-2920 Charlottenlund Denmark	+45 33 963380	jd@dfu.min.dk
Mark Dickey-Collas	Netherlands Institute for Fisheries Research, P.O. Box 68, 1970 AB IJjmuiden, The Netherlands	+255 564 685	mark.dickeycollas@wur.nl
Súni Lamhauge	Faroese Fisheries Laboratory, P.O. Box 3051, FO-100 Tórshavn, Faroe Islands	+298 353900	sl@frs.fo
Mikko Heino	Institute of Marine Research, P.O. Box 1870, N-5817 Bergen, Norway	+47 55236962	mikko@imr.no
Jens Christian Holst	Institute of Marine Research, P.O. Box 1870, N-5817 Bergen, Norway	+47 55238411	jensh@imr.no
Jan Arge Jacobsen (Chair)	Faroese Fisheries Laboratory, P.O. Box 3051, FO-100 Tórshavn, Faroe Islands	+298 353900	janarge@frs.fo
Alexander Krysov	PINRO 6,Knipovich Street, 183763, Murmansk, Russia	+78152473424	a_krysov@pinro.ru

NAME	ADDRESS	PHONE/FAX	EMAIL
Webjörn Melle	Institute of Marine Research, P.O. Box 1870, N-5817 Bergen, Norway	+47 55 23 8477	webjorn@imr.no
Thorstein Sigurdsson	Marine Research Institute Skúlagata 4 101 Reykjavík Iceland	+354 2752116	steini@hafro.is
Leon Smith	Faroese Fisheries Laboratory, P.O. Box 3051, FO-100 Tórshavn, Faroe Islands	+298 353900	leonsmit@frs.fo
Sveinn Sveinbjörnsson	Marine Research Institute Skúlagata 4 101 Reykjavík Iceland	+354 2752113	sveinn@hafro.is
Øyvind Tangen	Institute of Marine Research, P.O. Box 1870, N-5817 Bergen, Norway	+47 55 23 8414	oyvind.tangen@imr.no
Irina Prokopchuk	PINRO 6, Knipovich Street, 183763, Murmansk, Russia	+7 8152472464	irene_pr@pinro.ru

Annex 2: Survey report in the blue whiting spawning area 2005

Toktrapport/Havforskningsinstituttet/ISSN 1503-6294/Nr. 9 - 2005

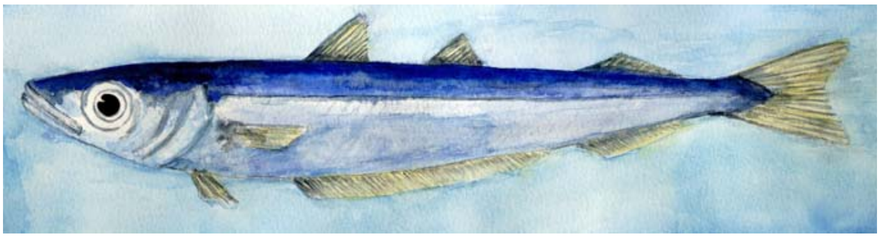
Working Document

Planning Group on Northeast Atlantic Pelagic Ecosystem Surveys

Galway, Ireland, 16–18 August 2005

Northern Pelagic and Blue Whiting Fisheries Working Group

Copenhagen, Denmark, 25 August–1 September 2005



INTERNATIONAL BLUE WHITING SPAWNING STOCK SURVEY SPRING 2005

Mikko Heino[1*], Henrik Søiland[1*], Martin Dahl[1],
Jaime Alvarez[1*], Valentine Anthonypillai[1*], Øyvind Tangen[1*]

R/V G. O. Sars

Vladimir Shnar[2], Alexander Malyshko[2], Mikhail Sokolov[2]

R/V Atlantniro

Ciaran O'Donnell[3], Eugene Mullins[3], Gavin Power[3]

R/V Celtic Explorer

Jan Arge Jacobsen[4], Leon Smith[4]

R/V Magnus Heinason

Ivan Oganin[5*], Sergey Ratushnyy[5*], Aleksey Astakhov[5], Vladimir Guzenko[5]

R/V Fridtjof Nansen

Sytse Ybema[6*], Ronald Bol[6], Martien Warmerdam[6], Mark Dickey-Collas[6]

R/V Tridens

1 Institute of Marine Research, Bergen, Norway
2 AtlantNIRO, Kaliningrad, Russia
3 Marine Institute, Galway, Ireland
4 Faroese Fisheries Laboratory, Tórshavn, the Faroes
5 PINRO, Murmansk, Russia
6 Netherlands Institute for Fisheries Research, IJmuiden, The Netherlands
* Participated in the after-survey workshop

Introduction

In spring 2005, six research vessels representing the Faroe Islands, Ireland, the Netherlands, Norway and Russia surveyed the spawning grounds of blue whiting west of the British Isles. International co-operation allows for wider and more synoptic coverage of the stock and more rational utilisation of resources than uncoordinated national surveys. The survey was the second coordinated international blue whiting spawning stock survey since mid-1990s. The primary purpose of the survey was to obtain estimates of blue whiting stock abundance in the main spawning grounds using acoustic methods as well as to collect hydrographic information. Results of all the surveys are also presented in national reports (Atlantniro: Shnar et al. 2005; Celtic Explorer: O'Donnell et al. 2005; F. Nansen: Oganin et al. 2005; G. O. Sars: Heino et al. 2005; M. Heinason: Jacobsen et al. 2005; Tridens: Ybema et al. 2005).

This report is based on a workshop held after the international survey in Bergen, 20–22/4/2005, where the data were analysed and the report written. Parts of the document were worked out through correspondence during and after the workshop.

Material and methods

Coordination of the survey was initiated in the meeting of the Planning Group on Northeast Atlantic Pelagic Ecosystem Surveys (PGNAPES, formerly Planning Group on Surveys on Pelagic Fish in the Norwegian Sea) in August 2004 (ICES 2004a), and continued by correspondence until the start of the survey. The participating vessels together with their effective survey periods are listed below:

Vessel	Institute	Survey period
Atlantniro	AtlantNIRO, Kaliningrad, Russia	15/3–8/4
Celtic Explorer	Marine Institute, Ireland	28/3–11/4
Fridtjof Nansen	PINRO, Murmansk, Russia	18/3–14/4
G. O. Sars	Institute of Marine Research, Bergen, Norway	17/3–13/4
Magnus Heinason	Faroese Fisheries Laboratory, the Faroes	1/4–12/4
Tridens	Netherlands Fisheries Research Institute, the Netherlands	10/3–21/3

The cruise lines are shown in Figure 1. Figures 2 and 3 show respectively trawl and CTD stations. Survey effort by each vessel is detailed in Table 1. All vessels worked their survey in a northerly direction (Figure 4). Frequent contacts were maintained between the vessels during the course of the survey, primarily through electronic mail.

Bad weather hampered the survey during the periods from about 17/3 to 18/3 and from about 6/4 to 12/4.

The survey was based on scientific echo sounders using 38 kHz frequency. Transducers were calibrated with the standard sphere calibration (Foote et al. 1987) prior to [Atlantniro, Celtic Explorer, F. Nansen, M. Heinason, Tridens, G. O. Sars (2 weeks earlier)] and/or after (Celtic Explorer, G. O. Sars, Tridens) the survey. Salient acoustic settings are summarized on page 3.

Post-processing software and procedures differed among the vessels. On Celtic Explorer, acoustic data were backed up every 24 hrs and scrutinised using Sonar data's Echoview (V 3.25) post processing software for the previous days work. Data was partitioned into the following categories plankton (<200 m depth layer), mesopelagic species, blue whiting and bottom fish (including argentines, mackerel and horse mackerel). Partitioning of data into the above categories was largely subjective and was viewed by 3 scientists. Adjustments for drop-outs were applied where necessary.

On F. Nansen, the BI60 software was used as the primary post-processing tool for acoustic data. Data were partitioned into the following categories: blue whiting, plankton (<250 m depth layer), mesopelagic species and other species (including, plankton <250 depth layer and bottom fishes). Adjustments for drop-outs were applied where necessary using the "PRIDE" program developed by PINRO.

Table. Acoustic instruments and settings for the primary frequency (boldface).

	Atlantniro	Celtic Explorer	Fridtjof Nansen	G. O. Sars	Magnus Heinason	Tridens
Echo sounder	Simrad EK 500	Simrad EK 60	Simrad EK 60	Simrad EK 60	Simrad EK 500	Simrad EK 60
Frequency (kHz)	**38**	**38**, 18, 120, 200	**38**, 120	**38**, 18, 70, 120, 200	**38**	**38**
Primary transducer	ES 38B	ES 38B - Serial	ES 38B	ES 38B - SK	ES38B	ES 38B
Transducer installation	Hull (steel blister)	Drop keel	Hull	Drop keel	Hull	Towed body
Transducer depth (m)	5	8.7	5	8	3	7
Upper integration limit (m)	10	15	10	15	7	12
Absorption coeff. (dB/km)	10	9.6	10.1	9.785	10	9.6
Pulse length (ms)	1	1.024	1.024	1	Medium	1.024
Band width (kHz)	3.8	2.425	2.425	2.425	Wide	2.43
Transmitter power (W)	2000	2000	2000	2000	2000	2000
Angle sensitivity (dB)	21.9	21.9	21.9	21.9	21.9	21.9
2-way beam angle (dB)	-20.6	-20.6	-20.9	-20.8	-20.6	-20.6
Sv Transducer gain (dB)	27.75				25.32	
Ts Transducer gain (dB)	27.88	25.22	25.55	25.71	25.33	26.5
s_A correction (dB)		-0.53	-0.67	-0.66		-0.58
3 dB beam width (dg)						
alongship:	6.9	7.5	6.99	6.98	7.03	7.10
athw. ship:	6.8	7.5	6.75	6.97	6.93	7.10
Maximum range (m)	750	750	750	750	750	600
Post processing software	Sonardata Echoview	Sonardata Echoview	BI60	BEI	Sonardata Echoview	Sonardata Echoview

On G. O. Sars, the acoustic recordings were scrutinized using the Bergen Echo Integrator (BEI, Foote et al. 1991) once or twice per day. Blue whiting were separated from other recordings using catch information, characteristics of the recordings, and frequency response between integration on 38 kHz and on other frequencies by a scientist experienced in viewing echograms. Adjustments for drop-outs were unnecessary although noise of unknown origin plagued data when swell was against the cruise track.

On Magnus Heinason, acoustic data were scrutinised every 24 hrs on board using Sonar data's Echoview (V 3.25) post processing software. Data were partitioned into the following categories: plankton (<200 m depth layer), mesopelagic species, blue whiting and krill. Partitioning of data into the above categories was based on trawl samples. No correction for drop outs were made, and this caused some problems during the latter part of the survey, i.e. the northernmost cruise tracks in the Faroese area.

On Tridens, acoustic data were backed up every 24 hrs and scrutinised later in the laboratory using Sonar data's Echoview (V 3.25) post processing software. Data was partitioned into the following categories plankton (all layers), mesopelagic species, blue whiting and bottom fish (including argentines, mackerel and horse mackerel). Partitioning of data into the above categories was largely subjective and was viewed by 1 scientist.

All vessels used a large or medium-sized pelagic trawl as the main tool for biological sampling. The salient properties of the trawls are as follows:

	Atlantniro	Celtic Explorer	F. Nansen	G. O. Sars	Magnus Heinason	Tridens
Circumference (m)	716	768	716	486	640	1120
Vertical opening (m)	50	48	50	25-30	38-48	30-70
Mesh size in codend (mm)	16	50	16	22	40	±20
Typical towing speed (kn)	3.3-4.0	3.5-4.0	3.3-3.9	3.0-4.0	3.0-4.0	3.5-4.0

On G. O. Sars, some additional samples were taken with a larger version of normal pelagic trawl that had 586 m circumference and vertical opening of about 35 m (6 samples), and one sample was taken with a large blue whiting trawl with 1200 m circumference and 55 m vertical opening. On Magnus Heinason, some samples of krill and mesopelagic fish were taken with a small meshed trawl (7 mm meshes in the cod-end).

Catch from the trawl hauls was sorted and weighed; fish were identified to species (when possible) and other taxa to higher taxonomic levels. Normally a sub-sample of 50 (Celtic Explorer, G. O. Sars, Tridens) or 50-100 (F. Nansen, M. Heinason) blue whiting were sexed, aged, and measured for length and weight, and their maturity status were estimated using established methods. An additional sample of 50 fish (M. Heinason, G. O. Sars, occasionally 150), 100 (Celtic Explorer), 250 (Tridens, only length) or 300-400 (F. Nansen) was measured for length and weight. On Atlantniro 50 fish were measured for length, weight and sex and an additional 250 were measured for length.

The acoustic data as well as the data from trawl hauls were analysed with a SAS based routine called "BEAM" (Totland and Godø 2001) to make estimates of total biomass and numbers of individuals by age and length in the whole survey area and within different sub-areas (i.e., the main areas in the terminology of BEAM). Strata of 1º latitude by 2º longitude were used. The area of a stratum was adjusted, when necessary, to correspond with the area that was representatively covered by the survey track. This was particularly important in the shelf break zone where high densities of blue whiting dropped quickly to zero at depths less than 200 m.

To obtain an estimate of length distribution within each stratum, samples from the focal stratum were used. If the focal stratum was not sampled representatively, also samples from the adjacent strata were used. In such cases, only samples representing a similar kind of registration that dominated the focal stratum were included. Because this includes a degree of subjectivity, the sensitivity of the estimate with respect to the selected samples was crudely assessed by studying the influence of these samples on the length distribution in the stratum. No weighting of individual trawl samples was used because of differences in trawls and numbers of fish sampled and measurements. The number of fish in the stratum is then calculated from the total acoustic density and the length composition of fish.

The methodology is in general terms described by Toresen et al. (1998). More information on this survey is given by, e.g., Anon. (1982) and Monstad (1986). Traditionally the following target strength (TS) function has been used:

$$TS = 21.8 \log L - 72.8 \text{ dB},$$

where L is fish length in centimetres. For conversion from acoustic density (s_A, m^2/n.mile^2) to fish density (ρ) the following relationship was used:

$$\rho = s_A / \langle\sigma\rangle,$$

where $\langle\sigma\rangle = 6.72 \cdot 10^{-7} L^{2.18}$ is the average acoustic backscattering cross section (m^2). The total estimated abundance by stratum is redistributed into length classes using the length distribution estimated from trawl samples. Biomass estimates and age-specific estimates are calculated for main areas using age-length and length-weight keys that are obtained by using estimated numbers in each length class within strata as the weighting variable of individual data.

BEAM does not distinguish between mature and immature individuals, and calculations dealing with only mature fish were therefore carried out separately after the final BEAM run separately for each sub-area. Proportions of mature individuals at length and age were estimated with logistic regression by weighting individual observations with estimated numbers within length class and stratum (variable 'popw' in the standard output dataset 'vgear' of BEAM). The estimates of spawning stock biomass and numbers of mature individuals by age and length were obtained by multiplying the numbers of individuals in each age and length class by estimated proportions of mature individuals. Spawning stock biomass is then obtained by multiplication of numbers at length by mean weight at length; this is valid assuming that immature and mature individuals have the same length-weight relationship.

The hydrographical situation in the surveyed area was mapped by G. O. Sars, Fridtjof Nansen and Celtic Explorer (Figure 3, Table 1). Three sections with higher horizontal resolution were occupied: two east-west sections at the western shelf edge of the Porcupine Bank at latitude 53° 30'N and 53° 00'N and a section from the Faroes to Shetland (the Nolsø-Flugga section). G. O. Sars and Celtic Explorer are equipped with SBE911 CTDs and Fridtjof Nansen with a FSI CTD. In addition, on G. O. Sars surface (~4m) temperature, salinity and fluorescence were continuously registered along the complete track of the cruise using a ship-mounted thermosalinograph (SBE21).

Results

Inter-calibration results

Results from the inter-calibrations are summarized in the Appendices 1-4. Acoustic inter-calibrations showed that the performance of Magnus Heinason was similar to G. O. Sars (which was used as the reference vessel). Bad weather prevented the planned inter-calibration between F. Nansen and G. O. Sars, while inter-calibration between F. Nansen and Atlantniro was conducted under good conditions and suggested little difference in performance. Celtic Explorer tended to record lower values than G. O. Sars, but the most plausible explanation for this is—given the similarity of the acoustic equipment and sphere calibrations before and after the survey—the strong small-scale spatial heterogeneity observed in the inter-calibration area.

Results from Tridens suggested much lower recordings than G. O. Sars (by a factor of about six), probably caused by a bad cable connection found after the survey. A scrutiny of single target echoes, blue whiting acoustic densities and comparisons with other vessels suggests that the problem started only after the port call of Tridens to Galway. It was decided to exclude acoustic data after that time, but use the earlier data as they stand. Acoustic data from all other vessels were used as they stand, subject to exclusion of some data from very shallow waters where no blue whiting were observed.

Catchability varies greatly among the vessels due to the large variety of gear employed (see the text table on page 3). In particular, G. O. Sars is typically using a trawl that has much smaller vertical opening than the trawls on other vessels. This tended to yield catches that were rather low (often <100 kg). Tows during the inter-calibration exercises nevertheless suggested rather small differences in size selectivity [differences in mean length relative to G. O. Sars: +0.8 cm (Celtic Explorer), +0.3 cm (Tridens), –0.5 cm (M. Heinason)].

Based on the inter-calibration trawl hauls, age readings on G. O. Sars and Celtic Explorer appear to be rather similar. There is a significant difference in aging between Tridens and G. O. Sars with mean age at length being about one year higher on the former vessel as compared to the latter. No inter-calibration hauls were available to compare aging between F. Nansen and G. O. Sars, but comparing all survey hauls suggests a significant difference (blue whiting of ages 1–5 years tend to be larger on G. O. Sars compared to F. Nansen, while the opposite is true for older fish). At the time of running the stock estimate age data from Atlantniro and M. Heinason were not available. Age readings from G. O. Sars and Celtic Explorer only were used in the final stock estimate whereas length distributions from all vessels were utilized. As no calibrated age readings from the southern Porcupine Bank sub-area were available, age-length key from the northern Porcupine Bank was used for both sub-areas.

Distribution of blue whiting

Blue whiting were recorded in most of the survey area that covered almost 172 thousand square nautical miles (Figure 5, 6). The highest concentrations were recorded in the area between the Hebrides, Rockall and Bill Bailey/Faroes Banks. In comparison to 2004, the bulk of the biomass was observed further offshore in relation to the Hebrides shelf brake.

As most strata were surveyed by more than one vessel, there is some inevitable variability in vessel-specific acoustic observations. This is illustrated by displaying among-vessel coefficients of variability (Figure 6), based on data weighted by survey effort by vessel. These are often higher than 50%, showing that the degree of spatial and temporal heterogeneity in abundance of blue whiting is often large.

The highest recordings were observed at depths of 450-600 m, sometimes extending to around 300 m depth (or even shallower) on the slope areas. Looser layers of blue whiting in the upper parts of the water column (mostly juveniles) were observed only in the eastern parts of the Faroes/Shetland sub-area. Blue whiting southwards of the Porcupine Bank were only observed on the slope areas, clearly associated with the bottom at depths of 400-500 meters.

When interpreting the results on the distribution and abundance, one should bear in mind that distribution of blue whiting is highly dynamic because of migrations in and out of the spawning area. For example, fishing activity began well before the survey in the international waters and near the Porcupine Bank.

Stock size

The estimated total abundance of blue whiting for the 2005 international survey was 8.0 million tonnes, representing an abundance of 90.3×10^9 individuals (Table 2). The spawning stock was estimated at 7.6 million tonnes and 83.1×10^9 individuals. The geographical distribution of total stock biomass by stratum is shown in Figure 7.

In comparison to the results in 2004, the decrease in stock numbers and biomass are substantial, despite an increase in the area covered:

		2004	2005	Change (%)
Biomass (mill. t)	Total	11.4	8.0	–30
	Mature	10.9	7.6	–30
Numbers (10^9)	Total	137	90	–34
	Mature	128	83	–35
Survey area (nm^2)		149 000	172 000	+15

There was heterogeneity in the temporal trend between the sub-areas, however. There was no change in the southern Porcupine Bank, whereas biomass increased in the Rockall sub-area:

Sub-area		Biomass (million tonnes) 2004		2005		
			% of total		% of total	Change (%)
I	S. Porcupine Bank	0.21	2	0.21	3	0
II	N. Porcupine Bank	1.1	10	0.47	6	–56
III	Hebrides	5.8	52	4.3	54	–26
IV	Faroes/Shetland	2.7	24	1.4	18	–47
V	Rockall	1.3	12	1.6	20	+21

In order to allow comparisons with earlier results, a separate estimate was calculated for the international zone. This gave a biomass estimate of 1.08 million tonnes, which is substantially less than the estimate calculated on basis of Russian data in 2003, 2.9 million tonnes. This difference can, at least to a certain extent, be probably explained by the later coverage of the area in 2005 in comparison to 2003. In 2004, the coverage was less than in 2003 and in 2005 as only one Russian vessel participated the survey; the estimate in 2004 was correspondingly low at 0.6 million tonnes.

Stock composition

Stock in the survey area is dominated by age classes 5 and 4 years (year classes 2000 and 2001), which make together about 60% of spawning stock biomass (Table 3, Figure 8). The same year classes were dominating in 2004. Blue whiting of ages 3 and 6 years make most of the remaining spawning stock biomass (31 %).

More than half of the spawning stock biomass was recorded in the Hebrides sub-area. Blue whiting of ages 5 and 4 years, in that order, were most common (Figure 9). In other areas, younger blue whiting were relatively more abundant. This pattern is consistent with the observations in 2004.

The majority of fish older than one year in age were mature. The proportion of mature fish was the highest in the Hebrides and northern Porcupine Bank sub-areas (Table 2). The highest proportion of juvenile fish was observed in the Faroes/Shetland sub-area. In contrast, the proportion of juvenile blue whiting in 2004 was the highest in the southern Porcupine Bank sub-area, although also the Faroes/Shetland sub-area hosted a large proportion of juveniles.

Hydrography

The horizontal distribution of temperature and salinity at 10, 200, 400 and 600 meters depths are shown in Figures 10–17. The maps are based on CTD data collected on board G. O. Sars, Fridtjof Nansen and Tridens (Figure 3). The cooperation has given a good horizontal coverage of the area.

The Wyville Thompson ridge (~60°N) divides the survey area into two very different hydrographic regimes. South of the Wyville Thompson ridge the vertical gradients in temperature are small. In this area the differences in temperature between 10m and 400m are less than 1°C and at 1000m depth the temperatures are between 6 and 9°C, with the lowest temperatures at the Porcupine section (Figure 16) and in the north west. In the Faroe-Shetland channel the situation is very different with a strong thermocline around 500m depth separating a layer of warm saline Atlantic water overlying cold (~ –0.5°C), deep waters originating in the Norwegian Sea (See Figure 19, Faroe-Shetland section). This gives rise to the strongest horizontal gradients in the area too, particularly in deep water.

The horizontal gradients are generally very small in the area south of the Wyville Thompson ridge, in particular, the north-south gradient is very small. In the Rockall Through the temperature drops by less than 2°C from 52°N to 60°N at 10m, 200m, 400m and 600m depths (Figures 10-13). Due to a northward flowing shelf edge current, the warmest and most saline water is found in a narrow band along the shelf edge. The thickness of the mixed layer was 600-800m deep along the continental slope and between the Rockall Bank and the Faroe Banks. In the Rockall Channel the thickness of the mixed layer is more variable. On some station the thickness was only 250-300m whereas on the stations with the deepest mixed layer it was 800–900m deep.

In the last couple of years and this year the temperatures in the southern part of the area were above 11°C.Both last year and this year the 10°C isotherm extended north to about 58°N and the warmest water in the Faroe-Shetland channel was just above 9°C. The temperature is lower this year than last year.

At the Porcupine section (Figure 18) the temperature is quite homogeneous down to about 500m with a gradual change in the thermocline between 500m and 1000m. The most conspicuous feature this year is the intrusion of low salinity water on the western most station with salinities about 0.2 lower than the neighbouring station. The strong influence of water of Mediterranean origin seen last year was not observed this year, resulting in lower salinities.

On the Faroe-Shetland section (Figure 19) there is a characteristic wedge shaped core of Atlantic water on the eastern slope and Atlantic water in the upper hundred meters across the whole channel. Below the Atlantic water, cold and low salinity (S<34.90) intermediate water of Norwegian Sea origin extending up to about 500m. The 0°C isotherm is found at 600m depth at the western side, 500m central in the channel and it slopes downward to nearly 700m at the eastern side. This is about the same depth as last year, but shallower than in 2003. The temperature and salinity (S<34.4) in the core of the Atlantic water are lower than last year, and this a continuation of a cooling and freshening seen last year compared to the record warm and saline water in 2003.

Based on the hydrographic observations obtained during the blue whiting surveys, the mean temperature and salinity from 50 to 600m of all the stations in deep water (bottom depth>600m) in 2° latitude times 2° longitude boxes have been calculated for each survey. The box with limits 52° to 54°N and 16° to 14°W had few gaps, and the time series of mean temperature and salinity for this box is shown in Figure 20. The pattern seen is that after some years with temperatures around 10.1°C in the 1980s, it dropped to a minimum in 1994 (~9.8°C). After 1994 an increase in temperature is seen, and in 1998 temperature reached a local maximum (~10.5°C) with the three following years a few tenths of a degree colder. 2002 was a warm year with ~10.7°C, and in 2003 the temperature dropped to (~10.5°C). In 2004 was the warmest on record (~10.8°C), but this year (~10.4°C) is colder than the three preceding years. This is above the long-term average, but about average for the last 10 years.

Concluding remarks

- The second international blue whiting spawning stock survey, in comparison to the survey in 2004, shows a clear reduction in stock numbers and biomass (~30–35%), despite an increase in the area surveyed (+15%).
- The stock continues to be dominated by age classes 2000 and 2001 (in that order) that make 60% of SSB.
- The effort by six participating vessels gave a very broad spatial coverage. In addition, through overlapping coverage in core areas, information on the spatial and temporal dynamics of blue whiting is gained, giving a better idea of accuracy of the results. In addition, biological sampling was extensive. Thereby more confidence on the results is obtained.
- Abundance estimates from acoustic surveys should generally be interpreted as relative indices rather than absolute measures. In particular, acoustic abundance estimates critically depend on the applied target strength. The target strength currently used for blue whiting is based on cod and considered to be too low, possibly as much as by 40% (see Godø et al. 2002, Heino et al. 2003, 2005). This would imply an overestimation of stock biomass by a similar factor. This bias is, however, roughly constant from year to year, and does not affect conclusions about relative change in abundance of stock.
- The overall timing of survey appears to be rather suitable with respect to weather and covering the traditional core distribution area of blue whiting. The possibility of covering western (west of Rockall) and southern (off Porcupine Bank) areas earlier in the season, at the time of the peak fishery in those areas, should be considered.
- Data exchange during the survey continues to be a problem. It is essential that all data are available well in advance of the meeting where they will be used. With all vessels, rate of the data delivery and/or the format of the data delivered to G. O. Sars left room for improvements. The conversion program from PGNAPES to the format required by BEAM (stock estimation program used at IMR) is still a beta version suffering from bugs and misspecifications. In addition, G. O. Sars is not yet able to automatically deliver its own data to other vessels in the PGNAPES format.
- Differences exist not only in the vessels themselves and their acoustic instrumentation and trawl gear, but also in survey procedures such as numbers of fish measured, parameters measured (and their scale and resolution) and survey design. Combining the data would be facilitated if a greater agreement on the procedures could be achieved.
- Because blue whiting often occur patchily, good trawl sample coverage can only be achieved if all vessels could fish at any time of the day.
- Age readings between the vessels still require calibration. On some vessels, otolith reading takes place only after the survey. We recommend compiling an updated estimate once calibrated age readings become available (age reading workshop will take place in June 2005), before the PGNAPES and WGNPBW meetings in August 2005.
- We recommend sharing expertise (e.g., in scrutinizing echograms) through exchange of scientific personnel.
- In order to facilitate planning of the survey in 2006, we recommend each participant to compile a list of most important problems encountered in running the survey. In addition, some problems have been identified when joining the data. Planning Group for North-east Atlantic Pelagic Ecosystem Surveys (PGNAPES) should agree upon how the problems are to be solved, including clear deadlines for key problems.

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Table 1. Survey effort by vessel.

Vessel	Effective survey period (dd/mm)	Length of cruise track (nm) *	Trawl stations	CTD stations	Aged fish	Length-measured fish
Atlantniro	15/3–8/4	1970	30	0 **	0 **	5789
Celtic Explorer	28/3–11/4	2169	16	15	709	1409
Fridtjof Nansen	18/3–14/4	2694	25	117	2343	15854
G. O. Sars	17/3–13/4	3117	25	91	1271	3919
Magnus Heinason	1/4–12/4	1295	8	4	0 **	1600
Tridens	10/3–21/3	1140	7	21	300	1364

* With acoustic observations used in the stock estimate.
** Available at the time of calculating the stock estimate.

Table 2. Assessment factors of blue whiting, spring 2005.

Sub-area		Numbers (milliards)			Biomass (million tonnes)			Mean weight	Mean length	Density
	n.mile^2	Mature	Total	%mature	Mature	Total	%mature	g	cm	t/n.mile^2
I S. Porcupine Bank	22568	2.48	2.70	91.8	0.20	0.21	96.1	77.0	24.3	9
II N. Porcupine Bank	28352	5.79	5.89	98.3	0.46	0.47	99.2	79.2	26.1	16
III Hebrides	35658	44.6	45.2	98.7	4.28	4.29	99.7	95.0	27.1	120
IV Faroes/Shetland	31468	11.8	15.8	74.5	1.14	1.43	79.2	90.5	26.2	45
V Rockall	53804	18.5	20.7	89.2	1.55	1.61	96.3	77.4	25.1	30
Tot.	171850	83.1	90.3	92.0	7.64	8.01	95.4	88.6	26.3	47

Table 3. Stock estimate of blue whiting, spring 2005.

	Age in years (year class)											Num-bers	Bio-mass	Mean weight	Prop. mature*
Length (cm)	1 2004	2 2003	3 2002	4 2001	5 2000	6 1999	7 1998	8 1997	9 1996	10 1995	11 1994	(10^6)	(10^6 kg)	(g)	(%)
13.0 – 14.0	2	0	0	0	0	0	0	0	0	0	0	2	0	13.1	8
14.0 – 15.0	46	0	0	0	0	0	0	0	0	0	0	46	0.6	14.1	7
15.0 – 16.0	451	34	0	0	0	0	0	0	0	0	0	485	9	17.8	11
16.0 – 17.0	985	28	0	0	0	0	0	0	0	0	0	1013	21	21.1	13
17.0 – 18.0	861	90	0	0	0	0	0	0	0	0	0	952	24	25.4	17
18.0 – 19.0	756	91	0	0	0	0	0	0	0	0	0	847	26	30.7	21
19.0 – 20.0	272	541	0	0	0	0	0	0	0	0	0	813	30	37.4	54
20.0 – 21.0	119	1125	25	0	0	10	0	0	0	0	0	1279	52	40.4	79
21.0 – 22.0	36	703	395	0	0	0	0	0	0	0	0	1134	54	47.2	85
22.0 – 23.0	33	419	1342	148	0	0	0	0	0	0	0	1941	111	57.2	85
23.0 – 24.0	0	823	3034	620	199	0	0	0	0	0	0	4676	294	62.9	86
24.0 – 25.0	49	262	4526	3507	1891	0	0	0	0	0	0	10236	711	69.5	91
25.0 – 26.0	0	204	5243	6608	3628	472	0	0	0	0	0	16155	1246	77.1	95
26.0 – 27.0	20	0	2645	6827	6516	579	16	0	0	0	0	16603	1404	84.6	97
27.0 – 28.0	0	0	1240	4270	5719	759	71	5	0	0	0	12063	1140	94.5	98
28.0 – 29.0	0	0	235	2348	3352	1282	254	85	0	0	0	7555	805	107	99
29.0 – 30.0	0	0	74	908	3285	1095	249	24	0	0	0	5635	663	118	99
30.0 – 31.0	0	0	9	238	1177	1484	68	129	37	0	0	3143	419	133	100
31.0 – 32.0	0	0	8	19	833	1480	311	18	5	0	0	2673	397	148	100
32.0 – 33.0	0	0	0	86	11	601	302	62	47	0	0	1108	183	165	100
33.0 – 34.0	0	0	0	0	11	347	295	146	0	0	0	799	146	183	100
34.0 – 35.0	0	0	0	0	0	142	295	81	79	2	4	602	121	201	100
35.0 – 36.0	0	0	0	0	7	9	61	8	43	0	0	128	27	209	100
36.0 – 37.0	0	0	0	0	31	37	47	140	0	0	0	254	63	247	100
37.0 – 38.0	0	0	0	0	0	0	44	3	14	0	0	62	15	241	100
38.0 – 39.0	0	0	0	0	0	0	0	13	14	0	0	28	8	282	100
39.0 – 40.0	0	0	0	0	0	1	3	10	43	0	0	58	18	311	100
40.0 – 41.0	0	0	0	0	0	0	0	5	39	0	0	45	17	382	100
41.0 – 42.0	0	0	0	0	0	0	0	0	2	0	0	2	0.5	343	100
TSN (10^6)	3631	4320	18774	25579	26660	8298	2016	728	323	2	4	90336			
TSB (10^6 kg)	99	217	1377	2194	2546	1046	320	128	76	0.5	0.7	8005			
Mean length (cm)	17.6	21.6	25.0	26.4	27.4	29.8	31.9	33.0	35.6	34.9	34.5	26.3			
Mean weight (g)	27.3	50.2	73.3	85.8	95.5	126	159	176	236	212	183	88.6			
Condition (g/dm^3)	5.0	5.0	4.7	4.7	4.6	4.8	4.9	4.9	5.2	5.0	4.5	4.9			
% mature*	13	79	93	93	100	100	100	100	100	100	100	92			
% of SSB	0	2	17	27	33	14	4	2	1	0	0				

* Percentage of mature individuals per age or length class

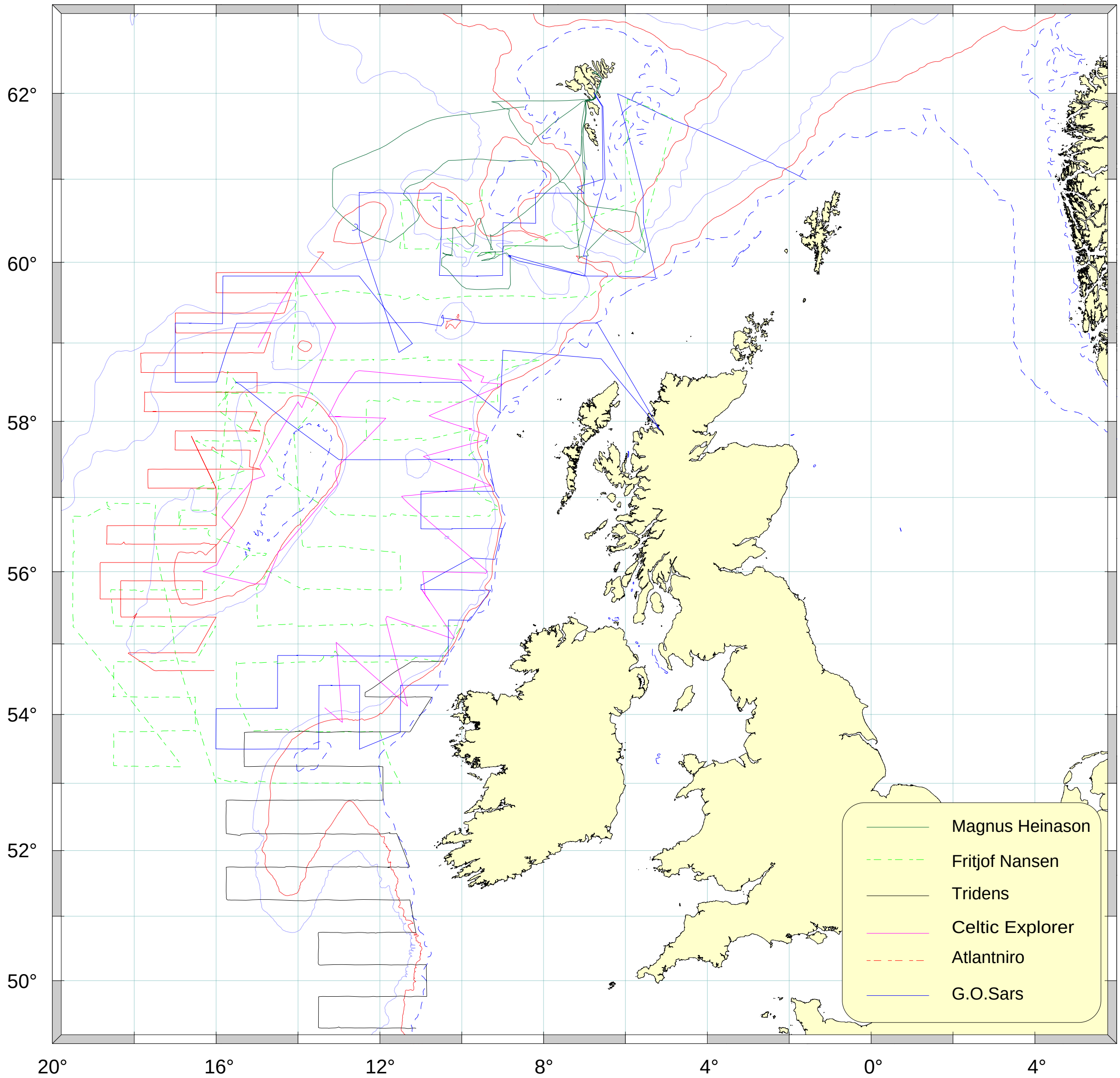


Figure 1. Cruise tracks during the International Blue Whiting Spawning Stock Survey in spring 2005. The figure shows all survey activity; in Figure 4, only the cruise tracks from which acoustic data were used in the stock estimate are shown.

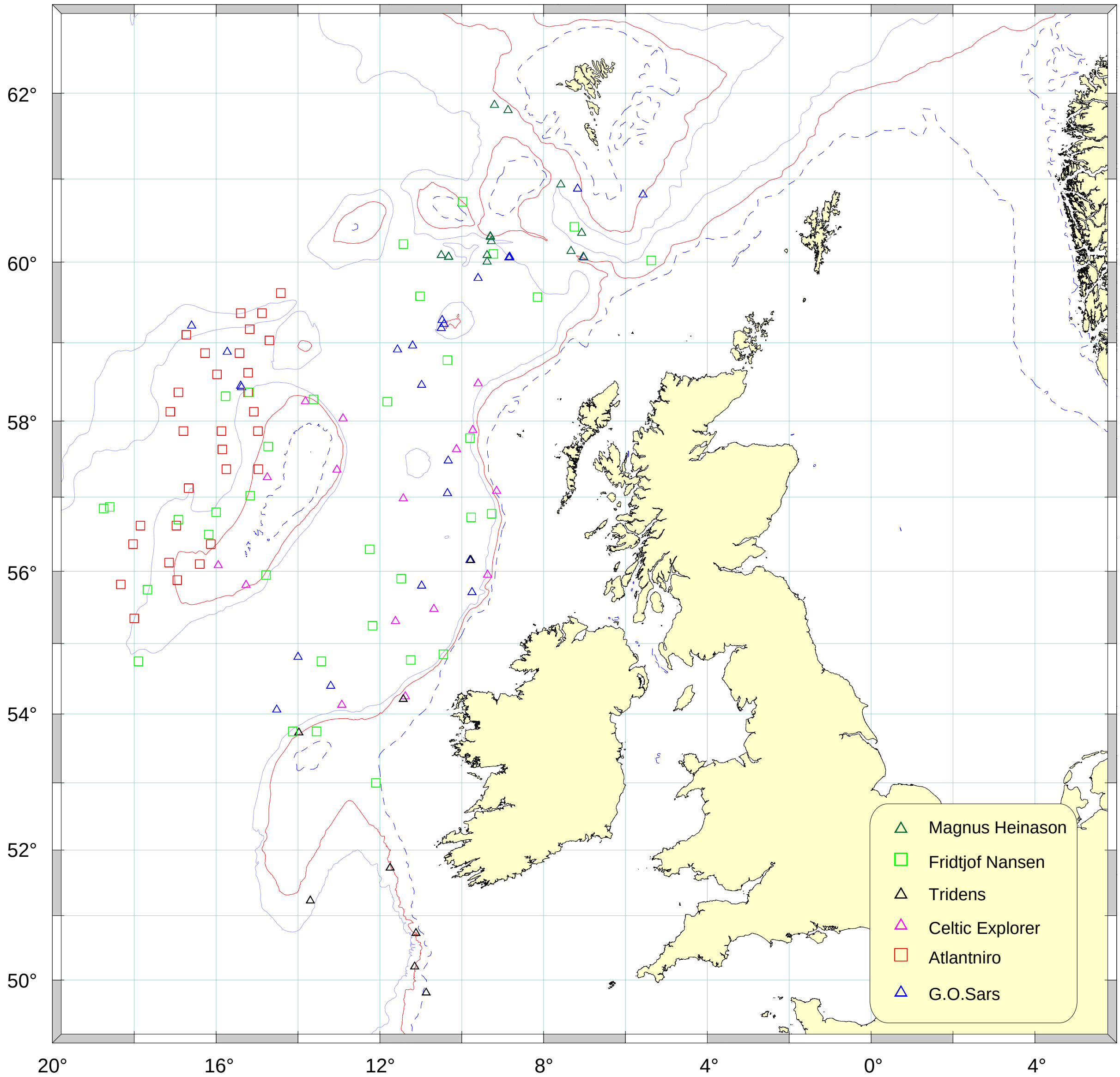


Figure 2. Trawl stations for R/V G. O. Sars, R/V Fridtjof Nansen, Celtic Explorer, R/V Atlantniro, R/V Magnus Heinason and R/V Tridens, in March-April 2005.

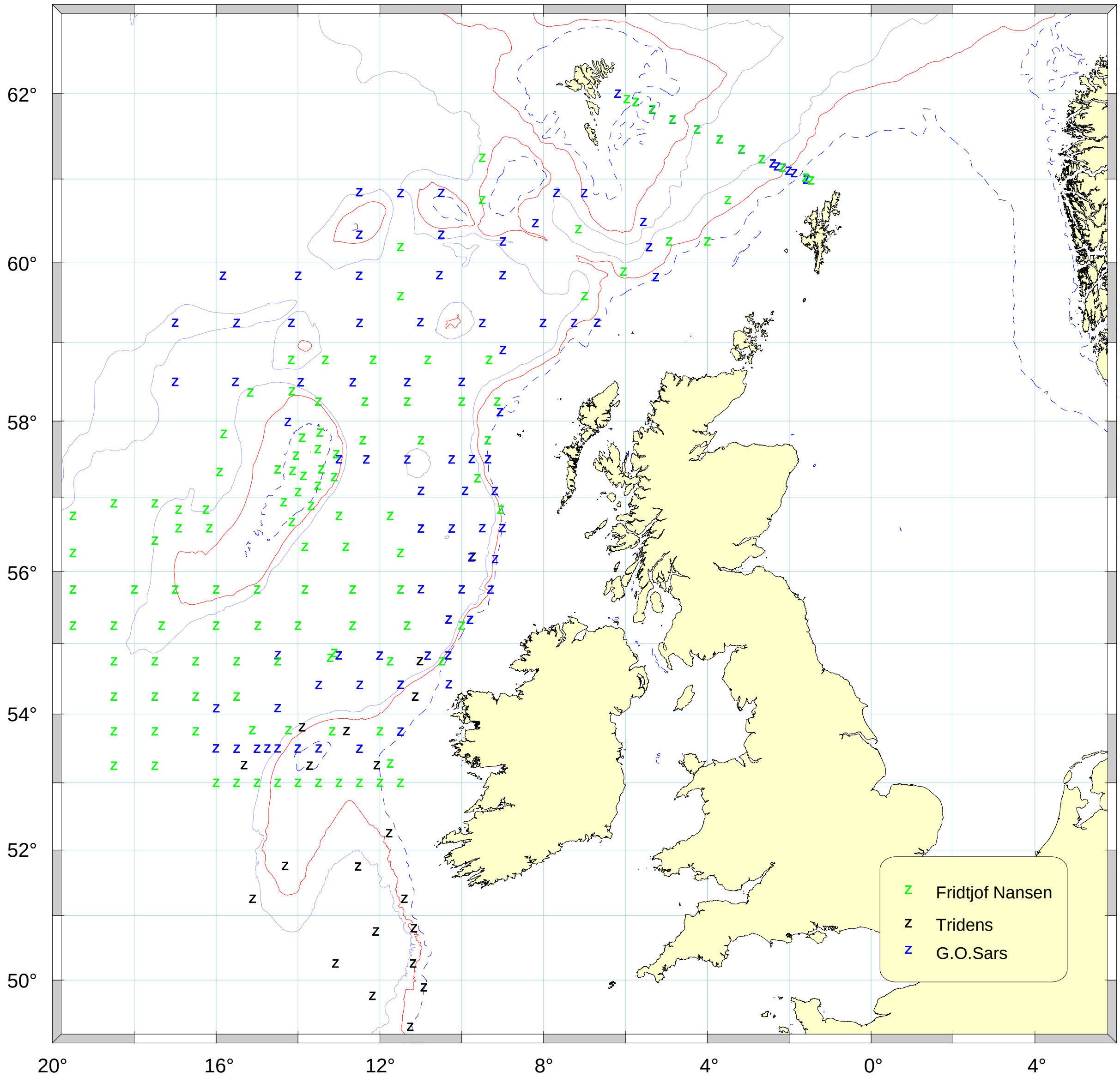


Figure 3. CTD stations for R/V G. O. Sars, R/V Fridtjof Nansen and R/V Tridens in March-April 2005.

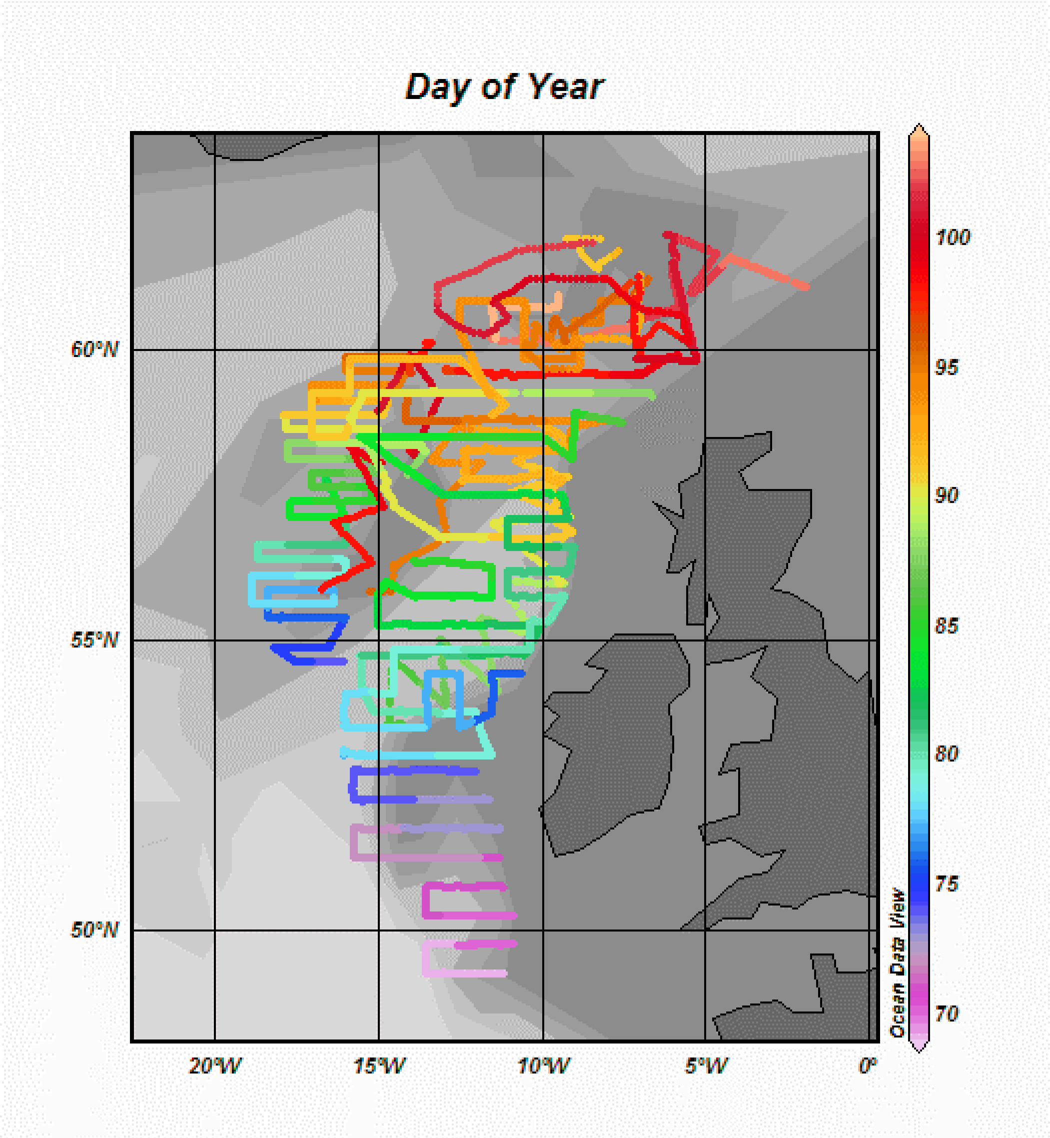


Figure 4. Temporal progression of the survey, 10 March–14 April 2005. Only cruise tracks from which acoustic data were used in the stock estimate are shown.

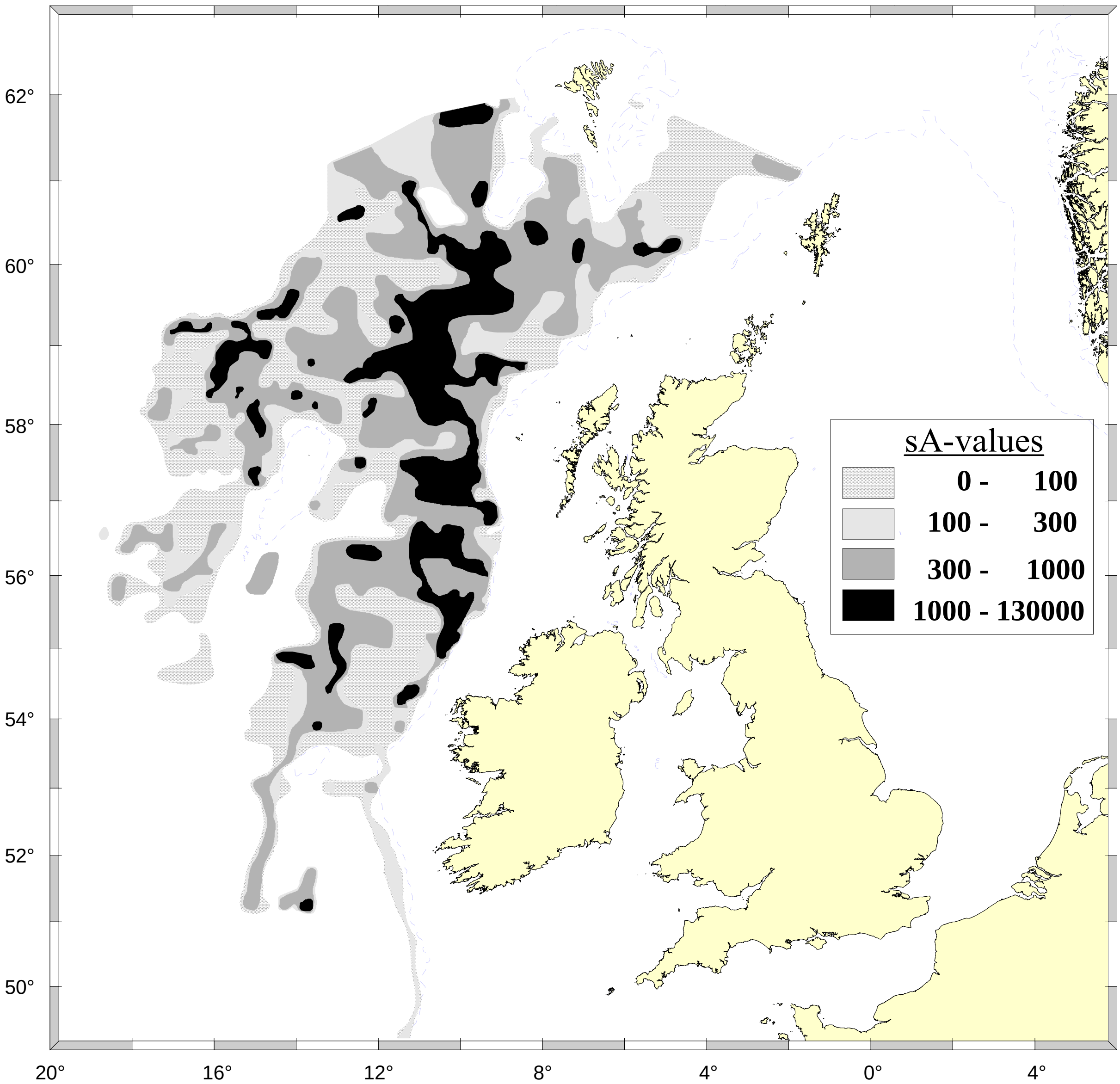


Figure 5. Schematic map of blue whiting acoustic density (s_A, m^2/nm^2) in spring 2005.

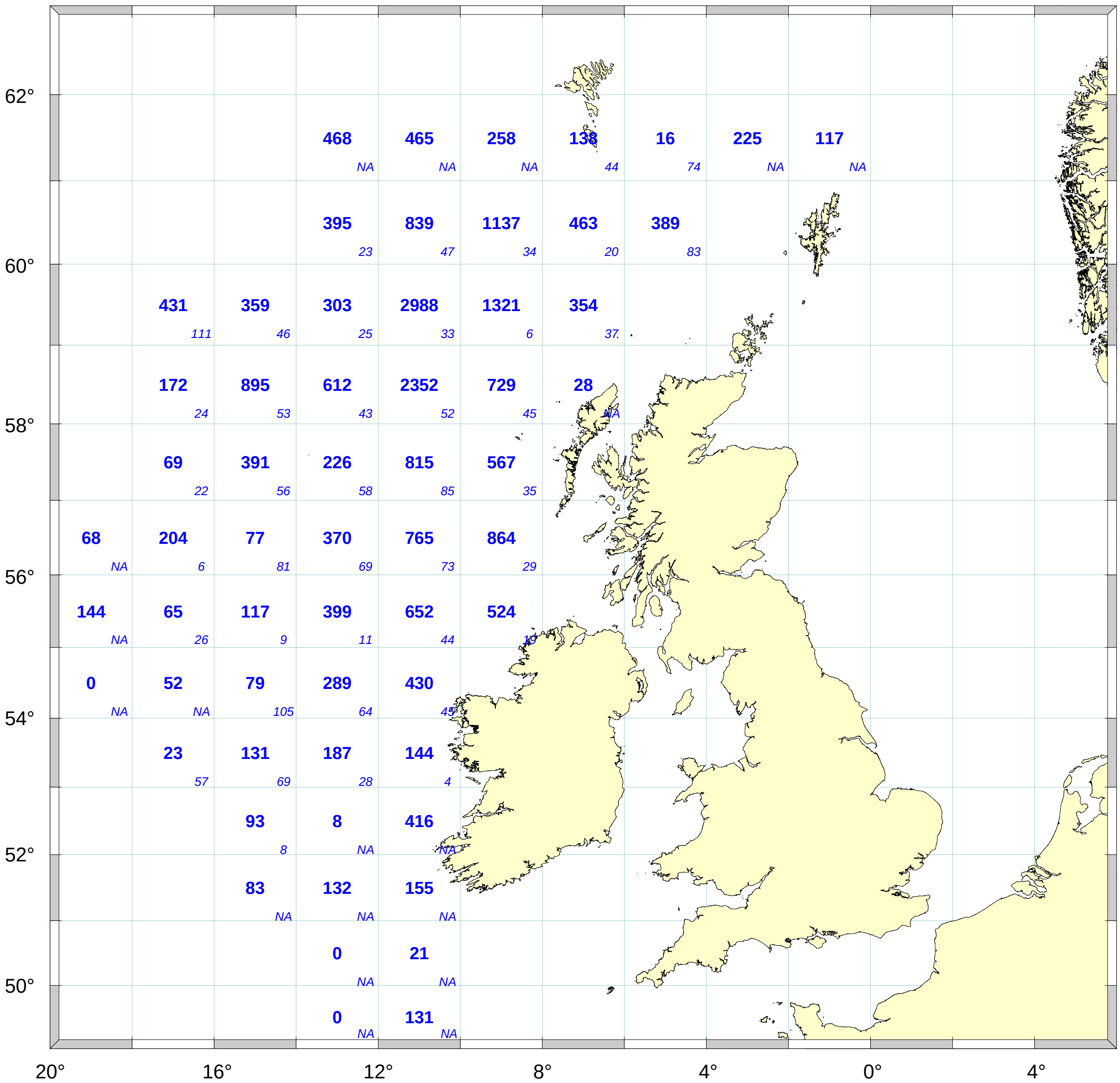


Figure 6. Mean acoustic density (s_A, m^2/nm^2) per stratum. The value printed in the lower right corner is among-vessel coefficient of variability (CV, %).

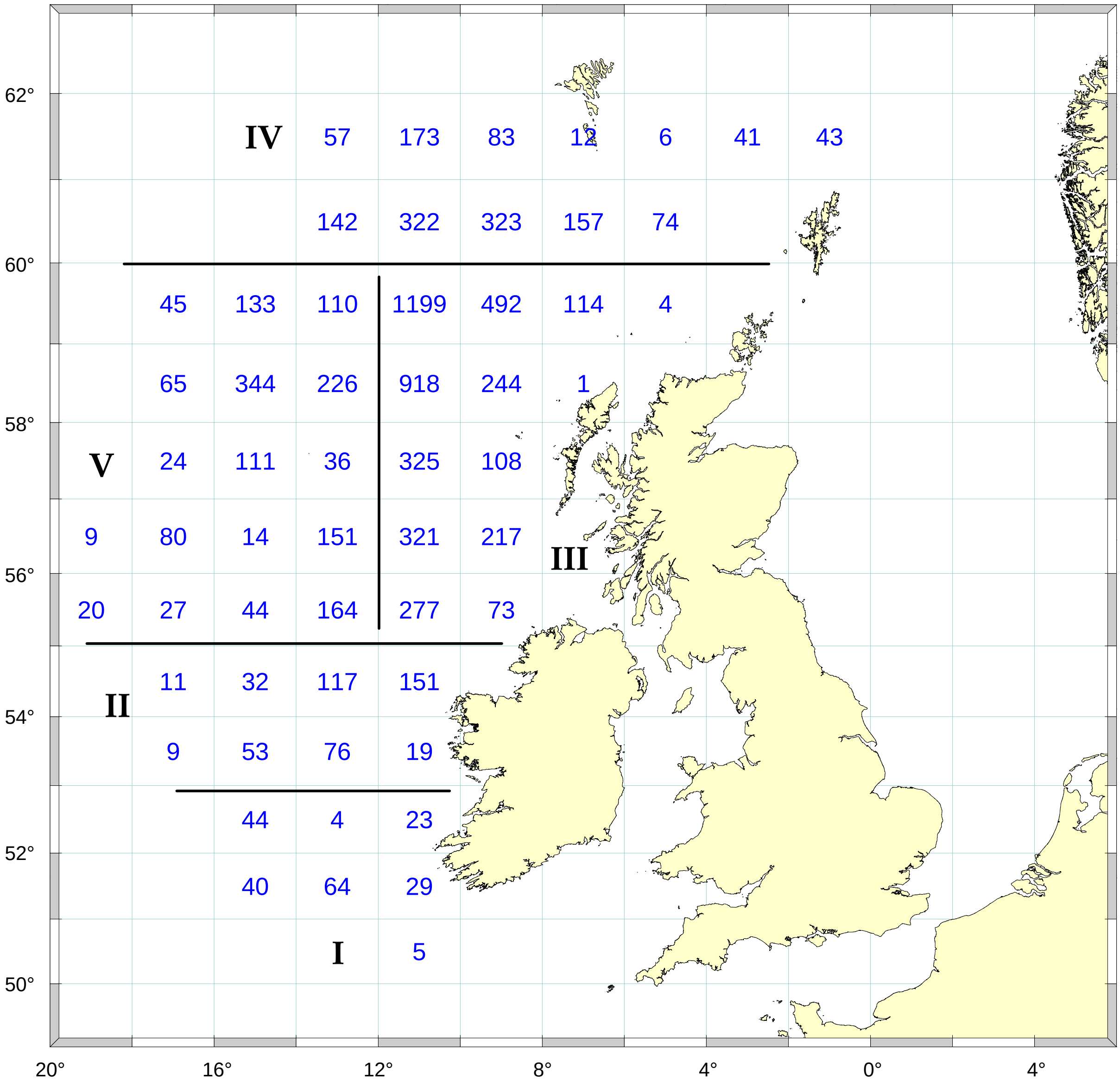


Figure 7. Blue whiting biomass in 1000 tonnes, spring 2005. Marking of sub-areas I-V used in the assessment.

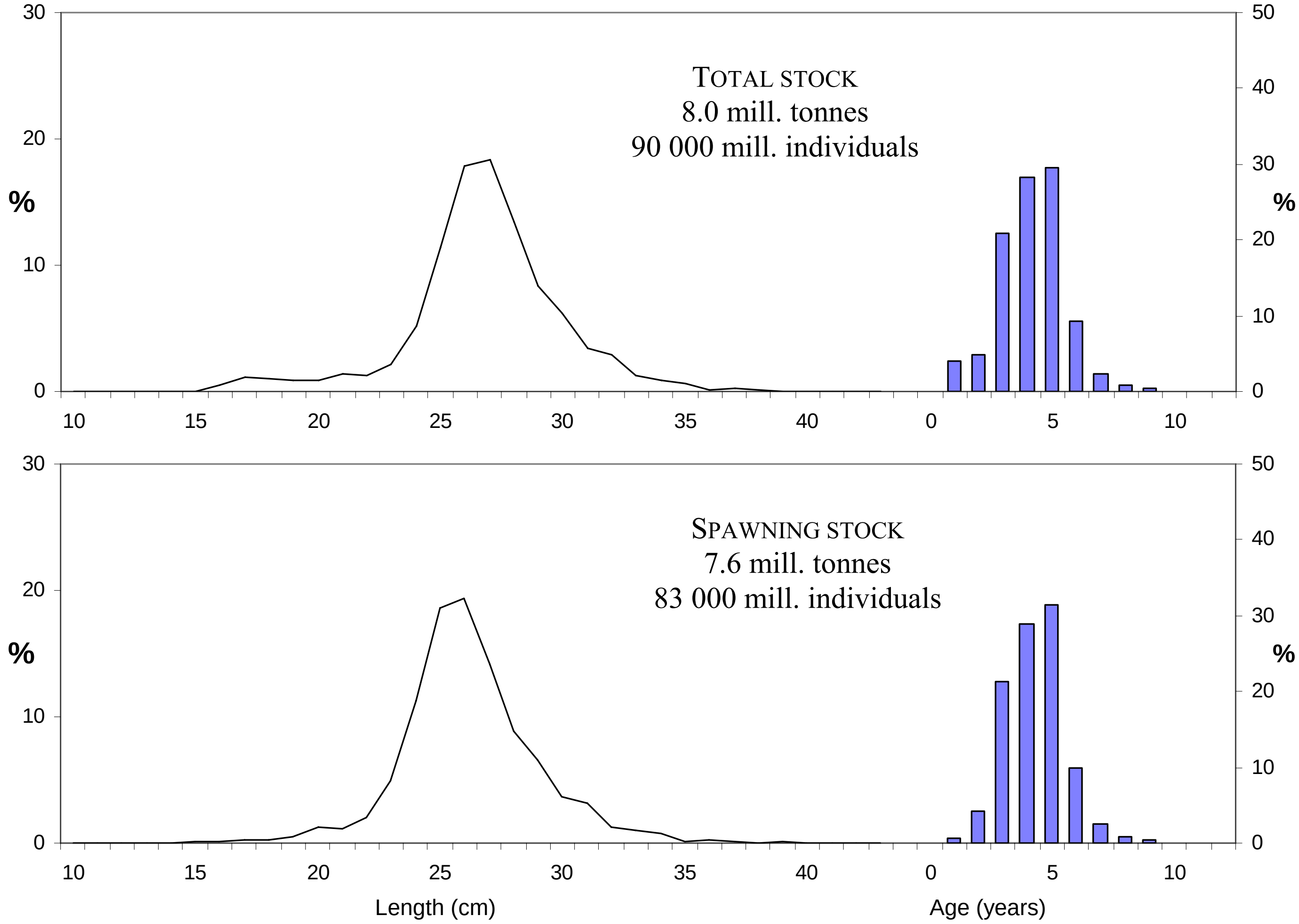


Figure 8. Length and age distribution in the total and spawning stock of blue whiting in the area to the west of the British Isles, spring 2005.

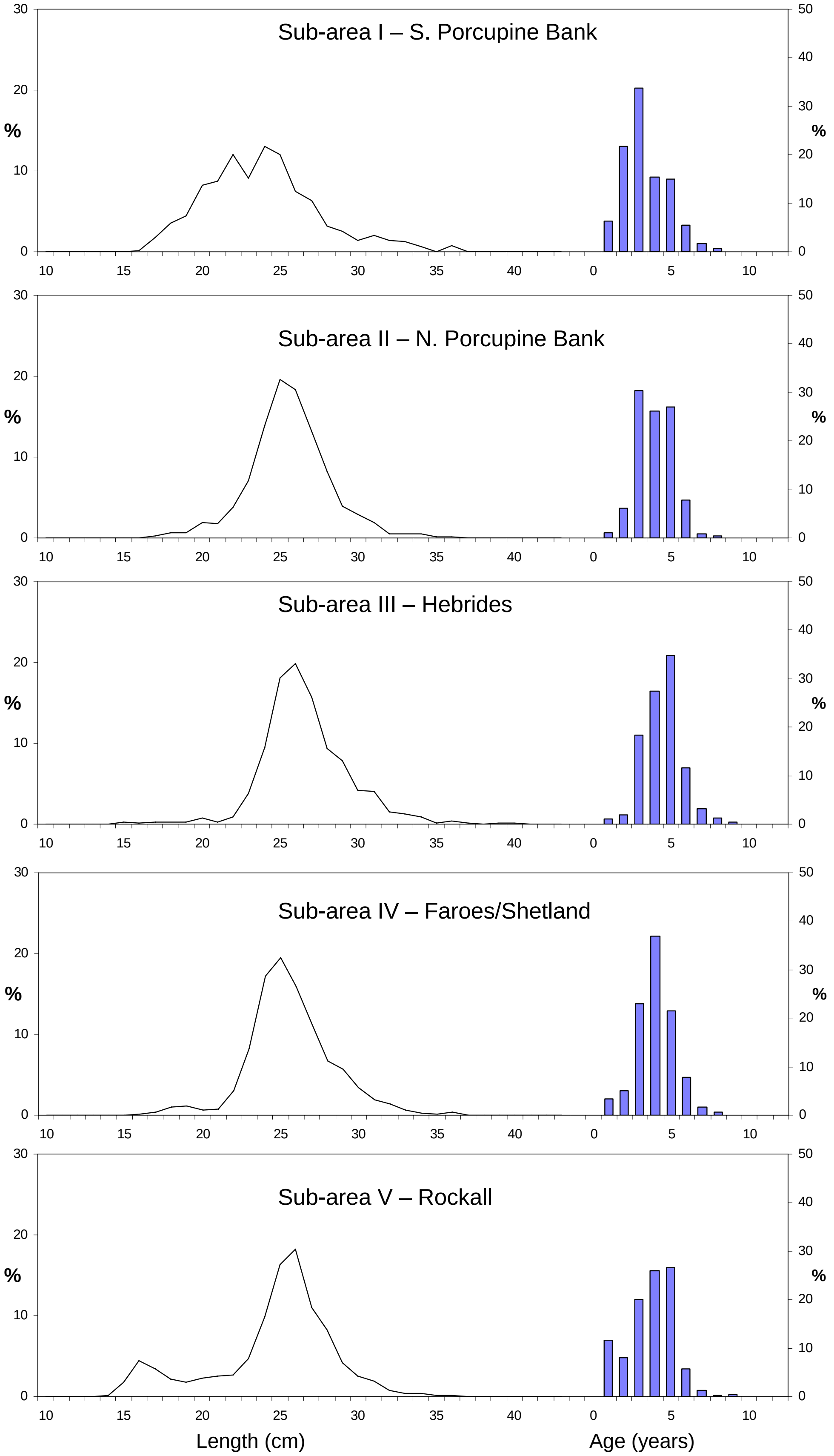


Figure 9. Length and age distribution of blue whiting by sub-areas (I–V), spring 2005.

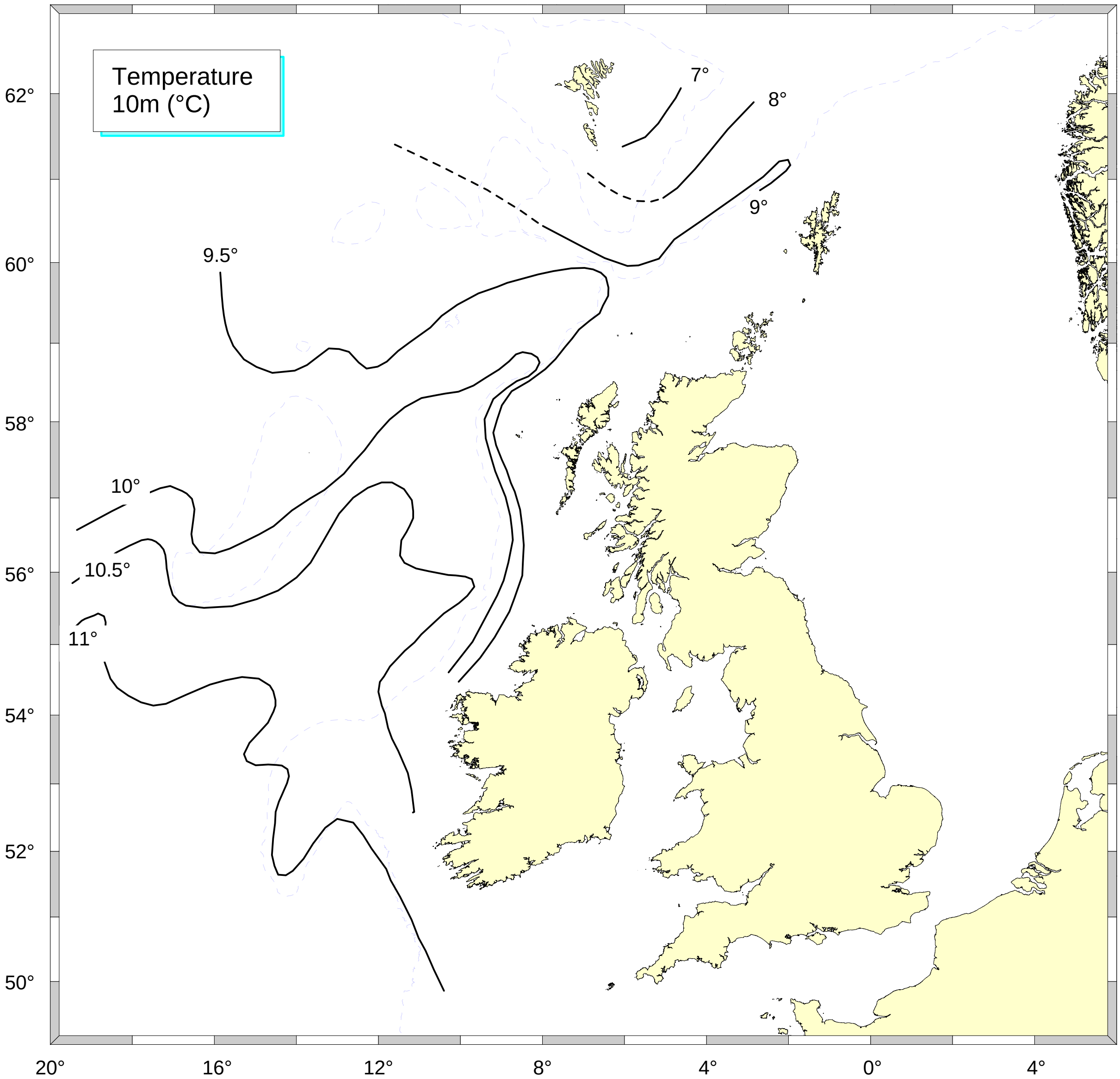


Figure 10. Horizontal temperature distribution, °C, in March-April 2005 at 10m depth.

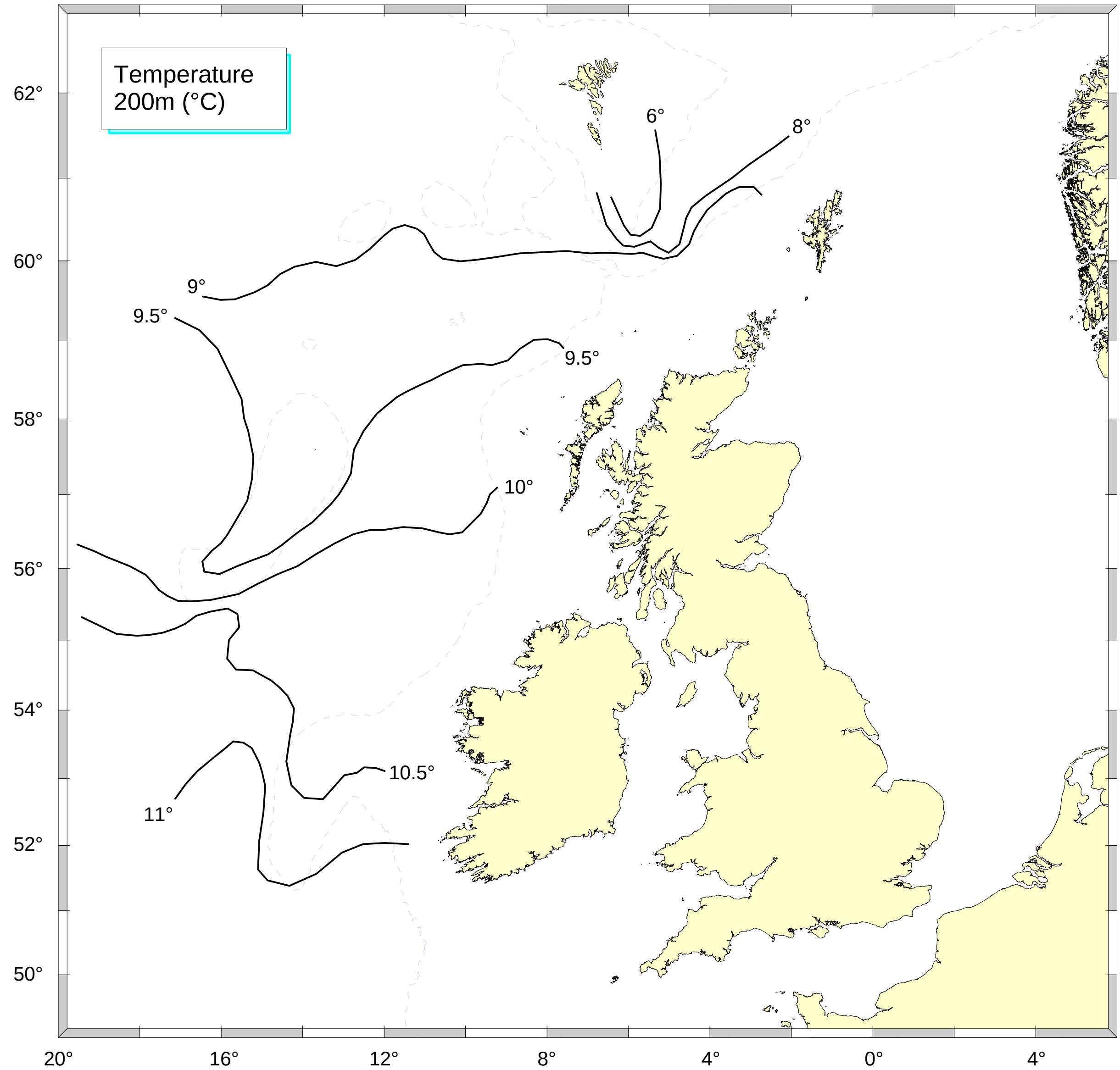


Figure 11. Horizontal temperature distribution, °C, in March-April 2005 at 200m depth.

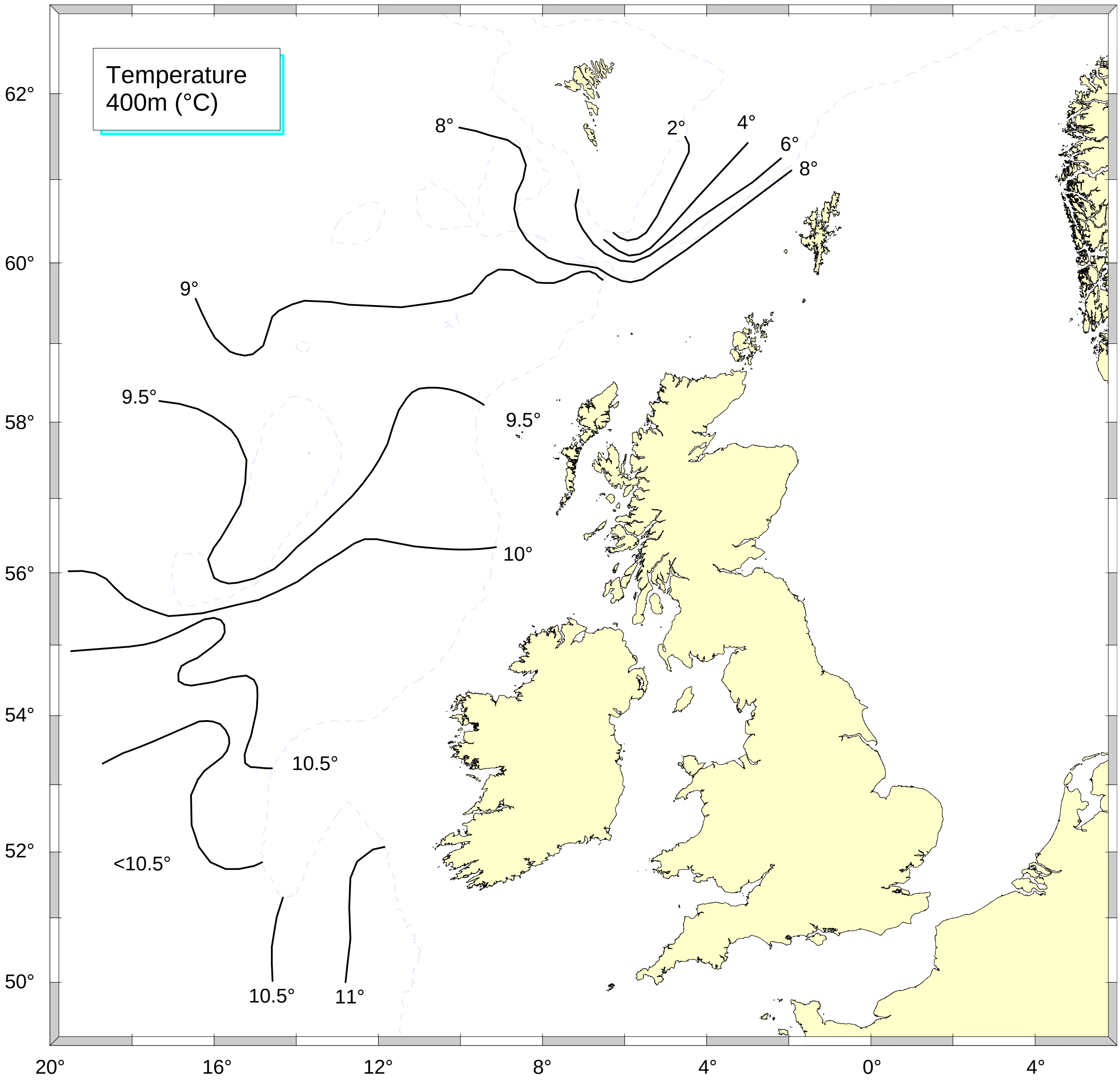


Figure 12. Horizontal temperature distribution, °C, in March-April 2005 at 400m depth.

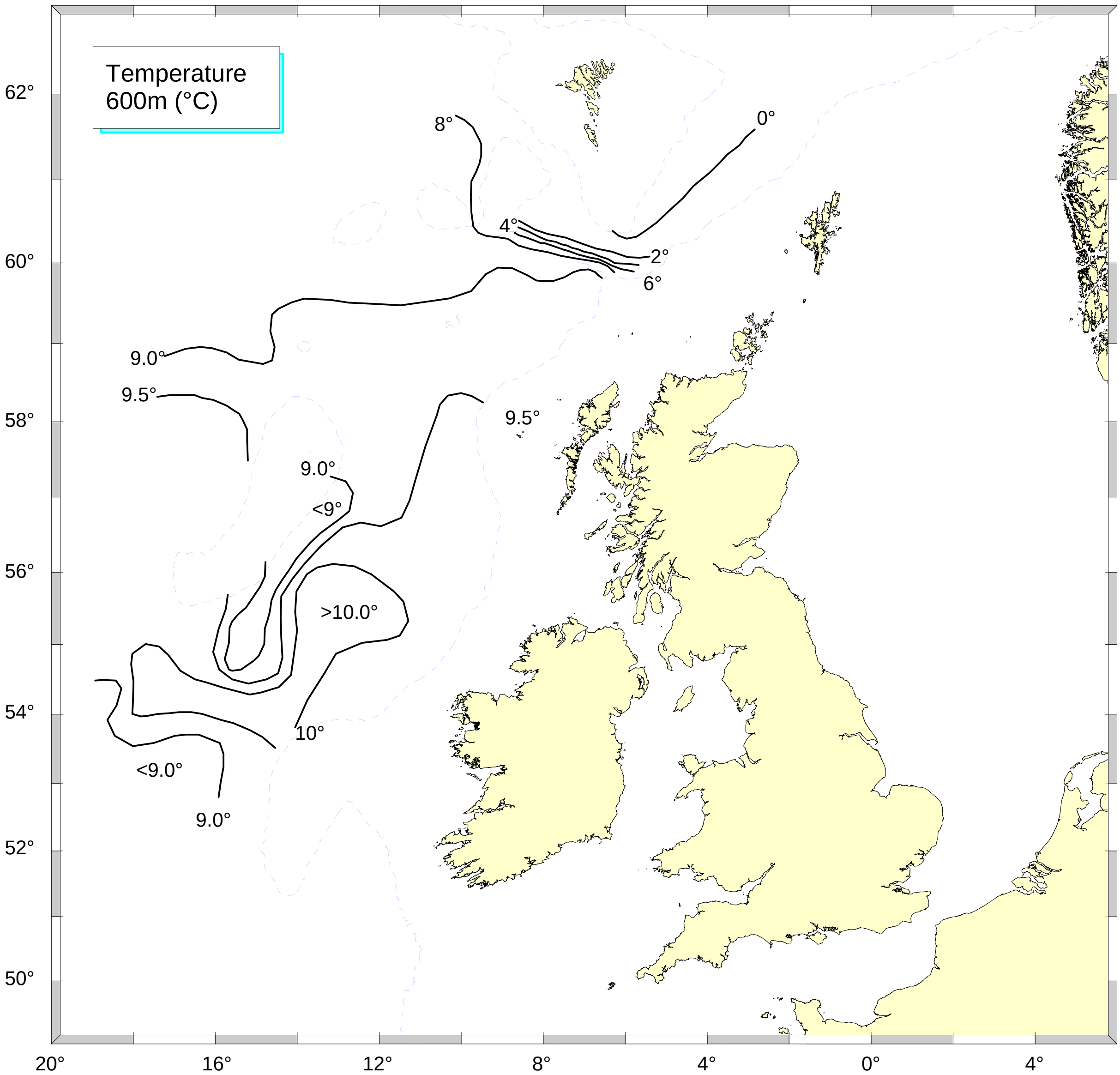


Figure 13. Horizontal temperature distribution, °C, in March-April 2005 at 600m depth.

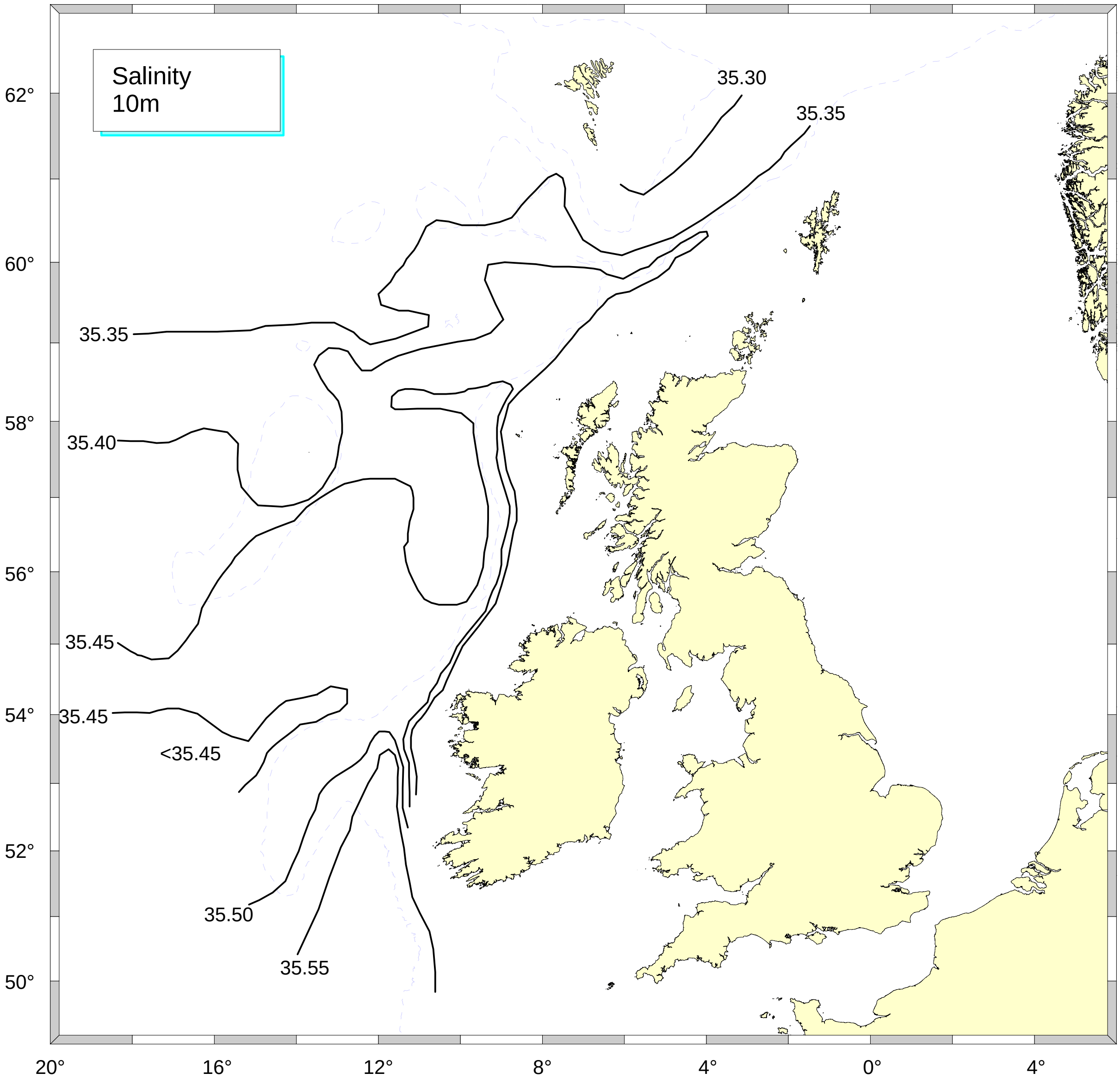


Figure 14. Horizontal salinity distribution, °C, in March-April 2005 at 10m depth.

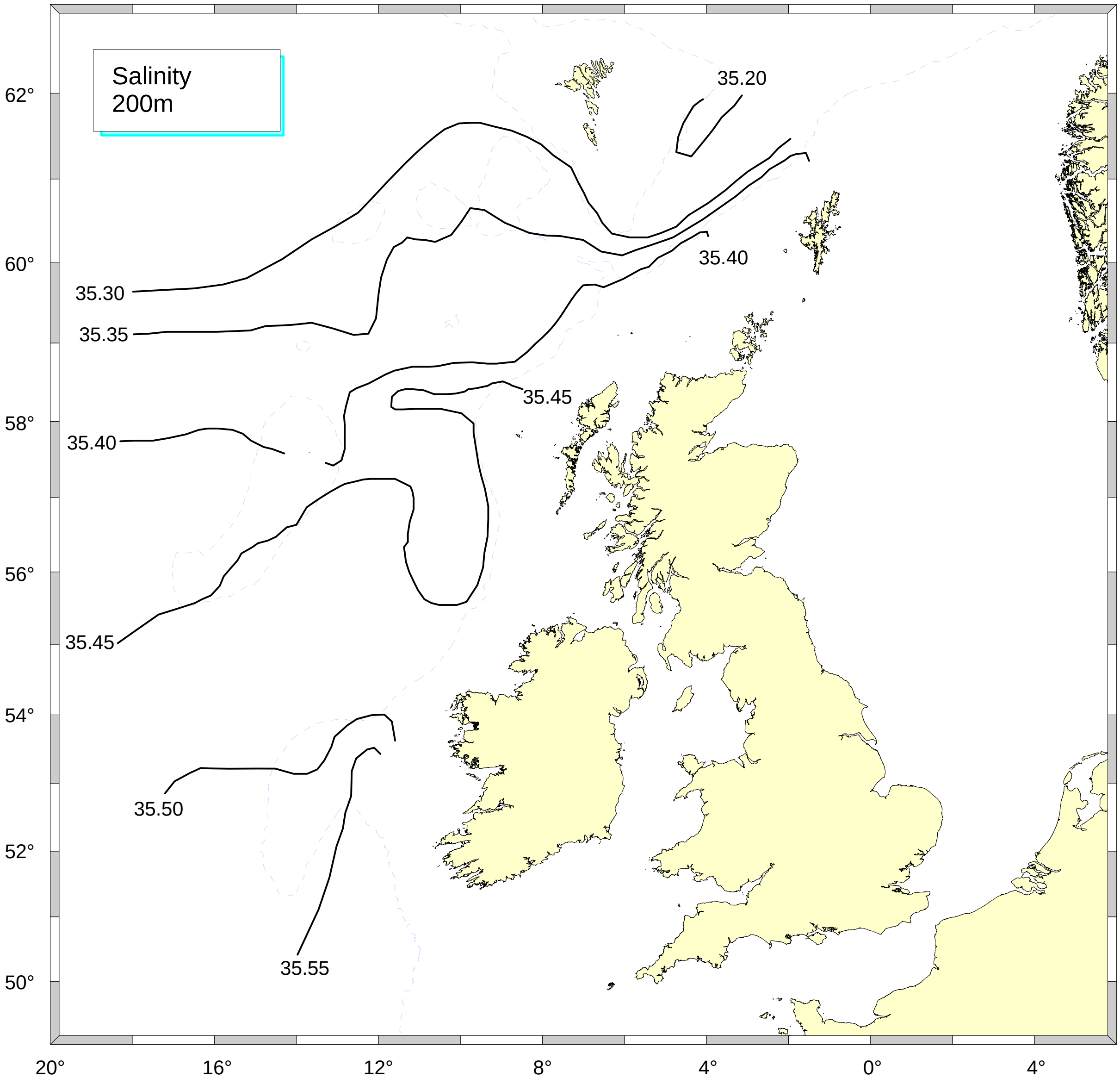


Figure 15. Horizontal salinity distribution, °C, in March-April 2005 at 200m depth.

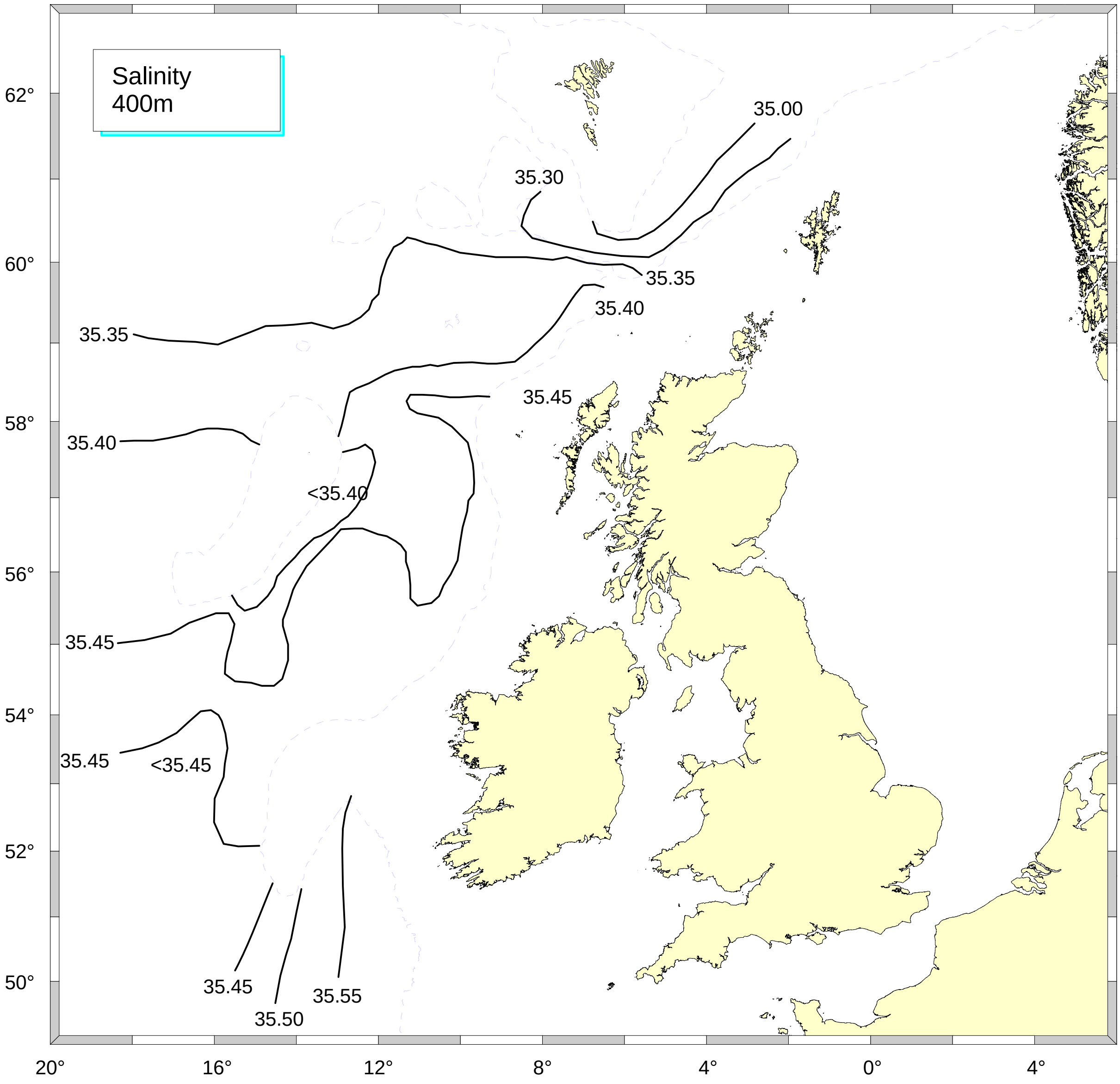


Figure 16. Horizontal salinity distribution, °C, in March-April 2005 at 400m depth.

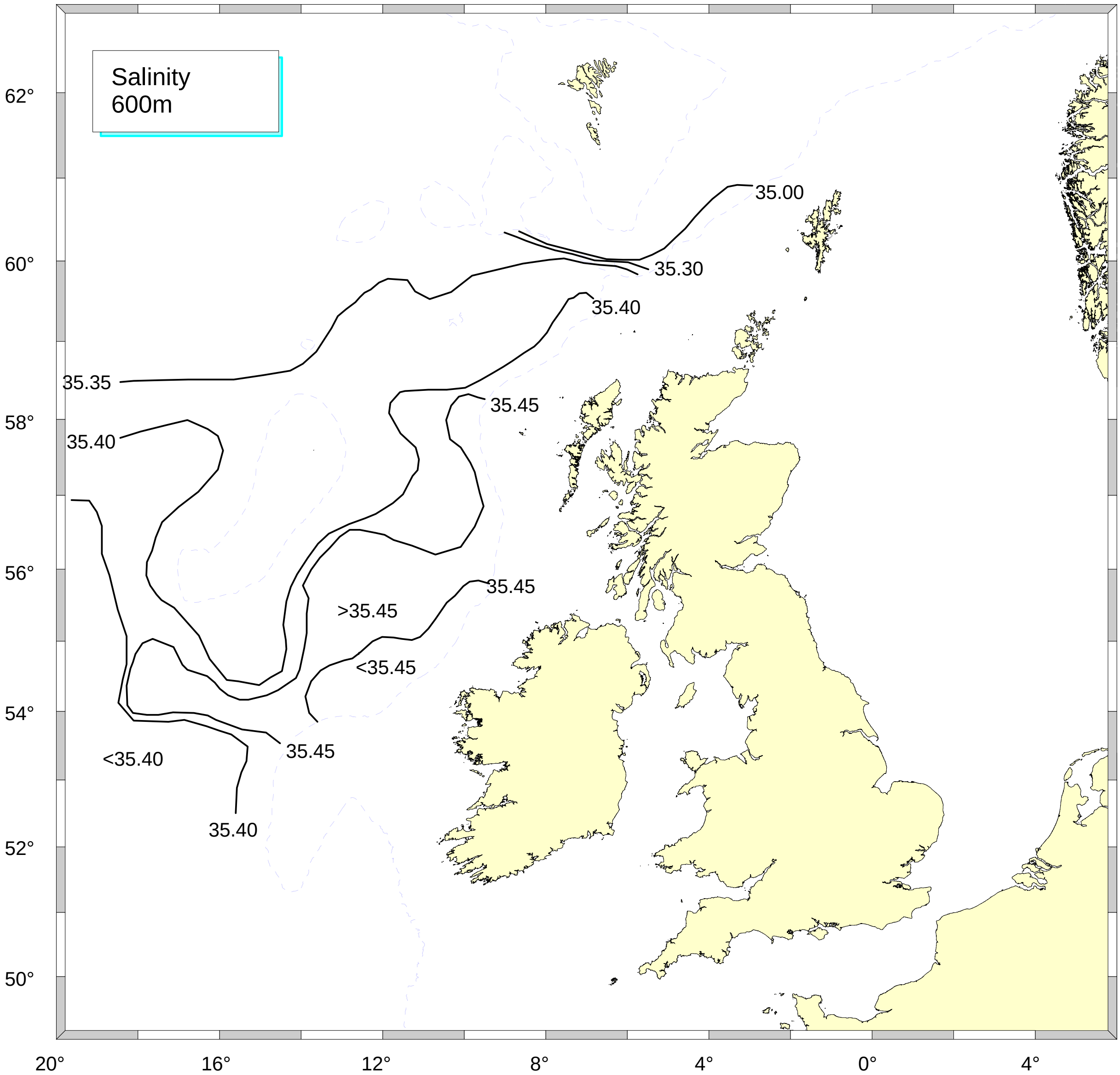
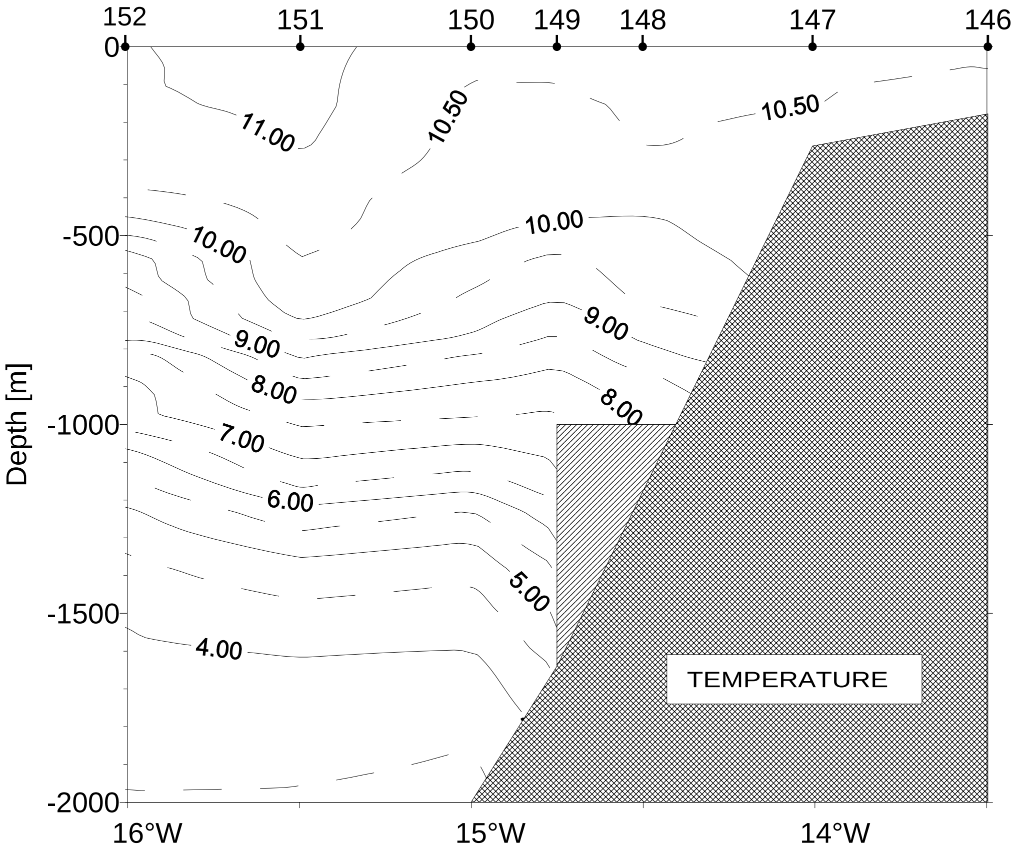


Figure 17. Horizontal salinity distribution, °C, in March-April 2005 at 600m depth.



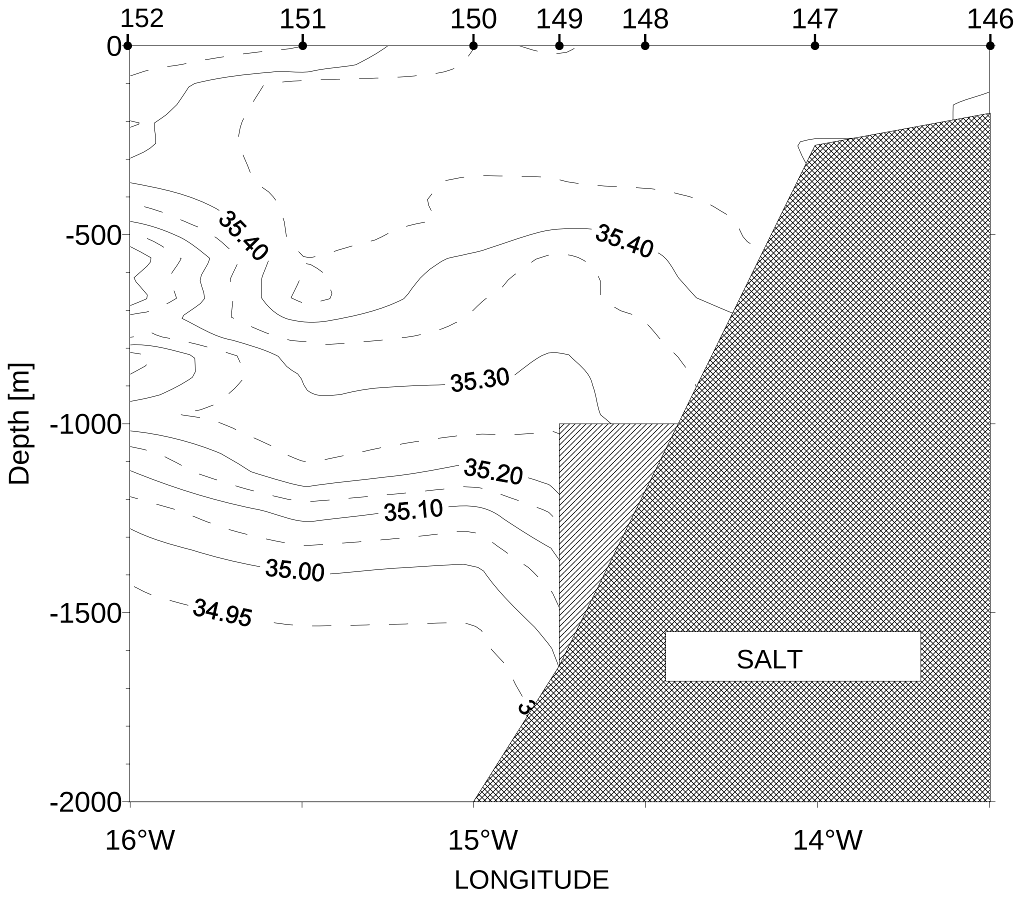


Figure 18. Vertical distribution of temperature (°C) and salinity in a section at the shelf edge at the Porcupine Bank at 53° 30'N. Station numbers at the top of the panels.

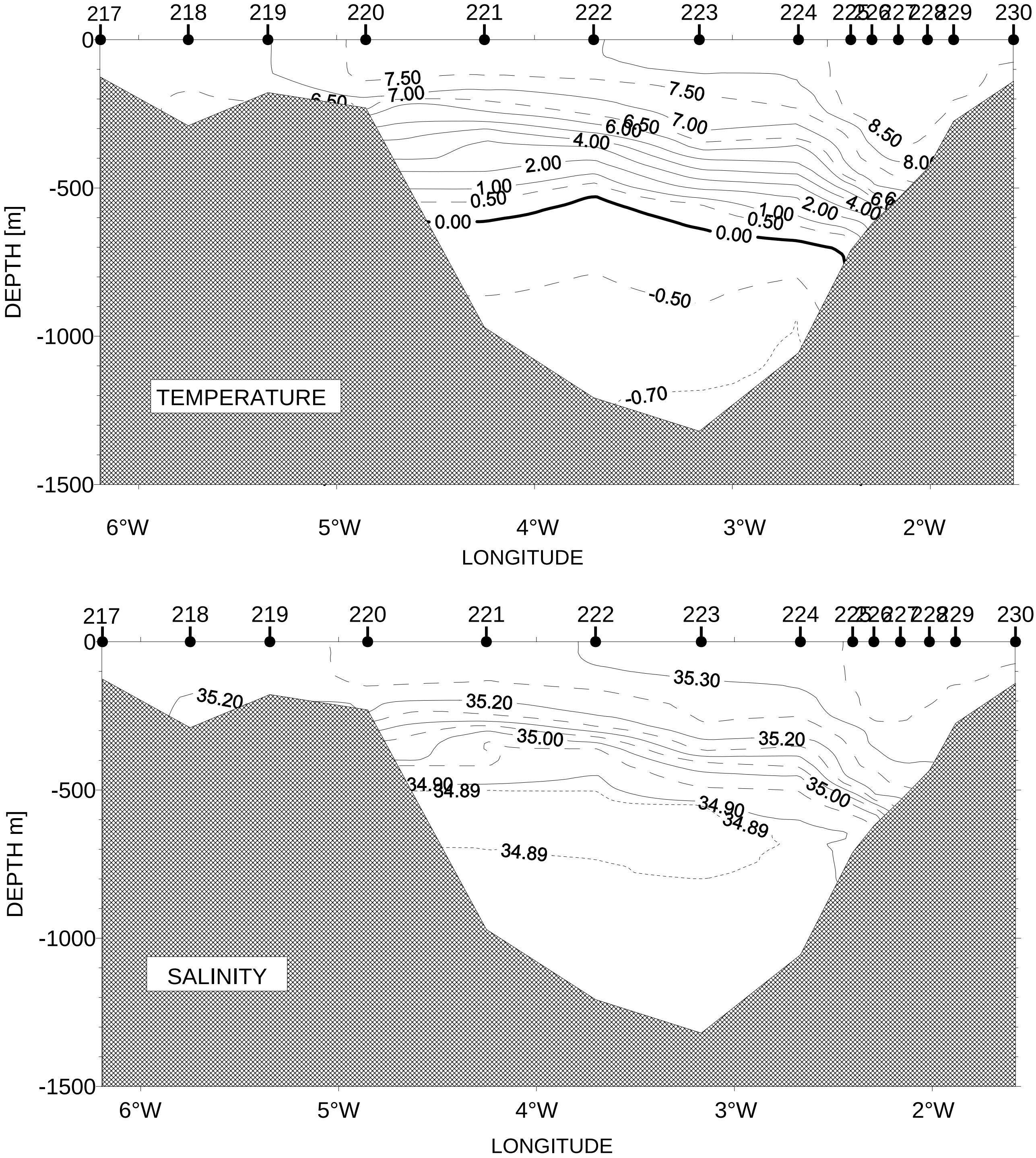


Figure 19. Vertical distribution of temperature (°C) and salinity in a section from the Faroes to Shetland (Nolsø-Flugga). Station numbers at the top of the panels.

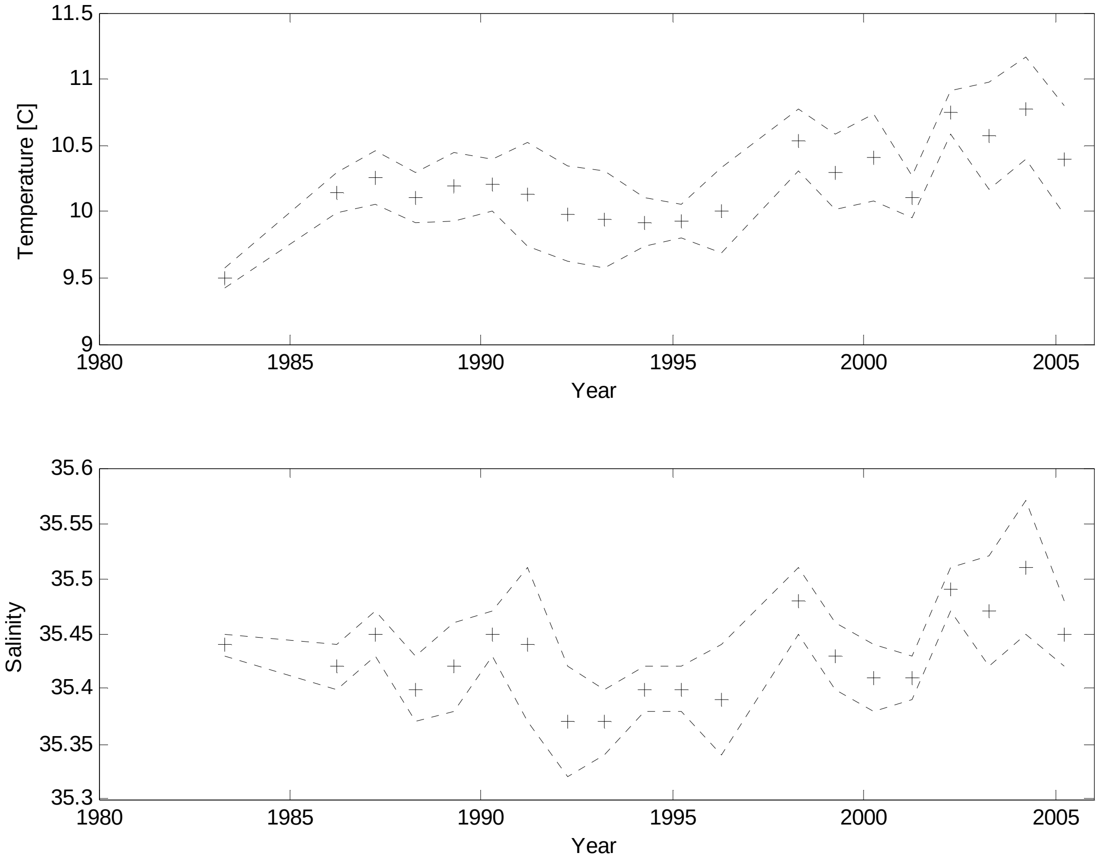


Figure 20. Yearly mean temperature and salinity from 50-600m (crosses) of all stations in a box with bottom depth>600m, west of the Porcupine bank bounded by 52° to 54°N and 16° to 14°W. Dotted lines are drawn at plus-minus one standard deviation of all observations in each box, each year.

Appendix 1. Inter-calibration between R/V Tridens and R/V G. O. Sars

Acoustic inter-calibration between R/V G. O. Sars and R/V Tridens was conducted on 22 March 2005 north of the Porcupine Bank at N 56° 10’ and W 10° 00’. The weather was initially favourable with fresh breeze from southeast, gradually increasing to strong breeze, eventually to southern near gale. The main acoustic feature in the area was a well-defined and almost continuous layer of blue whiting in depths around 400-600 metres.

In the beginning of the inter-calibration the logs were synchronized. The inter-calibration was the run over 44 nautical miles between 07:15-12:35 GMT. For the first 5 nm, both vessels were cruising northward at parallel courses, with G. O. Sars on the port side of Tridens at a distance of 0.1-0.2 nm. The vessels then turned 90 ° and continued towards east. Bottom depth was in the excess of 1000 m and false bottom echoes were minimal nuisance.

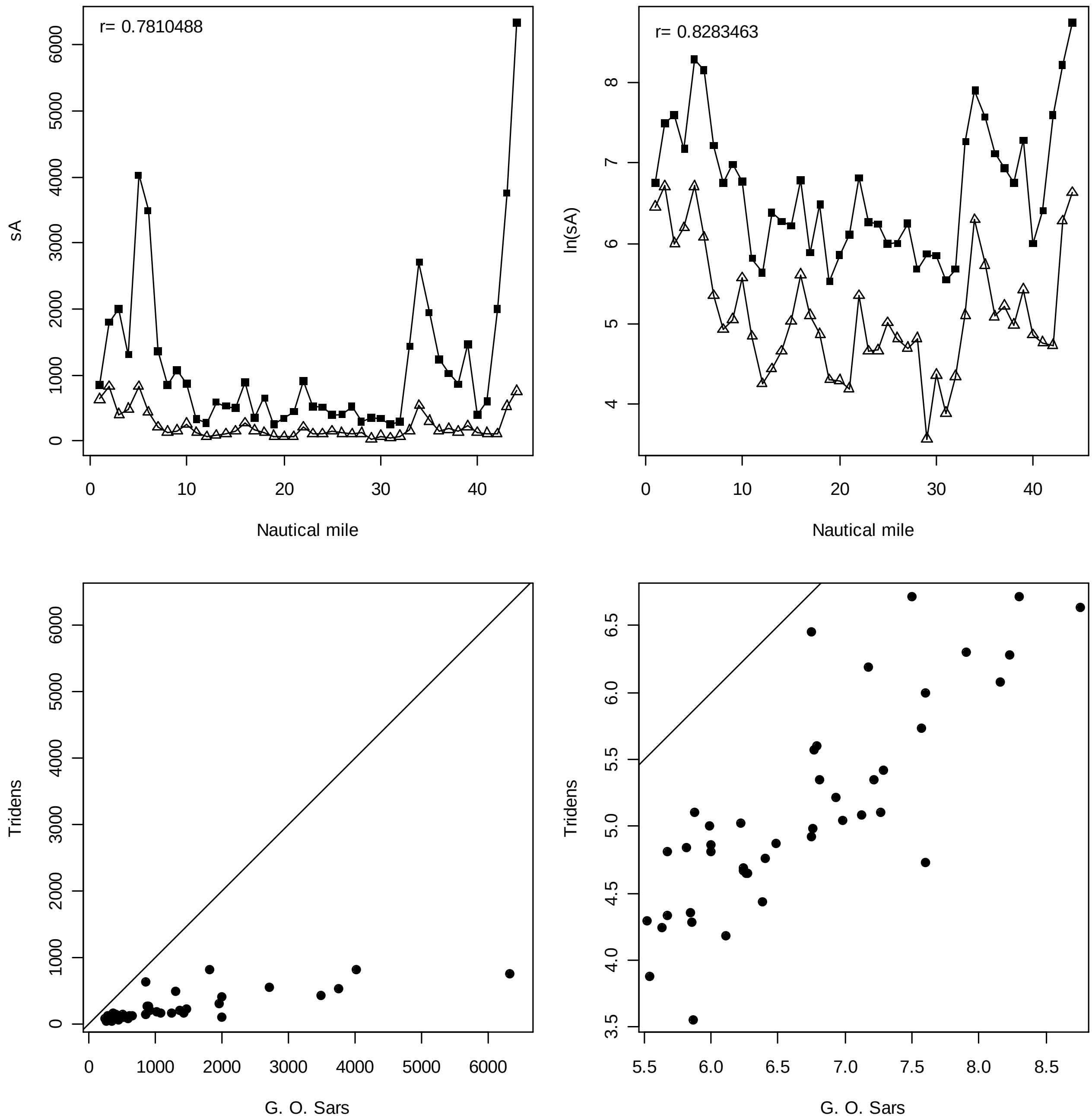


Figure 1. Comparison of blue whiting acoustic densities recorded by Tridens (triangles) and G. O. Sars (squares). The lower panels give same data as scatterplots.

Table 1. Regression models for the full data (n=44). Two regression models are estimated for both data, one with and without intercept (i.e. regression through the origin). The null hypothesis for t-tests on slope is that the slope is not different from one. Acoustic densities from G. O. Sars are taken as the independent variable and those from Tridens as the dependent variable.

Data	Parameter	Estimate	Std. Error	t value	Pr(>|t|)	R^2 (%)
All	Intercept	76.0	27.9	2.72	0.009	61.0
	Slope	0.134	0.017	52.4	<0.001	
All	Slope	0.165	0.013	65.3	<0.001	79.5
All, log scale	Intercept	-0.032	0.543	-0.06	0.953	68.6
	Slope	0.772	0.081	2.82	0.007	
All, log scale	Slope	0.768	0.010	23.9	<0.001	99.3

In the data analysis we focused on acoustic densities (s_A, m^2/nm^2) allocated to blue whiting. On both vessels the routine procedures were followed for scrutinizing the data. Figure 1 shows that there is a tendency for Tridens to record much lower acoustic densities than G. O. Sars. After the inter-calibration, a bad cable connection was found with Tridens and it was therefore concluded that this had probably caused the lower values. A closer look at the raw data files also raised the possibility of a non-continuous error. A pattern of appearance of single target positions in the transverse section of the beam was evidently present from 19 to 21 March.

After the acoustic inter-calibration, pelagic trawls of the two vessels were compared. Both vessels towed to the same direction at a distance of about half nautical mile apart. Tridens towed at depth of 450 m for 30 minutes and caught 3000 kg of blue whiting. G. O. Sars towed for 20 minutes at depths of 450-500 metres and caught 150 kg of blue whiting (first cod-end towed for 10 min: 70 kg; second cod-end towed for 10 min: 80 kg). As seen in Fig. 2, blue whiting in the pooled catch of G. O. Sars were slightly smaller in length (mean ±sd: 26.5 ±2.1 cm) than the blue whiting in the catch of Tridens (26.8±2.4cm). The difference was statistically insignificant (p=0.115). The same is true if the catch by G. O. Sars is split to sub-samples (first cod-end: 26.6±2.1 cm; second cod-end: 26.4±2.1 cm). Thus, despite the large difference in catch weight, the two trawls appear to display only a minor difference in size selectivity.

Mean age for the sample taken by G. O. Sars is 4.6 ±1.0 years (mean ±sd), whereas that for Tridens is 3.6 ±1.1 years, a highly significant difference (p<0.001) — despite the smaller length of fish aged on G. O. Sars, 26.5 ±2.6 cm, compared with 27.1 ±2.1 cm on Tridens. Linear model AGE~VESSEL+LENGTH shows a large vessel factor (-1.2 years) that is statistically significant (p<0.001). The age readings between the vessels are thus not consistent.

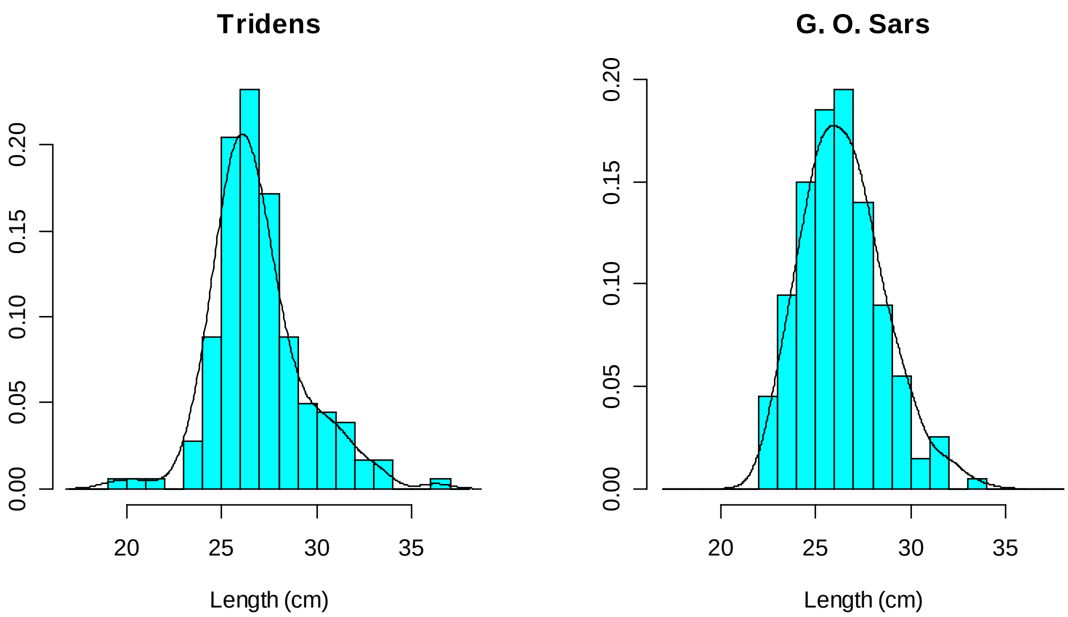


Figure 2. Length distributions from the trawls hauls by Tridens and G. O. Sars. Smoothing is obtained by normal kernel density estimates. G. O. Sars: n=200; Tridens: n=181

Appendix 2. Inter-calibration between R/V Celtic Explorer and R/V G. O. Sars

Acoustic inter-calibration between R/V G. O. Sars and R/V Celtic Explorer was conducted on 2-3 April southwest of the Rosemary Bank at N 59° 00' and W 11° 10'. The weather was rather favourable with fresh-strong breeze from southwest. The main acoustic feature in the area was a well-defined, almost continuous layer of blue whiting that varied greatly in density. The blue whiting layers was in depths between 400 and 600 metres.

In the beginning of the inter-calibration the logs were synchronized. The inter-calibration was the run over 29 nautical miles between 20:56-00:57 GMT. For the first 15 nm, both vessels were cruising southwest at parallel courses, with G. O. Sars leading and Celtic Explorer on starboard side at position ~135° at a distance of 0.5-0.6 nm. The vessels then turned 180° and continued back with Celtic Explorer leading. During the southwest course swell caused dropouts and noise in the recordings. Bottom depth was in the excess of 1000 m and false bottom echoes were of little nuisance.

In the data analysis we focused on acoustic densities (s_A, m^2/nm^2) allocated to blue whiting. On both vessels the routine procedures were followed for scrutinizing the data. Figure 1 shows acoustic densities recorded by the two vessels and allocated to blue whiting. These display some obvious discrepancies both in the beginning of the inter-calibration as well as in the very end. Regression model suggest that intercept is not significantly different from zero. Regression forced through the origin has a slope that is significantly smaller than one and rather moderate coefficient of determination (R2). However, visual inspection of both Figure 1 and the actual echograms suggests that the recordings in the beginning and the end of this exercise are not comparable because of spatial heterogeneity in blue whiting density even at small spatial scales. Another set of regressions was therefore run for the subset of data where the most discrepant recordings were omitted (nautical miles 1-5 and 29). Also in this case the data support regression through the origin. The slope is still significantly smaller than one, but the coefficient of determination is much higher. Thus, in this case the pattern suggested is that Celtic Explorer tended to record lower acoustic densities than G. O. Sars. However, as neither vessel consistently recorded the same registrations over the course of the exercise this remains uncertain. Overall, the results may be more of an artefact of the small-scale heterogeneity observed rather than an actual quantifiable difference in vessel performance.

The interpretation of the results must be made with caution. The difference between G. O. Sars and Celtic Explorer is obvious only at high densities, omission of which would leave a cluster of data points not showing any systematic difference (cf. Figure 1). The difference observed for high densities could still be accounted for spatial heterogeneity in density of blue whiting in the area (there is 24-fold difference between miles 3 and 4 for G. O. Sars and 18-fold difference between miles 5 and 6 for Celtic Explorer). The other possibilities are differences in (1) the performance of acoustic equipment, and (2) post-processing of the data. The former possibility seems unlikely, as both vessels are equipped with EK 60 echosounders with drop-keel mounted transducers. While the latter possibility cannot be excluded, it also appears unlikely because scrutinizing well-defined blue whiting aggregations observed during the exercise is easy and no difference was observed at low densities. While the conclusions from this inter-calibration are thus left open, calling for some caution in combining the data. For the purpose of generating a joint estimate the data from the Celtic Explorer can be used without correction.

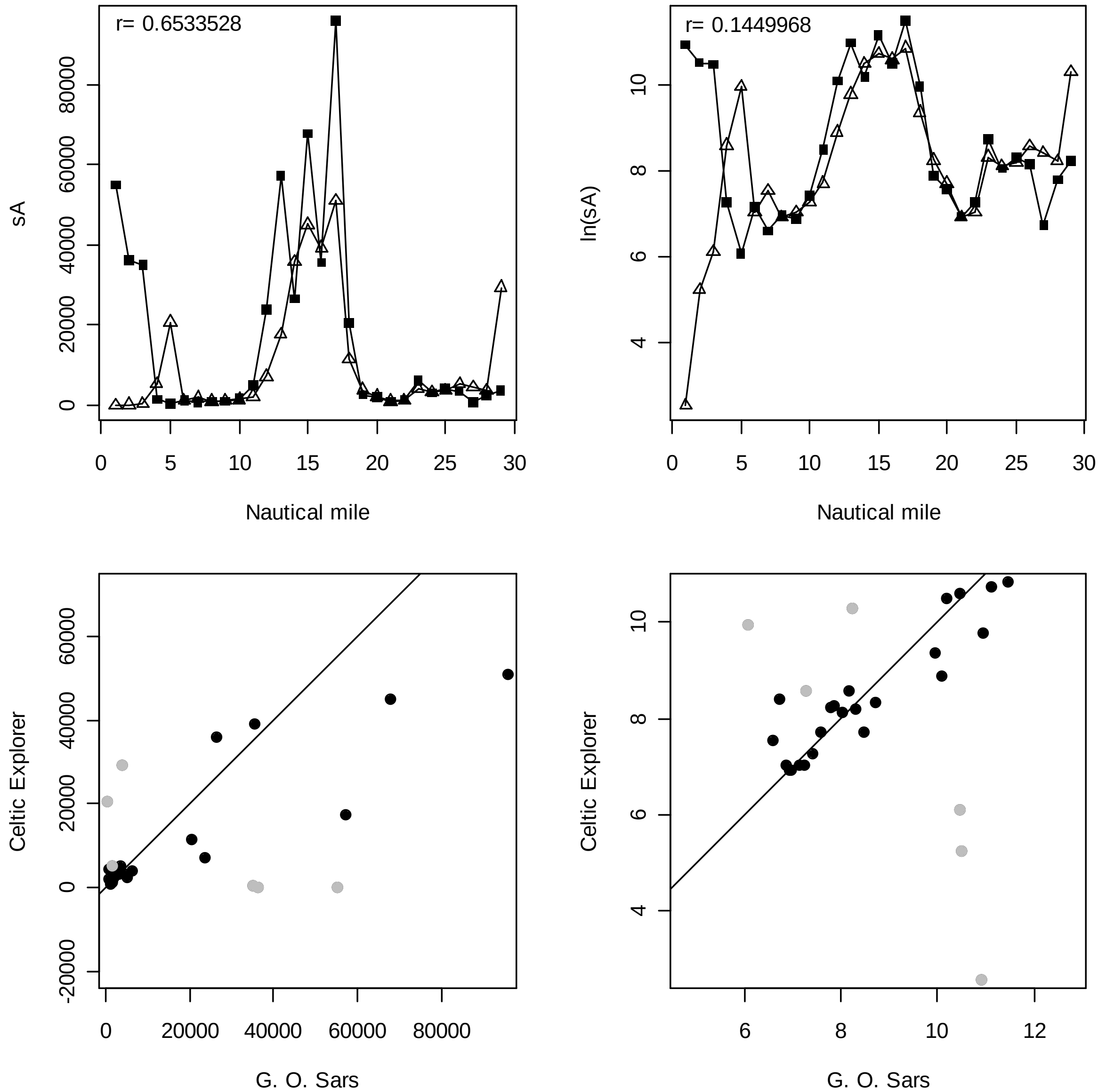


Figure 1. Comparison of blue whiting acoustic densities recorded by Celtic Explorer (triangles) and G. O. Sars (squares). The lower panels give same data as scatterplots. Grey dots correspond to miles 1-5 and 29 that were excluded from some regressions in Table 1. The diagonals are drawn as continuous lines.

Table 1. Regression models for the full data (n=29) and for the subset where the most deviating nautical miles are removed (n=23). Two regression models are estimated for both data, one with and without intercept (i.e. regression through the origin). The null hypothesis for t-tests on slope is that the slope is not different from one. Acoustic densities from G. O. Sars are taken as the independent variable and those from Celtic Explorer as the dependent variable.

Data	Parameter	Estimate	Std. Error	t value	Pr(>|t|)	R^2 (%)
All	Intercept	3794	2606	1.46	0.160	42.7
	Slope	0.392	0.087	6.96	<0.001	
All	Slope	0.465	0.073	7.34	<0.001	59.2
All\{1-5,29}	Intercept	2117	1769	1.20	0.245	80.6
	Slope	0.548	0.060	7.56	<0.001	
All\{1-5,29}	Slope	0.587	0.051	8.12	<0.001	85.8

After the acoustic inter-calibration, pelagic trawls of the two vessels were compared. Both vessels towed to the same direction at a distance of about half nautical mile apart. Celtic Explorer towed at depth of 480-520 m for 5 minutes and caught 3250 kg of blue whiting. G. O. Sars towed for 35 minutes at depths of 440-530 metres and caught 7 kg of blue whiting (first cod-end towed for 16 min: 2.3 kg; second cod-end towed for 19 min: 4.5 kg). In addition to the difference in the size of gear that favoured Celtic Explorer, acoustic observations suggested that Celtic Explorer trawled in an area of higher density of blue whiting than G. O. Sars did.

As seen in Fig. 3, blue whiting in the pooled catch of G. O. Sars were somewhat smaller (mean ±sd length: 27.1±2.2 cm) to the blue whiting in the catch of Celtic Explorer (27.9±2.7cm). The difference was statistically significant (p=0.013). The result is unaltered if the catch by G. O. Sars is split to sub-samples (first cod-end: 26.9±2.2 cm; second cod-end: 27.2±2.3 cm). Larger difference observed now (0.8 cm in favour of Celtic Explorer) as compared to similar comparison in 2004 (0.1 cm in favour of Celtic Explorer) may be related to heterogeneity of blue whiting in the area. The second cod-end of G. O. Sars represents a denser registration, probably more akin to the one fished on by Celtic Explorer, and is also more similar in size. However, given the difference in the size of the gear, it is expected that Celtic Explorer will catch larger fish than G. O. Sars.

Mean age for the sample taken by G. O. Sars is 4.4±0.9 years (mean±sd), whereas that for Celtic Explorer is 5.3±1.6 years, a highly significant difference (p=0.002). To some extent this reflects smaller length of fish aged on G. O. Sars, 26.5±3.0 cm, compared with 28.5±2.1 cm on Celtic Explorer. However, linear model AGE~VESSEL+LENGTH shows a non-negligible vessel factor (0.5 years) that is statistically significant (p=0.007 for all data and p=0.004 when only overlapping length range is considered). The age readings between the vessels are thus less consistent than they were in 2004.

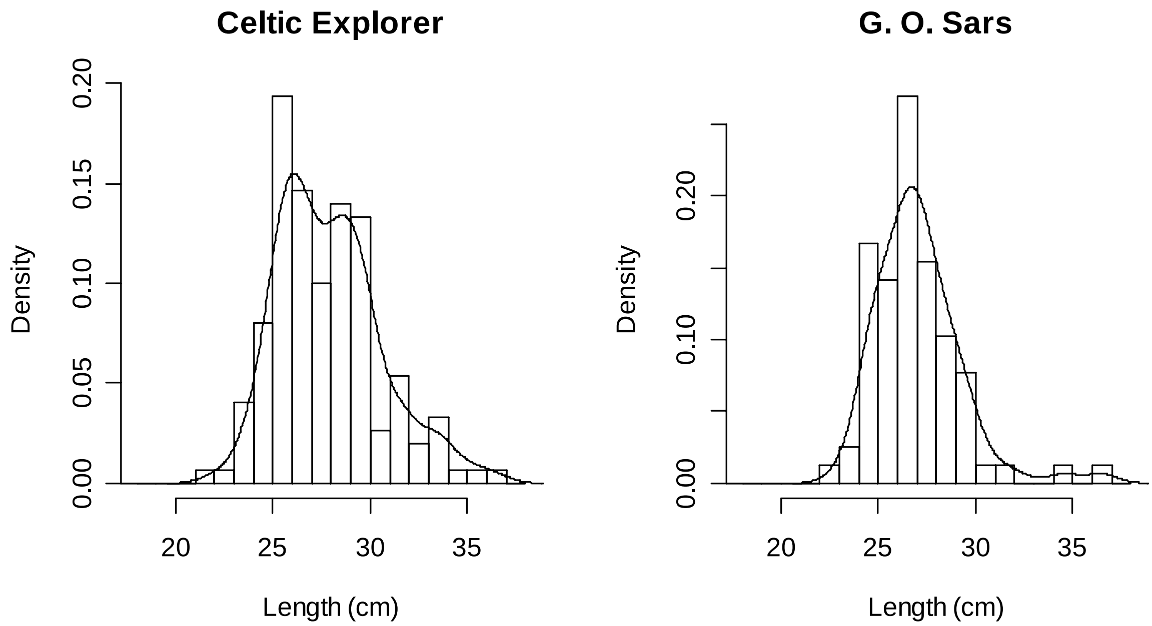


Figure 3. Length distributions from the trawls hauls by Celtic Explorer and G. O. Sars. Smoothing is obtained by normal kernel density estimates. G. O. Sars: n=78; Celtic Explorer: n=150.

Appendix 2. Inter-calibration between R/V Magnus Heinason and R/V G. O. Sars

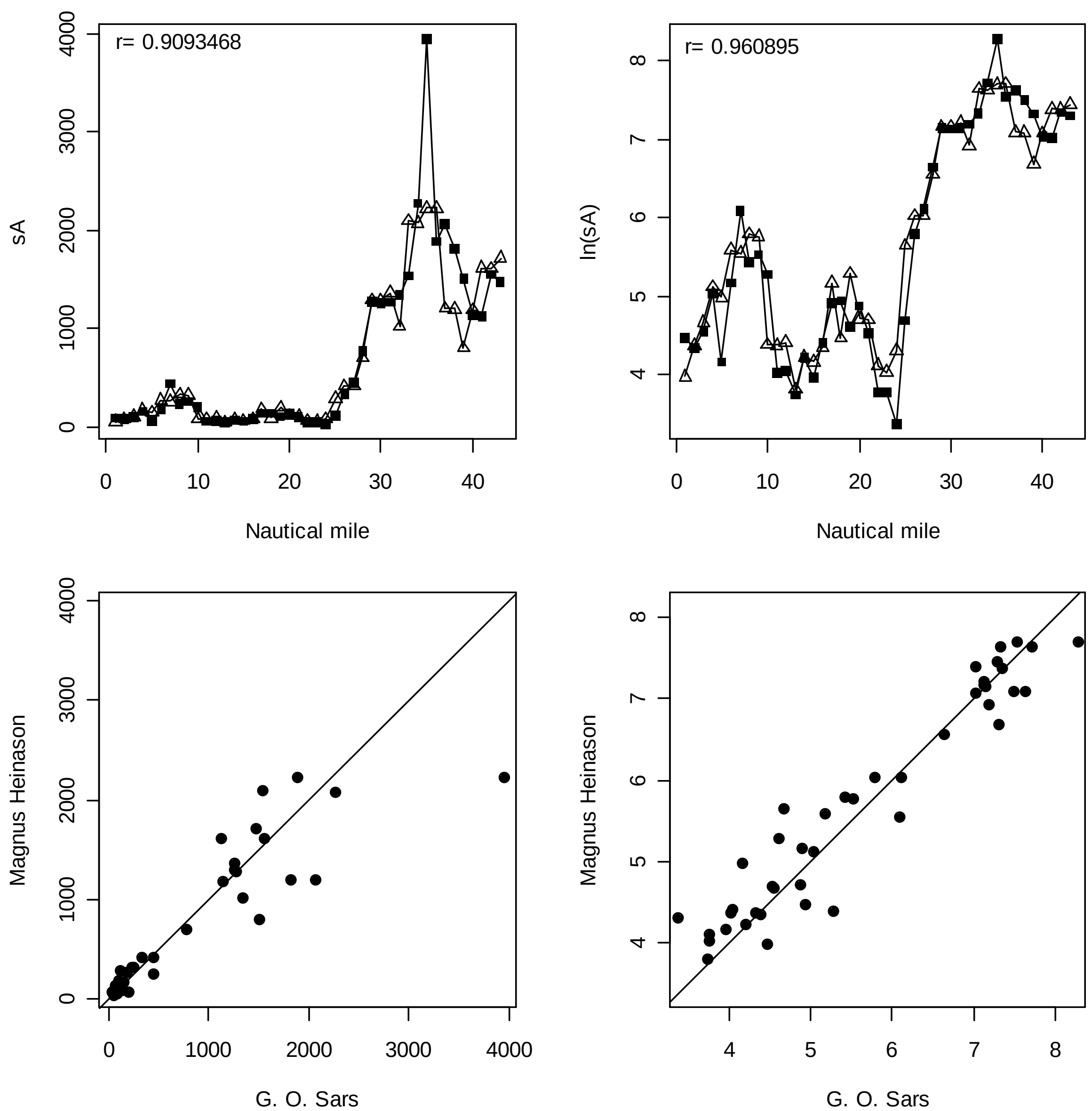
Acoustic inter-calibration between R/V G. O. Sars and R/V Magnus Heinason was conducted on 8 April south of the Faroes at N 60° 30' and W 7° 05'. The weather was not particularly favourable—near gale to gale from northwest—but as the inter-calibration was run from north to south, the acoustic recordings were of decent quality. The main acoustic features in the area were (1) a weak layer of blue whiting in depths between 350 and 450 metres that gradually got stronger closer to the Wyville-Thompson Ridge, (2) a layer of presumed macro-zooplankton immediate below and partly mixed with the blue whiting layer, and (3) mesopelagics, probably predominantly pearlside, in depths between 150 and 250 metres.

The inter-calibration was the run over 43 nautical miles between 09:16-13:51 GMT. Vessels were cruising southwest at parallel courses, with Magnus Heinason leading and G. O. Sars on port side at position ~160° at a distance of about 0.5 nm.

In the data analysis we focused on acoustic densities (s_A, m^2/nm^2) allocated to blue whiting. On both vessels the routine procedures were followed for scrutinizing the data. Figure 1 shows acoustic densities recorded by the two vessels and allocated to blue whiting. These are in good quantitative agreement, with only one nautical mile showing a larger discrepancy. Regression model suggests that intercept is not significantly different from zero. Regression forced through the origin has a slope that is significantly smaller than one and rather high coefficient of determination (R^2). Eliminating the outlier (nautical mile 35), the slope no longer is statistically significantly different from one. These results suggest that combining the acoustic data from these two vessels is unproblematic.

Table 1. Regression models for the full data (n=43) and for the subset where an outlier is removed (n=42). Intercept is estimated in the first regression, whereas regression through the origin is assumed in the latter one. The null hypothesis for t-tests on slope is that the slope is not different from one. Acoustic densities from G. O. Sars are taken as the independent variable and those from Magnus Heinason as the dependent variable.

Data	Parameter	Estimate	Std. Error	t value	Pr(>|t|)	R^2 (%)
All	Intercept	119.0	59.4	2.01	0.052	82.7
	Slope	0.758	0.054	4.47	<0.001	
All	Slope	0.827	0.043	3.99	<0.001	89.7
All\{35}	Intercept	48.8	51.5	0.95	0.349	86.9
	Slope	0.906	0.066	1.70	0.097	
All\{35}	Slope	0.941	0.041	1.43	0.159	92.7



Fiure 1. Comparison of blue whiting acoustic densities recorded by Magnus Heinason (triangles) and G. O. Sars (squares). The lower panels give same data as scatterplots. The diagonals are drawn as continuous lines.

After the acoustic inter-calibration, pelagic trawls of the two vessels were compared. Both vessels towed to the same direction at a distance of about half nautical mile apart. Magnus Heinason towed at depth of 400 m for 60 minutes and caught 700 kg of blue whiting. G. O. Sars towed for 61 minutes at depths of 380-420 metres and caught 155 kg of blue whiting (first cod-end towed for 21 min: 70 kg; second cod-end towed for 20 min: 50 kg; third cod-end towed for 20 min: 35 kg).

As seen in Fig. 3, blue whiting in the pooled catch of G. O. Sars were somewhat larger (mean±sd length: 26.8±2.7 cm) compared to the blue whiting in the catch of Magnus Heinason (26.3±2.1cm). The difference was statistically significant (p=0.015). When the catch by G. O. Sars is analysed by subsamples, only the fish in the first were significantly larger (27.1±2.4 cm) than the fish caught by Magnus Heinason (p=0.004), whereas the difference was qualitatively similar but smaller and insignificant for the second cod-end and third cod-end (respectively 26.6±3.0 cm and 26.7±2.7 cm, corresponding to p=0.387 and p=0.136). This suggests a small difference in selectivity, which might be related to slightly higher towing speed (~0.5 knot) by G. O. Sars.

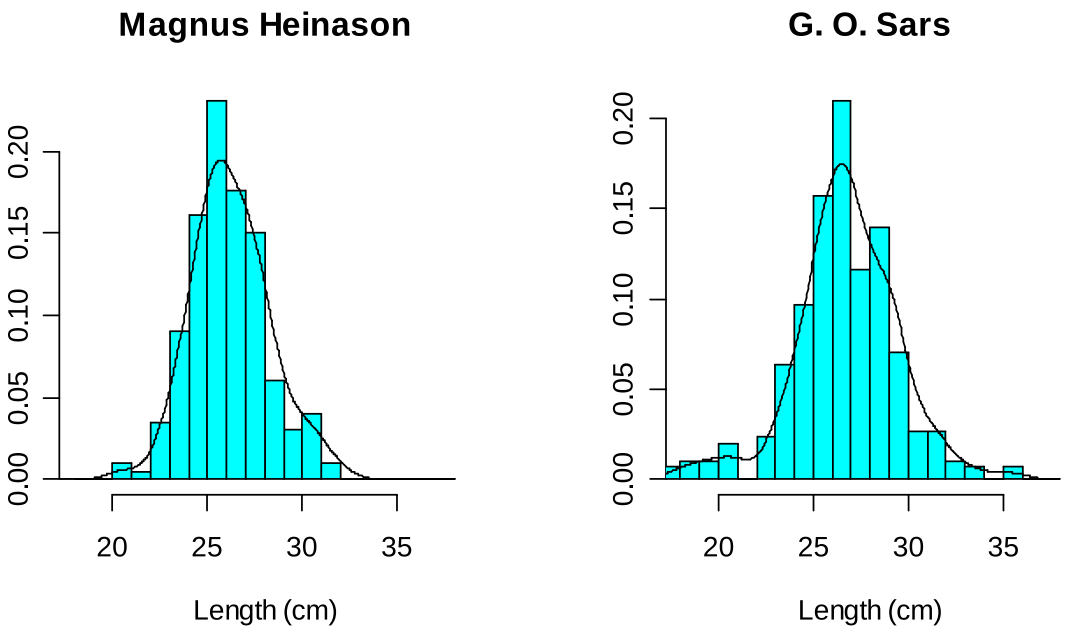


Figure 3. Length distributions from the trawls hauls by Magnus Heinason and G. O. Sars. Smoothing is obtained by normal kernel density estimates. G. O. Sars: n=300; Magnus Heinason: n=199.

Appendix 4. Inter-calibration between R/V Atlantniro and R/V Fridtjof Nansen

The acoustic inter-calibration between “Atlantniro” and “F. Nansen” was conducted on 03 April 2005 on the northern slopes of the Rockall Bank (N58° 22’ and W15° 00’) under very good weather conditions. The “F. Nansen” used the EK60 echosounder and the “Atlantniro” used EK500 echosounder. Standard instrument settings were kept during inter-calibration process (same as during the main survey).

The inter-calibration was run over 50 nautical miles. The ships following side-by-side at distance 0.3 nm and speed was 8.0 knots. The turn has been executed on a back course after first 25 nm and the logs were synchronized. During inter-calibration the depths were mainly between 750 and 1000 m.

The recording during the inter-calibration consisted of scatters of plankton in surface layer, mesopelagic fish (Myctophidae) in depths 100-200 m and blue whiting in depths around 500-550 m (Figure 1). The data were analysed using simple statistical comparisons and regression analysis by depth layers of 100 m. Only depths upper 600 m was analysed. In addition, the data were scrutinized, and the acoustic densities allocated to blue whiting were compared.

Figure 2 shows acoustic densities recorded by the two vessels for the depth layers corresponding to the main selected layers. These display similar overall patterns but considerable differences between individual observations in raw data (in spite of the fact that both ships are absolutely identical – with hull-mounted transducers).

We have decided that regression models fitted on both natural and logarithmic scales show reasonable fits (moderately high R^2) with positive intercepts and slope parameters less than one (Table 1); the deviations from one-to-one relationship are mostly statistically significant. The general pattern suggested by these regressions is that Atlantniro tends to record lower acoustic densities than “Fridtjof Nansen”. But in the scrutinized data this relationship may be reversed.

In our opinion the regressions presented here give a good basis for combining the results of the two vessels.

Figure 1. BI60 echogram obtained onboard r/v “F. Nansen” during the inter-calibration between r/v “F. Nansen” and r/v “Atlantniro”

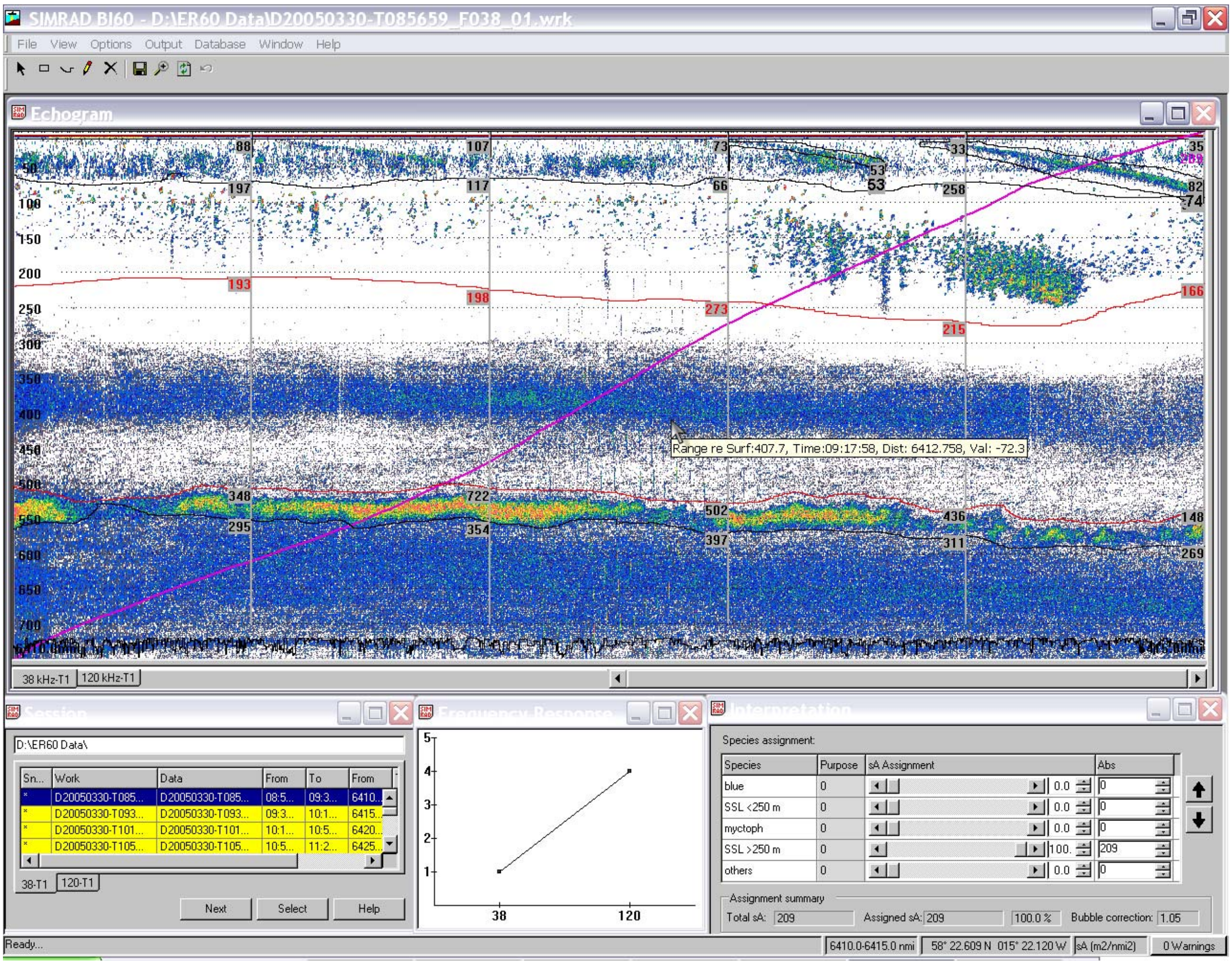


Figure 2. Time series of sA-values from r/v "Atlantniro" and r/v "F. Nansen". Correlation coefficients between the time series are inserted.

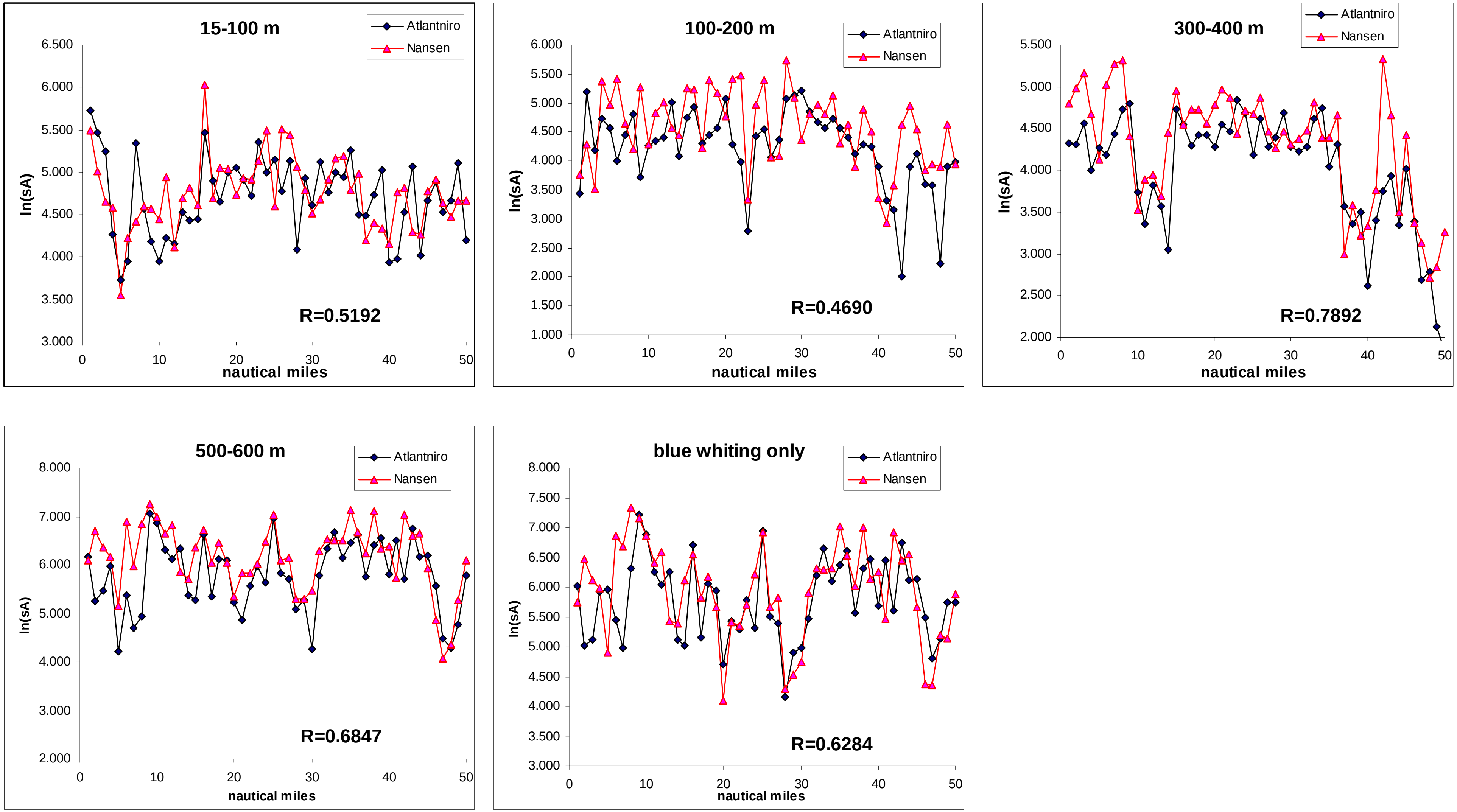


Figure 3. Scatter plots of sA-values from r/v "Atlantniro" and r/v "Fridtjof Nansen"

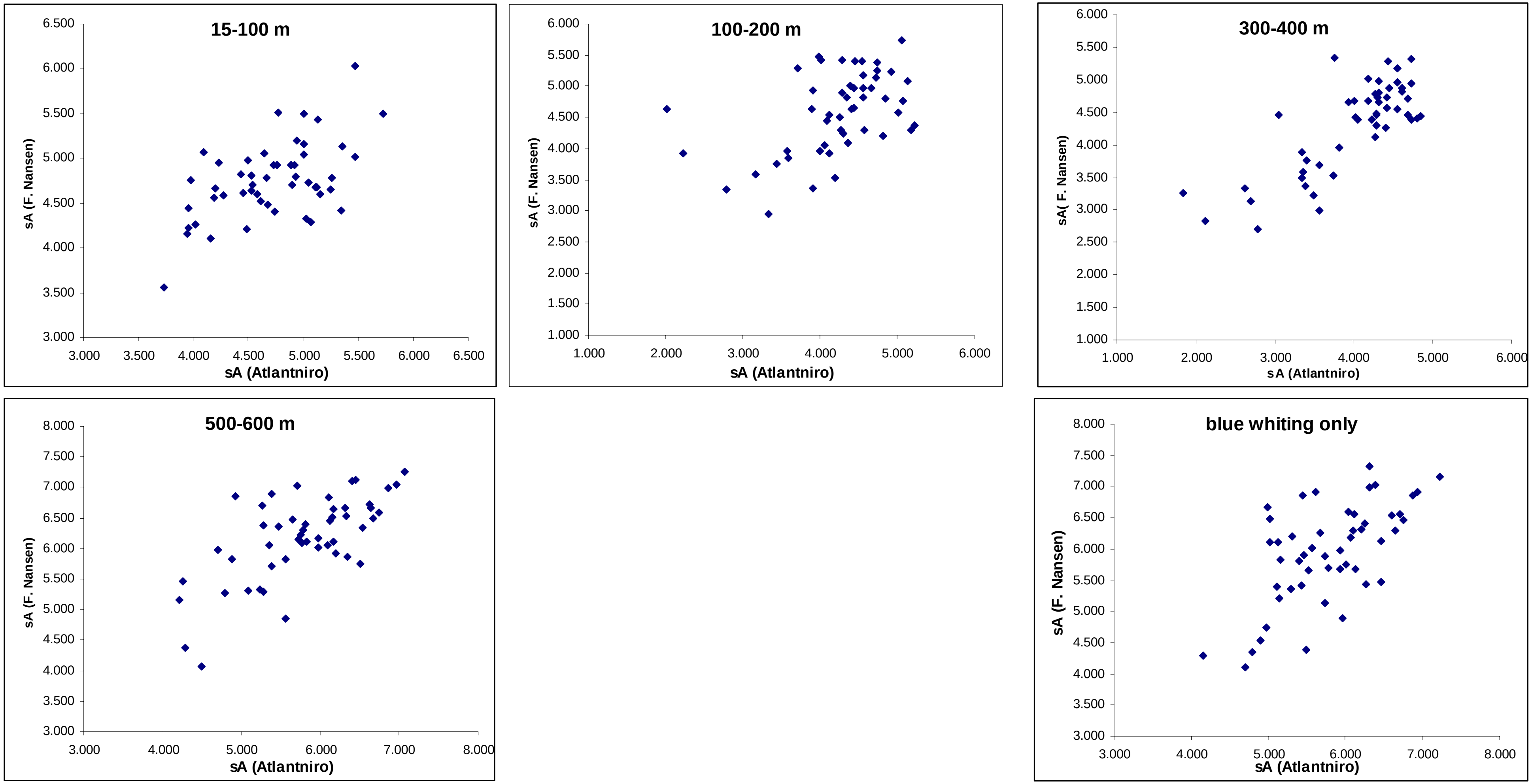


Table 1. Comparison of acoustic estimates between r/v "Atlantniro" and r/v "Fridtjof Nansen". All calculations are based on sA-values that have been transformed to logarithmic scale (base *e*). Logarithms of zeros have been replaced with a small number (-1, corresponding to sA=0.1).
(Values from "Atlantniro" are taken as the independent variable and those from "Fridtjof Nansen" as the dependent variable).

	15-100		100-200		200-300		300-400		400-500		500-600		600-700		15-500			
	Ch 1		Ch 2		Ch 3		Ch 4		Ch 5		Ch 6		Ch 7				bw only	
nm	Atlantniro	Nansen	Atlantniro	Nansen	Atlantniro	Nansen	Atlantniro	Nansen	Atlantniro	Nansen	Atlantniro	Nansen	Atlantniro	Nansen	Atlantniro	Nansen	Atlantniro	Nansen
1	5.724	5.493	3.442	3.761	0.711	1.099	4.318	4.804	4.159	3.989	6.163	6.103	5.339	5.170	6.858	6.812	6.010	5.747
2	5.466	5.017	5.188	4.290	1.477	0.000	4.313	4.977	3.977	3.892	5.264	6.711	5.424	5.438	6.602	7.122	5.027	6.477
3	5.250	4.654	4.192	3.526	1.232	1.386	4.560	5.170	4.356	4.454	5.465	6.363	5.827	5.631	6.502	6.889	5.121	6.113
4	4.269	4.585	4.738	5.380	4.247	2.773	4.006	4.673	4.157	4.585	5.976	6.168	5.157	5.489	6.549	6.905	5.930	5.973
5	3.731	3.555	4.565	4.977	-0.563	5.429	4.273	4.127	4.106	4.489	4.213	5.153	6.146	5.412	5.822	6.223	5.968	4.895
6	3.950	4.220	4.012	5.416	2.048	1.946	4.185	5.017	3.995	4.220	5.378	6.896	5.025	5.485	6.095	7.313	5.449	6.859
7	5.342	4.419	4.438	4.654	1.719	3.258	4.440	5.278	3.899	4.431	4.704	5.976	5.078	6.412	6.288	6.759	4.989	6.678
8	4.577	4.605	4.819	4.205	2.999	2.303	4.724	5.313	3.661	4.754	4.930	6.855	6.237	6.682	6.236	7.269	6.310	7.329
9	4.188	4.564	3.719	5.283	2.514	3.258	4.805	4.407	4.114	4.718	7.069	7.253	5.724	5.075	7.290	7.549	7.217	7.149
10	3.957	4.443	4.273	4.290	3.783	4.883	3.742	3.526	4.162	4.762	6.863	6.980	5.183	5.620	7.079	7.233	6.875	6.864
11	4.231	4.949	4.341	4.828	5.572	5.635	3.352	3.892	4.213	4.745	6.313	6.657	5.167	5.489	6.676	7.097	6.255	6.406
12	4.153	4.111	4.399	5.004	0.767	0.693	3.814	3.951	4.378	4.663	6.109	6.828	5.125	5.638	6.579	7.163	6.041	6.588
13	4.534	4.700	5.010	4.575	0.765	4.290	3.567	3.689	4.272	5.030	6.348	5.861	5.151	5.749	6.826	6.621	6.261	5.437
14	4.433	4.820	4.088	4.454	3.956	1.386	3.053	4.454	4.422	4.779	5.381	5.714	5.271	5.613	6.143	6.576	5.119	5.388
15	4.453	4.615	4.747	5.257	1.075	2.639	4.733	4.949	4.559	4.771	5.273	6.370	5.337	5.521	6.406	7.035	5.014	6.115
16	5.467	6.028	4.931	5.226	1.850	2.773	4.554	4.543	4.004	4.949	6.627	6.721	5.625	5.416	7.155	7.418	6.706	6.552
17	4.904	4.700	4.297	4.234	1.414	0.000	4.301	4.727	4.355	4.369	5.352	6.057	5.177	5.088	6.347	6.682	5.162	5.826
18	4.649	5.050	4.455	5.403	-0.440	0.693	4.424	4.736	3.911	4.043	6.124	6.447	4.839	5.247	6.660	7.073	6.065	6.180
19	5.003	5.037	4.567	5.176	0.532	1.099	4.419	4.564	3.282	4.127	6.085	6.059	5.252	5.771	6.677	6.821	5.934	5.669
20	5.048	4.736	5.078	4.771	0.397	2.944	4.276	4.779	3.531	4.673	5.228	5.338	5.447	5.687	6.411	6.501	4.709	4.098
21	4.921	4.927	4.281	5.425	2.346	1.099	4.549	4.963	4.053	4.477	4.877	5.826	5.462	5.743	6.200	6.841	5.434	5.421
22	4.727	4.920	3.979	5.468	0.503	1.386	4.458	4.868	3.210	3.807	5.566	5.826	5.455	5.677	6.290	6.789	5.295	5.355
23	5.351	5.136	2.785	3.332	0.881	0.693	4.847	4.443	3.762	4.605	5.967	6.023	5.452	5.659	6.669	6.680	5.783	5.704
24	5.003	5.497	4.437	4.963	2.419	0.693	4.687	4.718	3.938	4.290	5.649	6.479	5.382	5.638	6.518	7.109	5.310	6.208
25	5.156	4.605	4.540	5.394	4.188	4.043	4.179	4.673	4.226	4.787	6.968	7.038	5.063	4.745	7.289	7.430	6.934	6.918
26	4.774	5.509	4.055	4.060	1.321	0.000	4.620	4.875	3.348	4.564	5.830	6.107	5.509	5.541	6.472	6.889	5.519	5.667
27	5.136	5.438	4.363	4.094	-0.202	1.099	4.287	4.466	3.655	4.522	5.716	6.140	5.537	5.606	6.498	6.838	5.397	5.816
28	4.088	5.063	5.066	5.746	-0.221	0.000	4.400	4.263	3.407	3.850	5.091	5.308	5.450	5.583	6.199	6.673	4.161	4.297
29	4.928	4.796	5.141	5.088	3.835	2.833	4.692	4.466	4.112	4.234	5.283	5.293	5.331	5.509	6.516	6.458	4.892	4.536
30	4.611	4.522	5.221	4.369	4.238	1.792	4.282	4.304	4.334	4.543	4.263	5.460	5.220	5.568	6.226	6.353	4.977	4.741
31	5.126	4.682	4.850	4.804	1.327	4.304	4.227	4.382	3.968	4.205	5.788	6.293	5.346	5.714	6.612	6.822	5.464	5.895
32	4.762	4.920	4.664	4.970	2.813	0.693	4.289	4.477	3.913	4.369	6.331	6.537	5.328	5.371	6.811	7.037	6.204	6.313
33	5.003	5.159	4.566	4.820	1.325	2.708	4.617	4.820	3.495	3.664	6.675	6.501	4.946	5.075	7.066	7.027	6.648	6.290
34	4.939	5.193	4.722	5.130	1.236	0.000	4.737	4.394	3.895	4.745	6.156	6.503	5.072	5.273	6.788	7.100	6.095	6.304
35	5.259	4.787	4.571	4.304	-0.426	0.000	4.050	4.394	4.737	4.913	6.450	7.124	5.121	5.338	6.997	7.410	6.382	7.024
36	4.498	4.984	4.411	4.625	-1.827	1.099	4.311	4.654	4.733	5.043	6.634	6.673	5.124	5.606	7.022	7.169	6.605	6.532
37	4.484	4.205	4.123	3.912	-0.759	3.932	3.565	2.996	4.773	4.844	5.754	6.230	5.399	5.541	6.429	6.649	5.574	6.022
38	4.741	4.407	4.288	4.890	3.576	-1.000	3.364	3.584	4.738	4.710	6.409	7.102	5.264	5.447	6.844	7.363	6.319	6.998
39	5.023	4.331	4.256	4.500	-3.296	5.820	3.493	3.219	4.358	4.654	6.542	6.347	5.103	5.375	6.935	6.765	6.467	6.132
40	3.940	4.159	3.912	3.367	6.104	4.868	2.620	3.332	4.402	4.905	5.806	6.389	5.278	5.447	6.271	6.746	5.678	6.253
41	3.974	4.762	3.326	2.944	4.358	2.996	3.397	3.761	4.769	4.828	6.501	5.740	5.123	4.942	6.796	6.422	6.458	5.464
42	4.529	4.812	3.159	3.584	1.888	1.609	3.757	5.333	4.877	5.030	5.708	7.026	4.757	5.081	6.383	7.405	5.613	6.922
43	5.067	4.290	2.016	4.625	1.266	1.386	3.939	4.663	4.779	4.078	6.741	6.594	5.200	5.063	7.076	6.976	6.753	6.455
44	4.019	4.263	3.903	4.942	3.066	4.290	3.339	3.497	4.209	4.263	6.168	6.642	4.858	4.905	6.519	6.987	6.118	6.551
45	4.668	4.779	4.118	4.543	1.950	-1.000	4.019	4.419	3.274	3.829	6.199	5.919	4.765	5.037	6.610	6.571	6.136	5.672
46	4.892	4.920	3.592	3.850	2.095	-1.000	3.389	3.367	3.695	4.220	5.561	4.860	4.817	4.949	6.214	6.016	5.497	4.377
47	4.524	4.644	3.572	3.951	-5.205	-1.000	2.691	3.135	3.989	3.871	4.492	4.078	4.889	5.293	5.655	5.656	4.799	4.352
48	4.674	4.477	2.234	3.912	-3.438	-1.000	2.781	2.708	3.981	4.025	4.283	4.369	5.283	5.635	5.555	5.663	5.139	5.201
49	5.107	4.673	3.896	4.625	-2.137	-1.000	2.127	2.833	4.065	3.912	4.783	5.268	5.641	5.106	5.993	6.153	5.738	5.132
50	4.203	4.663	3.993	3.951	-2.727	-1.000	1.836	3.258	3.961	3.689	5.773	6.087	4.874	4.771	6.217	6.498	5.737	5.881
	int.	2.498	int.	2.711	int.	1.377	int.	1.248	int.	2.352	int.	2.395	int.	2.419	int.	1.746	int.	1.572
	slope	0.478	slope	0.444	slope	0.308	slope	0.763	slope	0.513	slope	0.654	slope	0.574	slope	0.779	slope	0.755
	r	0.519	r	0.469	r	0.364	r	0.789	r	0.568	r	0.685	r	0.502	r	0.708	r	0.628
	n	49	n	49	n	49	n	49	n	49	n	49	n	49	n	49	n	49
	p	0.000	p	0.001	p	0.010	p	0.000	p	0.000	p	0.000	p	0.000	p	0.000	p	0.000
min.	3.731	3.555	2.016	2.944	-5.205	-1.000	1.836	2.708	3.210	3.664	4.213	4.078	4.757	4.745	5.555	5.656	4.161	4.098
max.	5.724	6.028	5.221	5.746	6.104	5.820	4.847	5.333	4.877	5.043	7.069	7.253	6.237	6.682	7.290	7.549	7.217	7.329
average	4.709	4.736	4.227	4.601	1.331	1.828	3.988	4.272	4.083	4.459	5.777	6.156	5.272	5.443	6.537	6.825	5.786	5.928
st.dev.	0.471	0.419	0.684	0.651	2.307	1.972	0.706	0.688	0.424	0.383	0.727	0.702	0.310	0.361	0.388	0.431	0.666	0.813
abs.dev.		0.027		0.374		0.497		0.284		0.376		0.379		0.171		0.288		0.142
rel.dev.		0.6%		9%		37%		7.1%		9.2%		6.6%		3.3%		4.4%		2.5%

Annex 3: PGNAPES Survey protocol

ICES Planning Group on Northeast Atlantic Pelagic Ecosystem Surveys

MANUAL FOR ACOUSTIC SURVEYS ON NORWEGIAN SPRING SPAWNING HERRING IN THE NORWEGIAN SEA AND ACOUSTIC SURVEYS ON BLUE WHITING IN EASTERN ATLANTIC

Version 1.0
September 2005

International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

H. C. Andersens Boulevard 44–46 · DK-1553 Copenhagen V · Denmark
Telephone + 45 33 38 67 00 · Telefax +45 33 93 42 15
www.ices.dk · info@ices.dk

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1 Transducer and calibration

The standard frequency used for the Norwegian Sea and Blue whiting surveys is 38 kHz. In order of preference, it is advisable to mount the transducer in a dropped keel, a towed body or on the hull of the vessel. Steps should be taken to ensure that the flight of the towed body is stable and level, this should ideally be achieved with the aid of a motion sensor.

Calibration of the transducer should be conducted at least once during the survey. Calibration procedures are described in the Simrad EK500 manual, the EK60 manual and Foote *et al.* (1987). Ideally, the procedure as described in the Simrad manual should be followed with certain exceptions (see below). Minimum target range for the calibration of a split beam 38 kHz echosounder is 10 metres, although greater distances are recommended (about 20 m), because centering of the target below the transducer is facilitated if the target is suspended at a greater depth. An average integrated value for the sphere, taken when it is centrally located, should be taken as the measured NASC. The calculations should be then performed a number of times (two or three) in an iterative procedure such that the values of measured NASC and theoretical NASC should converge, as described in the Simrad manual. A choice is then made as to whether the S_v Transducer gain should be changed, rendering absolute **NASC's**, or alternatively, the S_v Transducer gain can be unaltered and a correction factor applied to the **NASC's**. Only one strategy should be applied during a cruise, such that for example, the latter option is to be employed when calibration is only possible after the cruise has started. If possible, the transducer should be calibrated both at the beginning and the end of the survey; with a mean correction factor applied to the data. If a new calibration differs less than 0.2 dB, the sounder system functions acceptably. If it differs more than 0.2 dB, the system should be thoroughly inspected.

There are a number of parameters that require knowledge of the speed of sound in water. It is therefore recommended that appropriate apparatus be used to determine the temperature and salinity of the water so that sound speed can be calculated (see MacLennan & Simmonds 1992 for equations) and entered into the EK500 or the EK60.

It is evident that all versions of the EK500 up to and including version 5.* do not take account of the receiver delay in the calculation of target range (see Fernandes & Simmonds 1996). This is particularly important when calibrating at short range (10 m) as it can lead to a systematic underestimate of biomass of 3%. The correct range to the target should therefore be applied in calibration (see below). The equivalent two way beam angle (ψ) should also be corrected for sound speed according to Bodholt (1999).

A number of calibration parameters and results (tabulated in Table 1) should be included as a minimum in the survey report. Some of these parameters are not included in the Simrad operator manual and are defined as follows.

Table 1. Calibration report sheet

Calibration report	
Frequency (kHz)	
Transducer serial no.	
Vessel	
Date	
Place	
Latitude	
Longitude	
Bottom depth (m)	
Temperature (°C)	
Salinity (ppt)	
Speed of sound (m.s-1)	
TS of sphere (dB)	
Pulse duration (s)	
Equivalent 2-way beam angle (dB)	
Receiver delay (s)	
Default S_v transducer gain	

Iteration no.	1	2	3
Time			
Range to half peak amplitude (m)			
Range to sphere (m)			
Theoretical NASC (m2.nmile-2)			
Measured NASC (m2.nmile-2)			

Calibated S_v transducer gain			
DeltaG = New gain - Old gain			
Correction factor for pre-calibration NASC's on EK			
Correction factor for pre-calibration S_v's			

Default TS transducer gain			
Iteration no.	1	2	3
Time			
Measured TS			
Calibrated TS gain			

Receiver delay = $\mathbf{t_{del}}$ This is related to the echosounder bandwidth (due to the band pass filters), to the transducer bandwidth, and to a lesser extent to the standard target and the pulse duration which may affect the peak value. Target, bandwidth and pulse duration specific values for the Simrad EK400 are given in Foote *et al.* (1987, their Table 1). Values for the EK500 are not available, but Simrad recommend using 3 sample distances (10 cm) in wide bandwidth (3 kHz). This equates to a value of $\mathbf{t_{del}}$ of 0.00039 s at 38 kHz.

The calibrating procedure for the Simrad EK and ER 60 are clearly laid out in the users manual and should be followed as such. The determination of sound speed for the ER 60 is calculated automatically in the environment dialogue box, when the parameters of temperature and salinity are inputted from CTD casts. During the actual calibration itself, Simrad recommend no less than 150 data points from the standard target sphere per frequency. Outlying points above or below the target reference TS value can be removed as required to further refine the accuracy of the result before final acceptance of the data set. Updating the beam pattern is the final stage of the calibration procedure and will result in an alteration of the beam pattern parameters. The Simrad ER 60 allows the beam pattern to be adjusted by loading the results of previous calibrations if erroneous values are entered by mistake. A calibration report for all survey calibrations should be included in the final cruise report.

Range to half peak amplitude = $\mathbf{r_m}$ This is the measured range between the start of the transmit pulse and the point on the leading edge of the echo at which the amplitude has risen to half the peak value (m). This is usually determined by experience with the readings from an oscilloscope display. For example, for a 38.1 mm tungsten carbide standard target insonified at 38 kHz at a colour threshold setting of -70 dB (S_v colour min.), it is measured as from the start of the transmit pulse to the leading edge of the pink colour on the target sphere echo.

Range to sphere = $\mathbf{r_{sph}}$ may then be calculated from:

$$\mathbf{r_{sph} = r_m - ((c \times t_{del})/2)}$$

Correction factor for pre-calibration NASC's on EK500 = K = 1/(2^(DeltaG/10))

Where:

DeltaG = Calibrated S_v Transducer Gain – Default S_v Transducer gain

Correction factor for pre-calibration S_v's on EK = $10(\log_{10}(s_A$ correction factor))

A calibration record should be available during the survey and should be included in the survey report.

2 Instrument settings during the survey

For most settings the default values from the manufacturer may be used, or alternatively the operator can choose his own settings depending on the circumstances. It is recommended that the same settings be used for the printer every year in order to facilitate comparison of echograms.

There are a number of settings that are set during calibration that have a direct influence on the fundamental operation for echo-integration and target strength measurement and therefore affect logged data. Once set according to the particular transducer, these should **NOT** be changed during the survey. These important settings dealt with in the following paragraghs.

Table 2. Important calibration and survey settings, which should not be changed during the survey. Those marked * indicate settings that are specific to the transducer / transceiver.

/TRANSCEIVER MENU/TRANSCEIVER-1 MENU/BANDWIDTH
/TRANSCEIVER MENU/TRANSCEIVER-1 MENU/PULSE LENGTH
/TRANSCEIVER MENU/TRANSCEIVER-1 MENU/MAX. POWER*
/TRANSCEIVER MENU/TRANSCEIVER-1 MENU/2-WAY BEAM ANGLE*
/TRANSCEIVER MENU/TRANSCEIVER-1 MENU/SV TRANSD. GAIN*
/TRANSCEIVER MENU/TRANSCEIVER-1 MENU/TS TRANSD. GAIN*
/TRANSCEIVER MENU/TRANSCEIVER-1 MENU/ABSORPTION COEF.*
/OPERATION MENU/TRANSMIT POWER
/BOTTOM DETECTION MENU/BOTTOM DETECTION-1 MENU/MINIMUM DEPTH
/BOTTOM DETECTION MENU/BOTTOM DETECTION-1 MENU/MAXIMUM DEPTH
/BOTTOM DETECTION MENU/BOTTOM DETECTION-1 MENU/MINIMUM LEVEL
/SOUND-VELOCITY MENU/PROFILE TYPE
/SOUND-VELOCITY MENU/VELOCITY MIN
/SOUND-VELOCITY MENU/ VELOCITY MAX

In the operation menu it is recommended to use as short a regular ping interval as possible. It is recommended to use the standard maximum setting.

Table 3 lists those settings, which are important for target strength measurements. It should be noted however, that the transducer depth setting might affect the calibration if the range to target is read form the echo sounder.

Table 3. Settings affecting tracking or locating objects within the beam. Those marked * indicate settings that are specific to the transducer / transceiver.

/TRANSCEIVER MENU/TRANSCEIVER-1 MENU/TRANSDUCER DEPTH
/TRANSCEIVER MENU/TRANSCEIVER-1 MENU/ANGLE SENS.ALONG*
/TRANSCEIVER MENU/TRANSCEIVER-1 MENU/ANGLE SENS.ATHW.*
/TRANSCEIVER MENU/TRANSCEIVER-1 MENU/ALONGSHIP OFFSET*
/TRANSCEIVER MENU/TRANSCEIVER-1 MENU/ATHW.SHIP OFFSET*
/TS DETECTION MENU/TS DETECTION-1 MENU/MIN. VALUE
/TS DETECTION MENU/TS DETECTION-1 MENU/MIN. ECHO LENGTH
/TS DETECTION MENU/TS DETECTION-1 MENU/MAX. ECHO LENGTH
/TS DETECTION MENU/TS DETECTION-1 MENU/MAX. GAIN COMP.
/TS DETECTION MENU/TS DETECTION-1 MENU/MAX. PHASE DEV.
/MOTION SENSOR MENU/HEAVE
/MOTION SENSOR MENU/ROLL
/MOTION SENSOR MENU/PITCH
/MOTION SENSOR MENU/TD-1 ATH. OFFSET
/MOTION SENSOR MENU/TD-1 ALO. OFFSET
/MOTION SENSOR MENU/TD-2 ATH. OFFSET
/MOTION SENSOR MENU/TD-2 ALO. OFFSET
/MOTION SENSOR MENU/TD-3 ATH. OFFSET
/MOTION SENSOR MENU/TD-3 ALO. OFFSET

2.1 For the Simrad EK500

Tranducer settings for the ES38B (Simrad 38kHZ splitbeam transducer):

/TRANSCEIVER MENU/Transceiver-1 Menu/Mode=Active
/TRANSCEIVER MENU/Transceiver-1 Menu/Transducer Type=ES38B
/TRANSCEIVER MENU/Transceiver-1 Menu/Transd. Sequence=Off
/TRANSCEIVER MENU/Transceiver-1 Menu/Transducer Depth=0.00 m
/TRANSCEIVER MENU/Transceiver-1 Menu/Absorption Coef.=10 dBkm
/TRANSCEIVER MENU/Transceiver-1 Menu/Pulse Length=Medium
/TRANSCEIVER MENU/Transceiver-1 Menu/Bandwidth=Wide
/TRANSCEIVER MENU/Transceiver-1 Menu/Max. Power=2000 W
/TRANSCEIVER MENU/Transceiver-1 Menu/2-Way Beam Angle=-20.8 dB**
/TRANSCEIVER MENU/Transceiver-1 Menu/Sv Transd. Gain=25.89 dB *
/TRANSCEIVER MENU/Transceiver-1 Menu/TS Transd. Gain=26.15 dB*
/TRANSCEIVER MENU/Transceiver-1 Menu/Angle Sens.Along=21.9*
/TRANSCEIVER MENU/Transceiver-1 Menu/Angle Sens.Athw.=21.9*
/TRANSCEIVER MENU/Transceiver-1 Menu/3 dB Beamw.Along=7.1 dg*
/TRANSCEIVER MENU/Transceiver-1 Menu/3 dB Beamw.Athw.=6.9 dg*
/TRANSCEIVER MENU/Transceiver-1 Menu/Alongship Offset=0.08 dg*
/TRANSCEIVER MENU/Transceiver-1 Menu/Athw.ship Offset=0.06 dg*
/TRANSCEIVER MENU/Transceiver-1 Menu/Frequency=38 kHz

Settings marked * are obtained by calibration of the transducer
Settings marked ** are obtained from the factory transducer calibration sheet

ETHERNET COM. MENU settings
For the Blue whiting spawning survey it is recommended to use these settings providing the postprocessing system with data with maximum resolution at 750m depth, because the blue whiting layer extends below 500 m.

/ETHERNET COM. MENU/Echogram-1 Menu/Range=750 m
/ETHERNET COM. MENU/Echogram-1 Menu/Range Start=0 m
/ETHERNET COM. MENU/Echogram-1 Menu/Auto Range=Off
/ETHERNET COM. MENU/Echogram-1 Menu/Bottom Range=10 m
/ETHERNET COM. MENU/Echogram-1 Menu/Bot. Range Start=10 m
/ETHERNET COM. MENU/Echogram-1 Menu/No. of Main Val.=700
/ETHERNET COM. MENU/Echogram-1 Menu/No. of Bot. Val.=14
/ETHERNET COM. MENU/Echogram-1 Menu/TVG=20 log R

Logging of data down to 500 m is sufficient for the May survey, when the BW layer and HE layer usually is above 500m.

Pelagic/Surface mode:
For the echogram paper record it is necessary to define integration layers, to ease the interpretation of the echogram. It is possible to have 9 layers + 1 superlayer. The 9 layers will provide integration results in the depth channel defined in the layer menu, and the superlayer will provide integration results for the depth channel defined in the layer menu for the super layer. The super layer is always defined as the whole echogram, e.g. integration in the depth channel ranging from 7m to 500m.

At bottom depths well below the echograms logged (500m or 750 m) it is recommended to go from Surface mode to Pelagic mode to the achieve the maximum possible ping rate. The bottom detection values have to be changed as well, to avoid false bottom detections on the echogram.

Layer menu Surface mode:
/LAYER MENU/Super Layer=10
/LAYER MENU/Layer-1 Menu/Type=Surface
/LAYER MENU/Layer-1 Menu/Range=93.0 m
/LAYER MENU/Layer-1 Menu/Range Start=7.0 m
/LAYER MENU/Layer-1 Menu/Margin=1.0 m
/LAYER MENU/Layer-1 Menu/Sv Threshold=-70 dB
/LAYER MENU/Layer-1 Menu/No. of Sublayers=1
/LAYER MENU/Layer-2 Menu/Type=Surface
/LAYER MENU/Layer-2 Menu/Range=50.0 m
/LAYER MENU/Layer-2 Menu/Range Start=100.0 m
/LAYER MENU/Layer-2 Menu/Margin=1.0 m
/LAYER MENU/Layer-2 Menu/Sv Threshold=-70 dB
/LAYER MENU/Layer-2 Menu/No. of Sublayers=1
/LAYER MENU/Layer-3 Menu/Type=Surface
/LAYER MENU/Layer-3 Menu/Range=50.0 m
/LAYER MENU/Layer-3 Menu/Range Start=150.0 m
/LAYER MENU/Layer-3 Menu/Margin=1.0 m
/LAYER MENU/Layer-3 Menu/Sv Threshold=-70 dB
/LAYER MENU/Layer-3 Menu/No. of Sublayers=1
/LAYER MENU/Layer-4 Menu/Type=Surface
/LAYER MENU/Layer-4 Menu/Range=50.0 m
/LAYER MENU/Layer-4 Menu/Range Start=200.0 m
/LAYER MENU/Layer-4 Menu/Margin=1.0 m
/LAYER MENU/Layer-4 Menu/Sv Threshold=-70 dB
/LAYER MENU/Layer-4 Menu/No. of Sublayers=1
/LAYER MENU/Layer-5 Menu/Type=Surface
/LAYER MENU/Layer-5 Menu/Range=50.0 m
/LAYER MENU/Layer-5 Menu/Range Start=250.0 m
/LAYER MENU/Layer-5 Menu/Margin=1.0 m
/LAYER MENU/Layer-5 Menu/Sv Threshold=-70 dB
/LAYER MENU/Layer-5 Menu/No. of Sublayers=1
/LAYER MENU/Layer-6 Menu/Type=Surface
/LAYER MENU/Layer-6 Menu/Range=50.0 m
/LAYER MENU/Layer-6 Menu/Range Start=300.0 m
/LAYER MENU/Layer-6 Menu/Margin=1.0 m
/LAYER MENU/Layer-6 Menu/Sv Threshold=-70 dB
/LAYER MENU/Layer-6 Menu/No. of Sublayers=1
/LAYER MENU/Layer-7 Menu/Type=Surface
/LAYER MENU/Layer-7 Menu/Range=50.0 m
/LAYER MENU/Layer-7 Menu/Range Start=350.0 m
/LAYER MENU/Layer-7 Menu/Margin=1.0 m
/LAYER MENU/Layer-7 Menu/Sv Threshold=-70 dB
/LAYER MENU/Layer-7 Menu/No. of Sublayers=1
/LAYER MENU/Layer-8 Menu/Type=Surface

/LAYER MENU/Layer-8 Menu/Range=50.0 m
/LAYER MENU/Layer-8 Menu/Range Start=400.0 m
/LAYER MENU/Layer-8 Menu/Margin=1.0 m
/LAYER MENU/Layer-8 Menu/Sv Threshold=-70 dB
/LAYER MENU/Layer-8 Menu/No. of Sublayers=1
/LAYER MENU/Layer-9 Menu/Type=Surface
/LAYER MENU/Layer-9 Menu/Range=50.0 m
/LAYER MENU/Layer-9 Menu/Range Start=450.0 m
/LAYER MENU/Layer-9 Menu/Margin=1.0 m
/LAYER MENU/Layer-9 Menu/Sv Threshold=-70 dB
/LAYER MENU/Layer-9 Menu/No. of Sublayers=1
/LAYER MENU/Layer-10 Menu/Type=Surface
/LAYER MENU/Layer-10 Menu/Range=493.0 m
/LAYER MENU/Layer-10 Menu/Range Start=7.0 m
/LAYER MENU/Layer-10 Menu/Margin=1.0 m
/LAYER MENU/Layer-10 Menu/Sv Threshold=-70 dB
/LAYER MENU/Layer-10 Menu/No. of Sublayers=1

Bottom detection menu surface mode:
/BOTTOM DETECTION MENU/Bottom Detection-1 Menu/Minimum Depth=7 m
/BOTTOM DETECTION MENU/Bottom Detection-1 Menu/Maximum Depth=1000 m
/BOTTOM DETECTION MENU/Bottom Detection-1 Menu/Min. Depth Alarm=10 m
/BOTTOM DETECTION MENU/Bottom Detection-1 Menu/Max. Depth Alarm=1154 m
/BOTTOM DETECTION MENU/Bottom Detection-1 Menu/Bottom Lost Al.=On
/BOTTOM DETECTION MENU/Bottom Detection-1 Menu/Minimum Level=-50 dB

Layer menu Pelagic mode:
/LAYER MENU/Super Layer=10
/LAYER MENU/Layer-1 Menu/Type=Pelagic
/LAYER MENU/Layer-1 Menu/Range=93.0 m
/LAYER MENU/Layer-1 Menu/Range Start=7.0 m
/LAYER MENU/Layer-1 Menu/Margin=1.0 m
/LAYER MENU/Layer-1 Menu/Sv Threshold=-70 dB
/LAYER MENU/Layer-1 Menu/No. of Sublayers=1
/LAYER MENU/Layer-2 Menu/Type=Pelagic
/LAYER MENU/Layer-2 Menu/Range=50.0 m
/LAYER MENU/Layer-2 Menu/Range Start=100.0 m
/LAYER MENU/Layer-2 Menu/Margin=1.0 m
/LAYER MENU/Layer-2 Menu/Sv Threshold=-70 dB
/LAYER MENU/Layer-2 Menu/No. of Sublayers=1
/LAYER MENU/Layer-3 Menu/Type=Pelagic
/LAYER MENU/Layer-3 Menu/Range=50.0 m
/LAYER MENU/Layer-3 Menu/Range Start=150.0 m
/LAYER MENU/Layer-3 Menu/Margin=1.0 m
/LAYER MENU/Layer-3 Menu/Sv Threshold=-70 dB
/LAYER MENU/Layer-3 Menu/No. of Sublayers=1
/LAYER MENU/Layer-4 Menu/Type=Pelagic
/LAYER MENU/Layer-4 Menu/Range=50.0 m
/LAYER MENU/Layer-4 Menu/Range Start=200.0 m

/LAYER MENU/Layer-4 Menu/Margin=1.0 m
/LAYER MENU/Layer-4 Menu/Sv Threshold=-70 dB
/LAYER MENU/Layer-4 Menu/No. of Sublayers=1
/LAYER MENU/Layer-5 Menu/Type=Pelagic
/LAYER MENU/Layer-5 Menu/Range=50.0 m
/LAYER MENU/Layer-5 Menu/Range Start=250.0 m
/LAYER MENU/Layer-5 Menu/Margin=1.0 m
/LAYER MENU/Layer-5 Menu/Sv Threshold=-70 dB
/LAYER MENU/Layer-5 Menu/No. of Sublayers=1
/LAYER MENU/Layer-6 Menu/Type=Pelagic
/LAYER MENU/Layer-6 Menu/Range=50.0 m
/LAYER MENU/Layer-6 Menu/Range Start=300.0 m
/LAYER MENU/Layer-6 Menu/Margin=1.0 m
/LAYER MENU/Layer-6 Menu/Sv Threshold=-70 dB
/LAYER MENU/Layer-6 Menu/No. of Sublayers=1
/LAYER MENU/Layer-7 Menu/Type=Pelagic
/LAYER MENU/Layer-7 Menu/Range=50.0 m
/LAYER MENU/Layer-7 Menu/Range Start=350.0 m
/LAYER MENU/Layer-7 Menu/Margin=1.0 m
/LAYER MENU/Layer-7 Menu/Sv Threshold=-70 dB
/LAYER MENU/Layer-7 Menu/No. of Sublayers=1
/LAYER MENU/Layer-8 Menu/Type=Pelagic
/LAYER MENU/Layer-8 Menu/Range=50.0 m
/LAYER MENU/Layer-8 Menu/Range Start=400.0 m
/LAYER MENU/Layer-8 Menu/Margin=1.0 m
/LAYER MENU/Layer-8 Menu/Sv Threshold=-70 dB
/LAYER MENU/Layer-8 Menu/No. of Sublayers=1
/LAYER MENU/Layer-9 Menu/Type=Pelagic
/LAYER MENU/Layer-9 Menu/Range=50.0 m
/LAYER MENU/Layer-9 Menu/Range Start=450.0 m
/LAYER MENU/Layer-9 Menu/Margin=1.0 m
/LAYER MENU/Layer-9 Menu/Sv Threshold=-70 dB
/LAYER MENU/Layer-9 Menu/No. of Sublayers=1
/LAYER MENU/Layer-10 Menu/Type=Pelagic
/LAYER MENU/Layer-10 Menu/Range=493.0 m
/LAYER MENU/Layer-10 Menu/Range Start=7.0 m
/LAYER MENU/Layer-10 Menu/Margin=1.0 m
/LAYER MENU/Layer-10 Menu/Sv Threshold=-70 dB
/LAYER MENU/Layer-10 Menu/No. of Sublayers=1

Bottom detection menu pelagic mode:
/BOTTOM DETECTION MENU/Bottom Detection-1 Menu/Minimum Depth=550 m
/BOTTOM DETECTION MENU/Bottom Detection-1 Menu/Maximum Depth=1000 m
/BOTTOM DETECTION MENU/Bottom Detection-1 Menu/Min. Depth Alarm=10 m
/BOTTOM DETECTION MENU/Bottom Detection-1 Menu/Max. Depth Alarm=1154 m
/BOTTOM DETECTION MENU/Bottom Detection-1 Menu/Bottom Lost Al.=On
/BOTTOM DETECTION MENU/Bottom Detection-1 Menu/Minimum Level=-50 dB

It is imperative to change the settings again, before reaching waters with depths within the echogram range, to avoid bottom integration. Monitoring the echogram to avoid false bottom is very important as well.
Changing the ping rate by either manipulating the Bottom detection menu or directly setting a manual ping rate is the method to avoid integration of false bottom.

Printer settings:
/PRINTER MENU/Printer-2 Menu/Model Type=Deskjet
/PRINTER MENU/Printer-2 Menu/Navig. Interval=200
/PRINTER MENU/Printer-2 Menu/Event Marker=On
/PRINTER MENU/Printer-2 Menu/Annotation=On
/PRINTER MENU/Printer-2 Menu/Naut.Mile Marker=On
/PRINTER MENU/Printer-2 Menu/TS Distribution=1
/PRINTER MENU/Printer-2 Menu/Integr. Tables=1
/PRINTER MENU/Printer-2 Menu/Echogram Speed=1:1
/PRINTER MENU/Printer-2 Menu/Echogram=1
/PRINTER MENU/Printer-2 Menu/Echogram-1 Menu/Transd. Number=1
/PRINTER MENU/Printer-2 Menu/Echogram-1 Menu/Range=500 m
/PRINTER MENU/Printer-2 Menu/Echogram-1 Menu/Range Start=0 m
/PRINTER MENU/Printer-2 Menu/Echogram-1 Menu/Auto Range=Off
/PRINTER MENU/Printer-2 Menu/Echogram-1 Menu/Bottom Range=5 m
/PRINTER MENU/Printer-2 Menu/Echogram-1 Menu/Bot. Range Start=4 m
/PRINTER MENU/Printer-2 Menu/Echogram-1 Menu/Bot. Range Pres.=Off
/PRINTER MENU/Printer-2 Menu/Echogram-1 Menu/Sub. Bottom Gain=1.0 dB/m
/PRINTER MENU/Printer-2 Menu/Echogram-1 Menu/Presentation=Contour
/PRINTER MENU/Printer-2 Menu/Echogram-1 Menu/TVG=20 log R
/PRINTER MENU/Printer-2 Menu/Echogram-1 Menu/Scale Lines=10
/PRINTER MENU/Printer-2 Menu/Echogram-1 Menu/Bot. Det. Line=1
/PRINTER MENU/Printer-2 Menu/Echogram-1 Menu/Trawl Lines=Off
/PRINTER MENU/Printer-2 Menu/Echogram-1 Menu/Layer Lines=On
/PRINTER MENU/Printer-2 Menu/Echogram-1 Menu/Integration Line=10000
/PRINTER MENU/Printer-2 Menu/Echogram-1 Menu/TS Colour Min.=-50 dB
/PRINTER MENU/Printer-2 Menu/Echogram-1 Menu/Sv Colour Min.=-70 dB

The examples above are valid for the May survey where the echogram depth is set to 500. The depth values and the layers have to be changed to suitable values when integrating at 750m.

2.2 For the Simrad EK60

The following steps should be checked:

<u>Settings in header menu:</u>

Install

/Transceiver

1. Check if all frequency channels appear in green text. If not, choose correct transducer in “transducer/selection”.

/Navigation

1. Select serial port of GPS device. If nothing present or other, check “port management” in Install – port control.
2. Select serial port of speed information (probably GPS)
3. Select distance calculation method (probably from speed). This box is also used to set the starting number of the overall distance of the survey.

/Environment

1. Set the temperature and salinity of the calibration site

Output à file

1. Directory: enter data recording directory
2. Raw data/file size: decide on the length of individual datafiles (based on distance or file length)

Operation à normal

2. Mode: active
3. Set pulse duration, sample interval bandwidt combination. This pulse duration should be equal to the one used in the calibration file.
4. Choose power which to use
5. Set depth of transducer from surface level

Operation à ping control

Choose a ping interval which does not give an error or warning.

<u>Input of calibration data</u>

After completing the above steps you should now be able to view correct echograms of the installed frequencies.
Right click on the single echo window which opens the single target detection dialog. Then click “calibration”. In the calibration window, open the calibration file made during calibration. Click “update beam data” to upload calibration data into the echosounder.

The echosounder should the be ready for use.

3 Survey design

Transects are spaced at a maximum distance of 60 nautical miles and minimum 30 nautical miles. Two aspects should be considered in choosing the direction of the transects. Transects should preferably run perpendicular to the greatest gradients in fish density, which are often related to gradients in bottom topography and hydrography. This means that transects will normally run perpendicular to the coast. The second aspect considers the direction in which the fish are migrating. If there is evidence of rapid displacement of the fish throughout the area, it is advisable to run the transects parallel to the direction of the migration. This survey design will minimise the bias caused by migration.

Ship’s speed during the survey is typically 10-12 knots. At higher speeds, problems are encountered with engine noise or propellor cavitation. These problems, however, depend on the vessel. In rough weather, the ship’s speed may be reduced in order to avoid problems with air bubbles under the ship, although this problem is alleviated by the use of a dropped keel.

If species identification depends on recognition of schools on the echogram warnings should be given that schools disperse during darkness, some of the herring may rise to the surface and get above the transducer and therefore will not be recorded. It is recommended – if time permits during the survey – to study the diurnal behaviour of fish schools, in order to determine at what time during the 24hr period the fish may not be available to the echosounder and take this into account.

4 Species allocation of acoustic records

The scrutinizing is based on combination of visual clues in the echograms, information from single echoes, dissappearance of echoes when chnging lower integration threshold, trawl catches, and possibly comparing echoes from different frequencies. This is an expert process prone to errors and subject to a large degree of subjectivity. Often it is useful to look observations over some tens of miles at time, as some continuity that facilitates scrutinizing can usually be expected.

During blue whiting spawning stock survey, the echoes are usually allocated to the following categories:

- blue whiting
- plankton (including krill)
- mesopelagic fish
- demersal fish (including saithe even when pelagic)
- other (may be split to argentines, horse mackerel, mackerel, when feasible)

4.1 Using the EK500 printer output and/or post processing systems

Scrutiny of the echo recordings may be done by measuring the increment of the integrator line on the printed paper output of the echogram. This is a simple and efficient way of scrutinising if one deals with single species schools and if there are no problems with bottom integration. Post processing systems may then be used as backup. More generally, computer based post-processing systems such as the Simrad BI500 or Sonardata Echoview systems are currently being used for scrutinising. The printer output is mostly used as a visual backup.

It is recommended that one depth-range is used for the whole area in the printer output and on post-processing systems. This will ensure that similar echo traces from all parts of the survey area will have the same appearance and hence are visually more comparable.

4.2 Using EK and ER 60 with Echoview

Acoustic data is collected directly through the EK or ER 60 units using pre-arranged survey settings, such as those used for the international spring survey for blue whiting.
It is important to collect and store all data in an ordered systematic approach so as to ease the transfer of data between participating countries. Commonly, acoustic data from the EK or ER systems is recorded onto the hard-drive of the PC used as processing unit. Simultanously data can be logged via a continuous Ethernet connection as “EK5” files to a receiving server on the vessel with either BI500 or Echoview® Echolog software. The RAW-files on the ER/EK60 hard drive is used as a backup in the event of data loss. In

addition, it is good practice to make a further hard copy back up of all data files on DVD-disks or removable external harddisks

Sonar Data's Echoview® Echolog 'live viewer' module can be used to display echograms during data collection to allow the scientists to scroll through echograms noting the locations and depths of fish shoals. It is good practice to keep a paper record of the time spent on and off the cruise track, fishing and hydrographic stations as well as any other general observations. As this can be useful when scrutinising the data.

The RAW-files can be directly scrutinized with the BI60-software, although some overview facilities are lacking or directly be displayed and processed with the Echoview® software.

Commonly acoustic data is backed up every 24 hrs, this will allow for the scrutinising of the previous days work. Species allocation should be coded in a way so as to be recognised by all participating countries in an agreed format. Depth layers, ESDU and other survey parameters can be applied to echoview files when post processing to allow the flow of common data sets between participating countries.

4.3 Allocation to classified schools

In the Norwegian Sea and eastern Atlantic covered by the survey, most of the herring occur in well-defined schools, often of a characteristic shape as pillar-shaped large dense schools or as layers of very small and dense school at the surface. The population of blue whiting in the Norwegian Sea occur during daylight hours as a disperce layer between 200 and 400 meters depth. During night light hours the blue whiting mix with herring the upper layer/survey layer.

Spawning aggregations of blue whiting often occur in large distinct schools. Generally, such schools are found at a depth of 450m (+/- 100m). The density of spawning blue whiting aggregations often makes identification relatively easy due to the large, dense, well-defined monospecific schools that occur. Diurnal migration is observed during the spawning season with schools migrating through a vertical range of approximately 150m. Post spawning individuals often form lower density aggregations that appear more dispersed, at or around the same water depth. Care should be taken when trying to scrutinise echograms where mixed species occur in single layers.

4.4 Use of trawl Information

The allocation of echo-traces to species is governed by the results of trawl hauls. In many cases these are considered together with observations from the netsonde/fisheye and the echogram during the haul. In some cases it is not possible to assign schools (echo traces) to species directly e.g. where the haul contains a mixture of species and no clear differentiation can be made between the observed schools. In such situations the integral is assigned to a species mixture category according to the trawl results. This is defined as percentage by number or weight taking into account the correct conversion to scattering length; post processing software is then used to apply weights and lengths. There are two main problems with using trawl data to define "acoustic" mixtures:

- Different species are known to have different catchabilities, so the exact proportions in the trawl are unlikely to be an exact sample of the true mixture. For instance herring are likely to be faster swimmers than blue whiting.
- Herring or blue whiting are often found in a mixture with pearlside, which are mostly lost through the meshes. This may also occur with other small fish. In this case the exact proportions are unavailable and the operator must make an informed guess.

4.5 Thresholding to filter out plankton

The following procedure is kept to on board the Norwegian and European vessel:

The main principle has been to use as little treshhold as possible at any time, but experience show that for herring down to approx 50 meters about -60db is suitable... However, this applies only at normal plankton concentrations. At extremely high levels, like experienced near the coast in the southern parts of this survey, we went all the way down to -54 db in order to remove the plankton. Testing the effect of such tresholding by using schollboxes and assessing the effect of the increased treshold show that we loose only small amounts of herring in these cases given the school is close to the surface, i.e. within the upper 50 meters.

Herring layer, approx upper 50 meter.
When starting a new 5 mile, first a layer is entered which defines the lower depth of the vertical herring distribution. This depth is found by looking for herring schools as discrete jumps in the integrator line and include the lowest school. We then set the treshold at a level where all the plankton is removed. This is done by varying the treshold and looking for changes in the coloring of the upper level. Herring schools will often appear as very tiny red dots, size only a few pixels, hardly visible. Note that this treshhold applies only for the upper channel, down to approx 50 meters. A note is made of the NASC when the correct treshold is found. This value is noted and is given to herring after the treshold has been reduced again to -85 db. The treshold is lowered again to -85 db, herring is given the noted value and the rest, up to 100 % is given to plankton.

Lower layers
In the western part of the survey area, herring may be encountered in deeper layers. Schools can be isolated in boxes.

The procedure for this depth is similar as for the upper layer: The treshold is reduced until the plankton disappears from the screen, normally till about -69db, sometimes as low as -66db. That NASC is kept for blue whiting and mesopelagic fishes. Normally 20-30 percent is given to mesopelagics and the rest to blue whiting, depending on the ration in the nearest trawlhauls. The rest, up to 100 % is then given to plankton.

During blue whiting spawning stock surveys, plankton can filtered out using –82 dB as the refence threshold level below which all increase in backscattering is assumed to come from targets of no interest. When increasing the threshold, one expects plankton and mesopelagics to disappear, usually around –69/66/63 dB, unless these are very dense. As a rough rule of thumb, if one has a registration that contains blue whiting and that does not coincide with dense plankton/mesopelagics registrations, proportion of sA that remains when threshold is increased to –66 dB can allocated to blue whiting. This is adjusted downwards if there is a reason to think that registrations are infested by non-blue whiting echoes, especially in deeper layers where echoes get cluttered. If small blue whiting is present, a lower thrershold can be appropriate.

4.6 Use of other frequencies

The echosounder frequency routinely used is 38 kHz. However, data may be collected at 18, 120 and 200 kHz. In some cases these can be used as an aid to identify marks to species. For instance, herring and mackerel may have different target strengths at different frequencies. Mackerel is believed to backscatter more strongly at 200 kHz than at 38 kHz, whilst for herring the reverse is the case. In the absence of good observations of such relationships, this approach should be used with caution.

4.7 Use of single target TS distribution data

The SIMRAD EK500 or EK60 used with a split-beam transducer allows the collection of TS values for all single targets detected in the beam. A TS distribution can then be produced for each EDSU. In some situations there may be two species present in an area with substantially different TS values, and this could be used to determine the species allocation. Again, this data must be used with caution. There are doubts about the precision of the TS detection algorithm, particularly in older firmware releases. By definition, single targets are unlikely to be detected from fish in schools. As schools are often the main subject for herring acoustic surveys, TS data may be unrepresentative for the population. However, where the survey encounters diffuse mixtures, there may be value in such data.

During blue whiting spawning stock surveys, TS distribution is often useful in separating blue whiting from mesopelagics in the upper layers. If blue whiting is present, one usually expects to see a prominent peak somewhere around –35 dB.

4.8 Allocation to mixed layers or mixed schools

Sometimes herring occur mixed with other species in aggregations of smaller schools. In this case, species allocation is based on the composition of trawl catches. Those schools are separated from other fish using the standard scrutinising procedures (see above) and the allocation of the proportion of herring or blue whiting and other fish is done afterwards on the basis of catch composition. Trawl catches within each stratum (or statistical rectangle) are combined to give an average species, stock, age and length composition of the clupeid fraction of the catch.
This procedure is normally not applied during the PGNAPES surveys but can be used if nessesary.

4.9 Other clues

Blue whiting usually shows an avoidance reaction towards a CTD sonde lowered through blue whiting layer. This is often a useful clue to see if blue whiting is present in the deep scattering layer where other targets do not show such behaviour. However, currents pushing the sonde far away from the echosounder's beam may also result in lack of visible reaction. One may also see reactions towards changes in vessel operation.

5 Biological sampling

5.1 Trawling

Proper species allocation of the acoustic records is not possible if no trawl information is available. The general rule is to make as many trawl hauls as possible, especially if echo traces are visible on the echosounder after a blank period. If surface schools are known to occur in the area it is often advisable to take occasional surface trawls even in the absence of any significant marks.

The principal objective is to obtain a sample from the school or the layer that appears as an echo trace on the sounder. The type of trawling gear used is not important as long as it is suitable to catch a representative sample of the target-school or layer.

Information about the most important dimensions of the trawls used should be included in the survey report from each of the participating vessels. Details to be recorded and reported are shown in appendix 1.

During trawling it is important to take note of the traces on the echosounder and the netsonde in order to judge if the target-school entered the net or if some other traces contaminates the sample. It is recommended that notes be made on the appearance and behaviour of fish in the net during every haul. If a target is missed during a haul, the catch composition should not be used for species allocation.

5.2 Biological sampling procedure

These procedures describe the work which is carried out on board fishing vessels when the catch is being sampled for scientific purposes. The procedures can also be used when fishing is conducted from platforms other than research vessels, e.g., commercial fishing vessels.

The ***Condition*** and ***Quality*** of the catch should be recorded by the person in charge of the biological sampling in consultation with the officer in charge or the fishing master.

Condition: Inspecting the gear when it comes back on deck.

Quality: Observe how the fishing was carried out and how the gear performed.

Condition	
Condition of the gear after the haul is finished	**Code**
Not inspected	blank
No damage or minor damage of the gear, nothing of consequence to selection and catch.	1
Gear is damaged. Some fish may have escaped the codend.	2
Trawl has long gashes, or large pieces of net are missing, codend intact. Codend torn, very little catch. Codend torned, very little catch. Gear completely destroyed or lost	3

Quality	
Indicates to what degree the catch represents the quantity of fish in the area, judged according to the manner in which the gear was used and the behaviour of the gear.	**Code**
Not observed	blank
The trawl has been set at a predetermined position, the trawl sensors have shown that the registrated schools have been hit.	1
The trawl has been set at a predetermined position; trawl sensors show problems with the gear, e.g. faulty door distance, or other indications of malfunction.	2
The trawl has been aimed at an acoustic registration; trawl sensors show problems with the traw, it has not been fishing properly due to technical problems, or the catch is not representative due to large quantities of corals, jellyfish or mud.	3

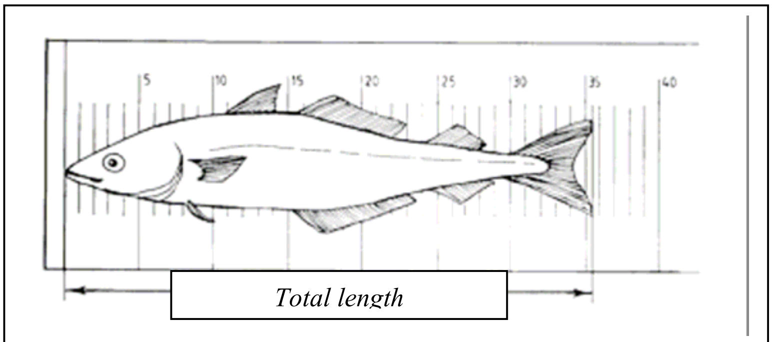
When the catch is on deck, the following procedures should be followed. If the catch contains specimens which differ significantly from the main catch, e.g., by size or low abundance, these may be set aside from the total catch, before handling the remaining catch. Decisions regarding the further handling of the catch depend on whether it is possible to get a representative sample without sorting the total catch. The final sample amount of each species taken out is either the total amount or a subsample of that species in the catch.

The word *sample* should be understood as the number of specimens of a species extracted from a catch for closer examination, e.g., individual sampling.

A representativde length sample should be made for each of the species in the catch (minimum resolution ½ cm).
Length intervals used for selected species:
Herring: ½ cm.
Blue whiting: 1 cm
Other species: 1 cm.

The length measured should be the total length of the fish as shown in figure 1 below, rounding down towards the nearest length interval.

Figure 1. Length measurement of fish



Individual sampling (or biological sampling) is a detailed study of each specimen where various biological parameters are measured; length, weight, sex, maturity and age.

The number of fish in the catch is found by dividing the total weight of this group by the mean weight. The mean weight is found by taking the weight of the sample divided by the number in the sample.

Catch_number = Catch_weight x (sample_number)/ (sample_weight).

For herring and blue whiting representative number of individuals, 100 fish per species if possible should be examined for:

- Length (measured in ½ cm intervals)
- Weigth (measured in grammes)
- Sex
- Maturity (maturity key is given in section 5.5)
- Age (in winter rings) (herring using scale and blue whiting using otoliths)

5.3 Collection of otoliths and scales

Scales

A sufficient number should be taken from each herring to obtain about 4-5 good scales for preparation. Before the scales are taken, stroke the area from front backwards with the tweezers to remove any loose scales that may have come from other fish. Place the scales on a blotting paper within numbered squares (the paper is soaked in water and placed in a box).

Use water to clean the scale and place it on a microscope slide which has a layer of gelatine (use tweezers). Place 4-5 scales from each of two specimens on a single slide. The slides must be numbered with permanent ink beforehand. The scale is slightly curved and must be placed on the slide with the convex side upwards. If the scales cannot be prepared on slides immediately after sampling, they must be frozen immediately to prevent them from drying up

Otoliths

Otolith may be read onboard using standard procedure for otoltih reading of blue whiting or scale reading of herring or they may be examined at a later stage in the institute laboratories.

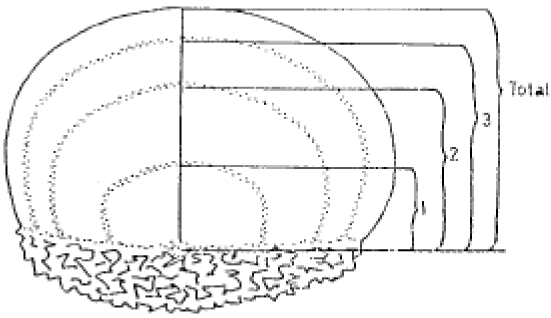
5.4 Age reading of otoliths and scales

Herring

Count the number of hyaline zones (winter zones; dark in reflected light) on the otoliths, number of zones on the scales. Figure 2 shows an example on a herring scale and how the number of winter ring can be read.

January 1 is the date on which the fish becomes one year older. If otoliths or scales from a fish caught in the autumn have started a new winter zone, this zone should not be counted (or measured). If otoliths or scales from a fish caught in the spring have not yet started the winter zone, this should be assigned a year more than the number of zones, i.e., the edge is counted (and measured) as a winter zone.

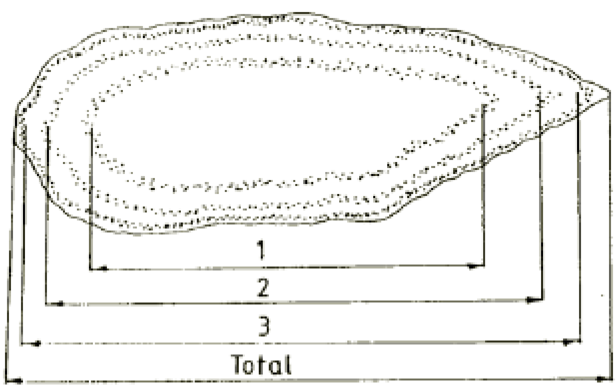
Figure 2. Herring scale



Blue whiting

It is difficult to give strict rules for the determination of zones, the width of rings and zones and the distance between them must be appraised continuously. In otoliths of young fish (<2 years) it may be difficult to distinguish between the first winter zone and «Bower's zone» («Bailey's zone») and other rings («checks»), particularly for I-group fish caught in the year's first quarter. The results of measurements of the first winter zone cover, on average, 53 measuring units at calibration 12 (12 marks per 2 mm). This may be used as a guide. In older fish the first zone that is counted is normally distinct. «Bower's zone» and other «checks» on the inside are distinguished from the other zones because they appear thinner and are often broken. Figure 3 shows an example on a blue whiting otolith and how the number of winter ring can be read.

Figure 3. Blue whiting otolith



5.5 Maturity stages

Different maturity staging keys can be used. At some institutes a 4 stage key and at other institutes a 8 stage key is used. At the surveys delt with in this manual both maturity staging keys can be used as long as the 8 stage kay can be converted to the 4 stage key.

Maturity stages for herring.

Stage	Females	Males
Blank	**Undecided/not checked**	**Undecided/not checked**
1	**Immature a)** Juvenile phase. Gonads thread-like, thin and completely transparent and colourless. Difficult to determine sex.	**Immature a)** Juvenile phase. Gonads thread-like, thin and completely transparent and colourless. Difficult to determine sex.
2	**Immature b)** Gonads are somewhat larger in volume, sex is easier to determine. The gonads continue to be transparent and colourless with a hint of colour.	**Immature b)** Gonads are somewhat larger in volume, sex is easier to determine. The gonads continue to be transparent and colourless with a hint of colour
4	**Maturing b)** Gonads larger in volume Distinct veins. Ovaries yellowish or white, can occupy 2/3 or more of the body cavity depending on the condition of the fish. The eggs can be seen distinctly and feel like grain. The eggs in the front part of the gonad are beginning to become transparent.	**Maturing b)** Gonads larger in volume. Distinct veins. Testes light grey or white, milt thick and slow-flowing.
5	**Maturing c)** Ovaries fill the entire body cavity. Most of the eggs are transparent.	**Maturing c)** Testes are grey or white. The milt runs easily. Gonads are not yet running, however, a light pressure on the abdomen causes the milt to run.
6	**Spawning** Running gonads. A light pressure on the abdomen causes the eggs to run.	**Spawning** Running gonads. A light pressure on the abdomen causes the milt to run.
7	**Spent** Gonads loose, contain remaining eggs	**Spent** Gonads loose, contain remaining milt.
8	**Resting** Gonads are small. Eggs are not visible. Difficult to distinguish from stages 2/ 3.	**Resting** Gonads are small. Eggs are not visible. Difficult to distinguish from stages 2/3

Maturity stages for blue whiting

Stage	Females	F	Males	F
blank	**Undecided/not checked**		**Undecided/not checked**	
1	**Immature** Ovaries transparent and white. No visible eggs.	<1/4	**Immature** Testes are thin and transparent. «Ribs» almost invisible.	<1/4
2	**Spent (new maturation) + First-time spawner** Ovaries transparent orange/red, somewhat spotted	1/3	**Spent (new maturation) + First-time spawner** Testes transparent pink/white, with some rolls or loops	1/2
3 - 4	**Maturing** Ovaries orange/pink. Opaque eggs barely visible.	1/2	**Maturing** Testes are in the process of becoming opaque pink/whit. Some blood vesssels with «bags». Curl when squeezed.	2/3
5	**Maturing** Ovaries harder orange/pink. Opaque eggs distinctly visible.	2/3	**Maturing** Testes opaque, white, plump.	3/4
6	**Maturing/mature** Ovaries orange/pink. Some hyaline eggs.	>3/4	**Maturing/mature** Testes opaque creme-white. Tightly curved bags or rolls.	1
7	**Spawning/running** Ovaries pink/white. Mainly hyaline eggs. Easy to squeeze out.	1	**Spawning/running** Testes opaque creme-white. Easy to squeeze out.	1

8	**Spent** Ovaries spotted pink/red, bloody. Some eggs remaining.	<1/2	**Spent** Testes yellow-white and bloody. Small crinkled band.	<3/4

F = Gonad length in relation to body cavity size.

Conversion from 8 to 4 stage key

8 point scale	4 point scale
1	I (**I**mmature)
2	
3	M (**M**ature)
4	
5	
6	R (**R**unning)
7	S (**S**pent and resting)
8	

6 Plankton sampling

The standard equipment for zooplankton sampling is the WP2 net, with 180 or 200 µm mesh size and 56 cm aperture. The net is hauled vertically from 200 m or the bottom to the surface at a speed of 0.5 m s^{-1}. It is important not to stop the haul or lower the speed until the net is above the sea surface.

Samples are divided in two, and one half is dried for 24 hours at 70° C before weighing. The weighing must be done in a laboratory on land, and samples can be dried onboard and frozen for storage and transportation. In that case samples must be dried again for at least 6 hours before weighing. The other half is fixed in 4% formaldehyde and seawater with proper buffering for later analyzes (species determination). If samples are very large further subsampling may be necessary.

7. Hydrographical sampling

At the Norwegian Sea survey a CTD profile should be taken for every 60 nm in connection with the plankton station. Temperature and salinity should be monitored from the surface layer and from the near-bottom or deepest layer regularly for calibration of the CTD sonde. It is importance to select relatively homogenous layers to take the samples in to obtain good calibration accuracy.

At the blue whiting survey at the spawning grounds a CTD profile should be taken at least every 60 nm. Temperature and salinity shall be monitored from the surface to a maximum depth of 1000 m. Water samples for calibration the CTD sonde shall be taken regularly.

8 Data analysis

This section describes the calculation of numbers and biomass by species from the echo-integrator data and trawl data. Most of this section is taken from Simmonds *et al.* 1992.

The symbols used in this section are defined in the text but for completeness they are listed together below:

F_i	Estimated area density of species i
K	Equipment physical calibration factor
$<\sigma_i>$	Mean acoustic cross-section of species i
E_i	Partitioned echo-integral for species i
E_m	Echo-integral of a species mixture
c_i	Echo-integrator conversion factor for species i
TS	Target strength
TS_n	Target strength of one fish
TS_w	Target strength of unit weight of fish
a_i, b_i	Constants in the target strength to fish length formula
a_n, b_n	Constants in formula relating TS_n to fish length
a_w, b_w	Constants in formula relating TS_w to fish length
a_f, b_f	Constants in the fish weight-length formula
L	Fish length. Total length in ½ cm.
W	Weight in grams
L_j	Fish length at midpoint of size class j
f_{ij}	Relative length frequency for size class j of species i
w_i	Proportion of species i in trawl catches
A_k	Area of the elementary statistical sampling rectangle k
Q	Total biomass
Q_i	Total biomass for species i

The objective is to estimate the density of targets from the observed echo-integrals. This may be done using the following equation from Foote *et al.* (1987):

$$F_i = \left(\frac{K}{<\sigma_i>}\right)E_i \qquad \textbf{(1)}$$

The subscript i refer to one species or category or target. K is a calibration factor, $<\sigma_i>$ is the mean acoustic cross-section of species i, E_i is the mean echo-integral aalocated to the species in the judging prpcess and F_i is the estimated area density of species i. The quantity is the number or weight of species i, depending on whether σ_i is the mean cross-section per fish or unit weight. $c_i= (K/<\sigma_i>)$ is the integrator conversion factor, which may be different for each species. Furthermore, c_i depends upon the size-distribution of the insonified target, and if this differs over the whole surveyed area, the calculated conversion factors must take the regional variation into account.

K is determined from the physical calibration of the equipment, which is described in section 1 above. K does not depend upon the species or biological parameters. Several calibrations may be performed during a survey. The measured values of K or the settings of the EK500 may be different but they should be within 10% of one another.

8.1 Conversion factors for a single species

The mean cross-section $<\sigma_i>$ should be derived from a function which describes the length-dependence of the target-strength, normally expressed in the form:

$$TS = a_i + b_i Log_{10}(L) \qquad \textbf{(2)}$$

Where a_i and b_i are constants for the i'th species, the recommended target strength relationships for herring surveys in the Norwegian Sea and blue whiting surveys in the North east Atlantic area is given below.

Target Strength Equation Coefficients		
Species	$\mathbf{b_i}$	$\mathbf{a_i}$
Herring	20.0	-67.5
Blue whiting	21.8	-72.8
Mackerel	20	-84.9
Horse mackerel	20	-71.2
Physoclist species	20.0	-71.9

The equivalent formula for the cross-section is:

$$\sigma_i = 4\pi 10^{\left(\left(a_i + b_i Log(L)\right)/10\right)} \qquad \textbf{(3)}$$

The mean cross-section is calculated as the σ average over the size distribution of the insonified fish. Thus L_j is the mid-point of the j'th size class and f_{ij} is the corresponding frequency as deduced from the fishing samples by the method described earlier. The echo-integrator conversion factor is $c_i= K/<\sigma_i>$. The calculation may be repeated for any species with a target strength function.

$$< \sigma_i >= 4\pi \sum_j f_{ij} 10^{\left(\left(a_i + b_i Log(L_j)\right)/10\right)} \qquad \textbf{(4)}$$

Note that it is the cross-section that is averaged, not the target-strength. The arithmetic average of the target-strengths gives a geometric mean, which is incorrect. The term "mean target-strength" may be encountered in the literature, but this is normally the target-strength equivalent to $<\sigma_i>$, calculated as $10\log_{10}(<\sigma_i>/4\pi)$. Some authors refer to TS as $10 \log(\sigma_{bs})$ the definition of σ is different from σ_{bs} and should not be confused.

8.2 Conversion factors for mixed species layers or categories

Sometimes several species are found in mixed concentrations such that the marks on the echogram due to each species cannot be distinguished. From inspection of the echogram, the echo-integrals can be partitioned to provide data for the mixture as one category, but not for the individual species. However, further partitioning to species level is possible by reference to the composition of the trawl catches (Nakken and Dommasnes, 1975).

Suppose E_m is the echo-integral of the mixture, and w_i is the proportion of the i'th species, calculated from fishing data. It is necessary to know the target-strength or the acoustic cross-section, which may be determined in the same manner as for single species above. The fish density contributed by each species is proportional to w_i. Thus the partitioned fish densities are:

$$F_i = \frac{w_i K}{(\sum_i w_i < \sigma_i >)} E_m \qquad \textbf{(5)}$$

The w_i may be expressed as the proportional number or weight of each species, according to the units used for $<\sigma_i>$ and c_i. Consistent units must be used throughout the analysis, but the principles are the same whether it is the number of individuals or the total weight that is to be estimated.

8.3 Using weight-length relationships

The abundance is expressed either as the total weight or the number of fish in the stock. When considering the structure of the stock, it is convenient to work with the numbers at each age. However, an assessment of the commercial fishing opportunities would normally be expressed as the weight of stock yield. Consistent units must be used throughout the analysis. Thus if the abundance is required as a weight while the target-strength function is given for individual fish, the latter must be converted to compatible units. This may be done by reference to the weight-length relationship for the species in question.

For a fish of length L, the weight W is variable but the mean relationship is given by an equation of the form:

$$W = a_f L^{b_f} \qquad \textbf{(6)}$$

Where a_f and b_f are taken as constants for one species. However, a_f and b_f could be considered as variables varying differently with stock and time of year as well as species. Suppose the target-strength of one fish is given as:

$$TS_n = a_n + b_n \log_{10}(L) \qquad \textbf{(7)}$$

The corresponding function TS_w, the target-strength of unit weight of fish has the same form with different constants:

$$TS_w = a_w + b_w \log_{10}(L) \qquad \textbf{(8)}$$

The number of individuals in a unit weight of fish is (1/W), so the constant coefficients are related to the formulae:

$$b_w = b_n - 10 b_f \qquad \textbf{(9)}$$

$$a_w = a_n - 10 \log_{10}(a_f) \qquad \textbf{(10)}$$

8.4 Abundance estimation

So far the analysis has produced an estimate of the mean density of the insonified fish, for each part of the area surveyed, and for each species considered. The next step is to determine the total abundance in the surveyed area. The abundance is calculated independently for each species or category of target for which data have been obtained by partitioning the echo-integrals. The calculations are the same for each category:

$$Q_i = \sum_{k=1}^{n} A_k F_i \qquad \textbf{(11)}$$

The total biomass for all species is:

$$Q = \sum_{i} Q_i \qquad \textbf{(12)}$$

The F_i are the mean densities and A_k are the elements of the area that have been selected for spatial averaging. The may be calculated from the shape of an area or measured, depending upon the complexity of the area. The presence of land should be taken into account, possibly by measuring the proportions of land and sea.

9 Cruise reports

A cruise report for each of the vessels should be produced following a standardised format.

The following can as an example be included in the cruise report:

- Itinerary of the survey
- Map showing
    - Cruise track
    - Trawling station location
    - CTD station location
    - Plankton station location (if collected)
- Materials and methods
    - Acoustic data
    - Hydrographical and zooplankton data
    - Biological data
- Results
    - Distribution and density of the acoustic data
    - Size and age distribution of the catches
    - Age-and size-stratified stock estimate(s)
    - Hydrographic conditions and zooplankton biomass
- Discussion
    - Acoustics
    - Scrutiny of the acoustic data
    - Trawling
    - Other relevant issues (e.g., weather)

10 Data exchange

Each individual country is responsible for working up its own survey data. However, the results need to be submitted to the coordinaters of each of main surveys, The Blue Whiting survey in March-April and the Herring survey in the Norwegian Sea in May-July in a standard format for the coordinated survey results. In addition, the **NASC's** per sampling unit allocated to target species together with all trawl information should be entered in the PGNAPES database.

10.1 PGNAPES Data Exchange format

At the PGSPFN meeting in Bergen 2001 the group agreed to set up a common database for the data collected in Norwegian Sea since 1996 by the different nations. This was due to the fact that the data handling was becoming more and more difficult, as the amount of data collected is huge. Already then a draft database design was made.

The participating institute should use the database in their work with the data. Data files should be interchanged between the vessels in the *.csv format (comma-separated-values) with tables arranged as described by the PGNAPES database format.

10.2 PGNAPES database table description

Parameters in bold indicate primary key variables, and used together they form a unique key from the logbook to the other sheets, except to the acoustic table. The acoustic table can be linked to the logbook by the cruise identifier together with country, vessel, cruise, log, year and month.

Logbook:

Country	Post code, 2 chars according to countries table
Vessel	Call sign, 2 or 6 digits acc. to Vessels table
Cruise	Cruise identifier
Station	National station number
StType	Geartype/activity: one line per activity at the same station: National definition of station type
Year	YYYY (4 digits)
Log	Value from the acoustic log (Nm)
Month	MM
Day	DD
Hour	HH, time GMT 0-24
Min	MM
Lat	Decimal degrees, negative latitude south 0° ”0.0000”
Lon	Decimal degrees, negative longitude west of 0° “0.0000”
BottDepth	Bottom depth (m)
WinDir	Compass degrees
WinSpeed	m/s

Acoustic:

Country	Post code, 2 chars according to countries table
Vessel	Call sign, 2 or 6 digits acc. to Vessels table
Cruise	Cruise identifier
Log	Min 4 digits (Nm)
Year	YYYY (4 digits)
Month	MM
Day	DD

Hour	HH, time GMT 0-24
Min	MM
AcLat	Decimal degrees, negative latitude south 0° "0.0000" The position refers to the beginning of the interval.
AcLon	Decimal degrees, negative longitude west of 0° "0.0000" The position refers to the beginning of the interval.
Logint	Nm, Log_end-Log start
Frequency	KHz
Sv.Threshold	DB

AcousticValues:

Country	Post code, 2 chars according to countries table
Vessel	Call sign, 2 or 6 digits acc. to Vessels table
Cruise	Cruise identifier
Log	Min 4 digits (Nm)
Year	YYYY (4 digits)
Month	MM
Day	DD
Species	Species code: HER, BLU,…
ChUppDepth	Upper channel depth (m) Rel. to surface
ChLowDepth	Lower channel depth (m) Rel. to surface
SA	Acoustic readings (m^2/nm^2)

Hydrography:

Country	Post code, 2 chars according to countries table
Vessel	Call sign, 2 or 6 digits acc. to Vessels table
Cruise	Cruise identifier
Station	National station numbers
StType	Geartype/activity: National definition of station type
Year	YYYY (4 digits)
Depth	Depth of measurement (m)
Temp	°C (at least 2 decimals)
Sal	Salinity (psu, at least 3 decimals)
QF	Quality of salinity data: 0-5 (IGOSS quality flags)

Plankton:

Country	Post code, 2 chars according to countries table
Vessel	Call sign, 2 or 6 digits acc. to Vessels table
Cruise	Cruise identifier
Station	National station numbers
StType	Geartype/activity: National definition of station type
Year	YYYY (4 digits)
UppStatDepth	Upper station depth (m)
LowStatDepth	Lower station depth (m), if only one depth then same as upper
SumDryWt	Plankton mg dry weigth/m^2 in each interval
Frac2000	Size graded values, 2000 my sieve
Frac1000	1000 my sieve
Frac180	180 my sieve
Krill	From 2000 my sieve
Fish	-"-
Shrimp	-"-

Catch:

Country	Post code, 2 chars according to countries table
Vessel	Call sign, 2 or 6 digits acc. to Vessels table
Cruise	Cruise identifier
Station	National station numbers
StType	Geartype/activity: National definition of station type
Year	YYYY (4 digits)
Species	Species code: HER, BLU,…
Catch	Kg
Towtime	Minutes
Wirelength	(m)
TowSpeed	Knots
Trawldepth	(m)

Biology:

Country	Post code, 2 chars according to countries table
Vessel	Call sign, 2 or 6 digits acc. to Vessels table
Cruise	Cruise identifier
Station	National station numbers
StType	Geartype/activity: National definition of station type
Year	YYYY (4 digits)
Species	Species code: HER, BLU,…
Length	cm with one decimal (dot as decimal sign)
Weight	G
AgeScale	Year from scale readings
AgeOtholit	Year from otolith
Sex	Empty means not sexed, 1= Female, 2= Male, 0= not possible to determine sex
Maturation	Maturation scale: Herring 1-8, Blue whiting 1-7
StomFullness	Stomach fullness, visual scale 1-5 (ICES)
StomachWt	Weight of stomach with content (g)
Recnr	Serial number identifying the fish

Support tables:

Countries:

CountryID	Postal code:FO,DE,NL,NO,IS,RU,SE,IE,DK
Countryname	Countryname

Values in Countries table:

CountryId	**Countryname**
FO	Faroe Islands
DE	Germany
NL	Netherlands
NO	Norway
IS	Iceland
RU	Russia
SE	Sweden
IE	Ireland
DK	Denmark

Vessels:

VesselID	Callsign
Vesselname	Vesselname

Values in Vesseltable:

VesselID	Vesselname
SEPI	Argos
TFJA	Arni Fridriksson (old)
TFNA	Arni Fridriksson
TFEA	Bjarni Sæmundsson
LLZG	G.O. Sars (old)
LDGJ	Johan Hjort
OW2252	Magnus Heinason
LHUW	Michael Sars
DBFR	Walter Herwig III
PBVO	Tridens
LMEL	G.O.Sars (new)
OXBH	Dana
UANA	Fridtjof Nansen
UHOB	Atlantniro
EIGB	Celtic Explorer

IGOSS:

QF	Quality Flag
Interpretation	Interpretation

Values in IGOSS table:

QF	Interpretation
0	No control
1	Correct
2	Inconsistent
3	Doubtful
4	Erroneous
5	Corrected

Species:

SpeciesID	3 character code
SpeciesName	Species name in English

Values in Species table:

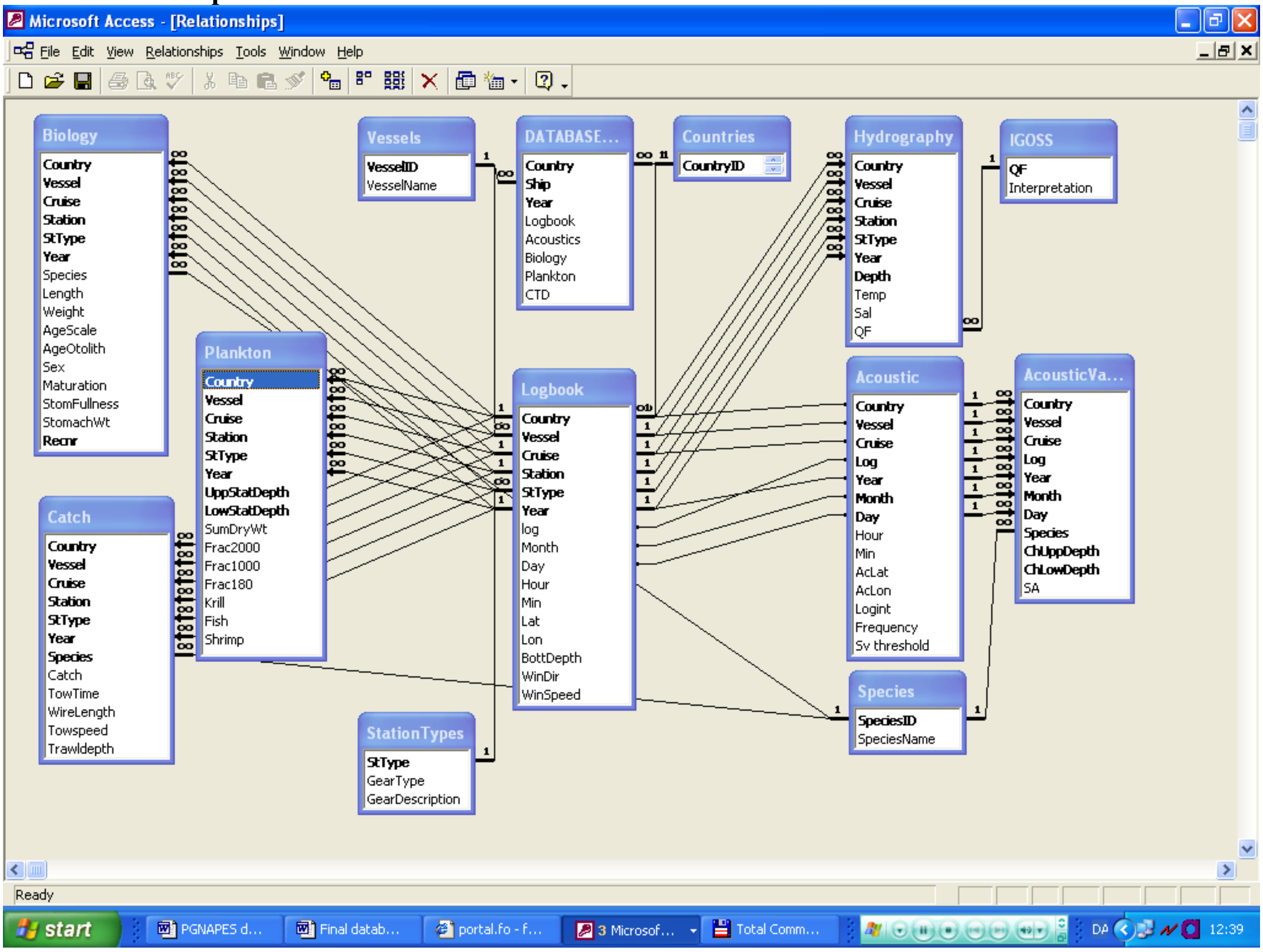
SpeciesID	SpeciesName
BLU	Blue whiting
CAP	Capelin
COD	Cod
HAD	Haddock
HER	Herring
HOR	Horse mackerel
LUM	Lumpsucker
MAC	Mackerel
MES	Mesopelagic fish
RED	Redfish
SAI	Saithe
SAL	Salmon

Gear:

STtype	Geartype/activity: National definition of station type
GearType	PLANKTON,CTD, or TRAWL (mandatory)
Geardescription	Informative desription of gear

StType	**GearType**	**GearDescription**
CTD	CTD	CTD
HYDR-300-HCSBC	CTD	CTD, Rosette, Fluorometer, Light meter
KRIL	PLANKTON	Krill trawl
MIK	PLANKTON	MIK net
MOC	PLANKTON	MOCNESS net
PBLÅ	TRAWL	Pelagic trawl with buoys (blåse)
PDYP	TRAWL	Pelagic trawl without buoys
PTRAWL	TRAWL	Pelagic trawl
TRAWL	TRAWL	Pelagic trawl
TRWL-114-FSV01	TRAWL	Blue Whiting trawl, 40mm small pelagic codend, No groundrope, Vágs ??? doors, 120 m bridles
TRWL-119-FLF01	TRAWL	Salmon trawl, Aquarium, No groundrope, Vágs doors, 60 m bridles
TRWL-126-FYN01	TRAWL	0-Group trawl from 1989, 5mm 0-Group codend, No groundrope, Vágs ??? doors, 60 m bridles
WP2	PLANKTON	WP2 net

Table relationships:



10.3 Example of dataexport

As the PGNAPES participating nations have agreed on using the new database format it is recommended to use the PGNAPES database as a working tool while on a cruise. Using the database actively, putting all relevant cruise data into the base during the cruise will ensure data integrity, and that exports of data will come out right.

To make exports from the base will ensure that data exported are ready to import into the other participants databases.

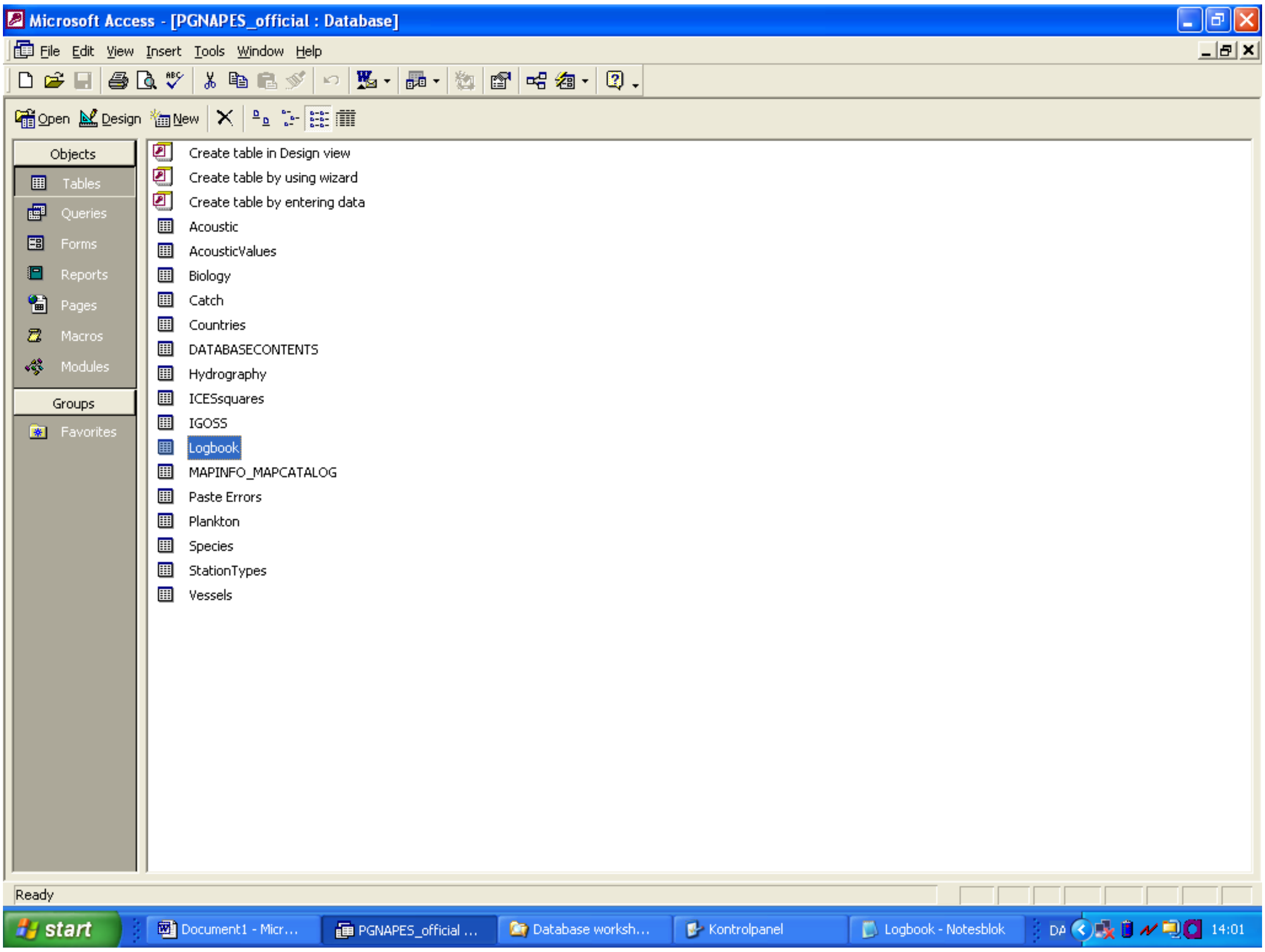
Exporting plankton, hydrography, biology, or catch data always implies the export of the Logbook table, as it is the parent table of those underlying tables.

Exporting acoustic values always implies the export of the Acoustic table, as the Acoustic table is a parent table of the Acousticvalues table.

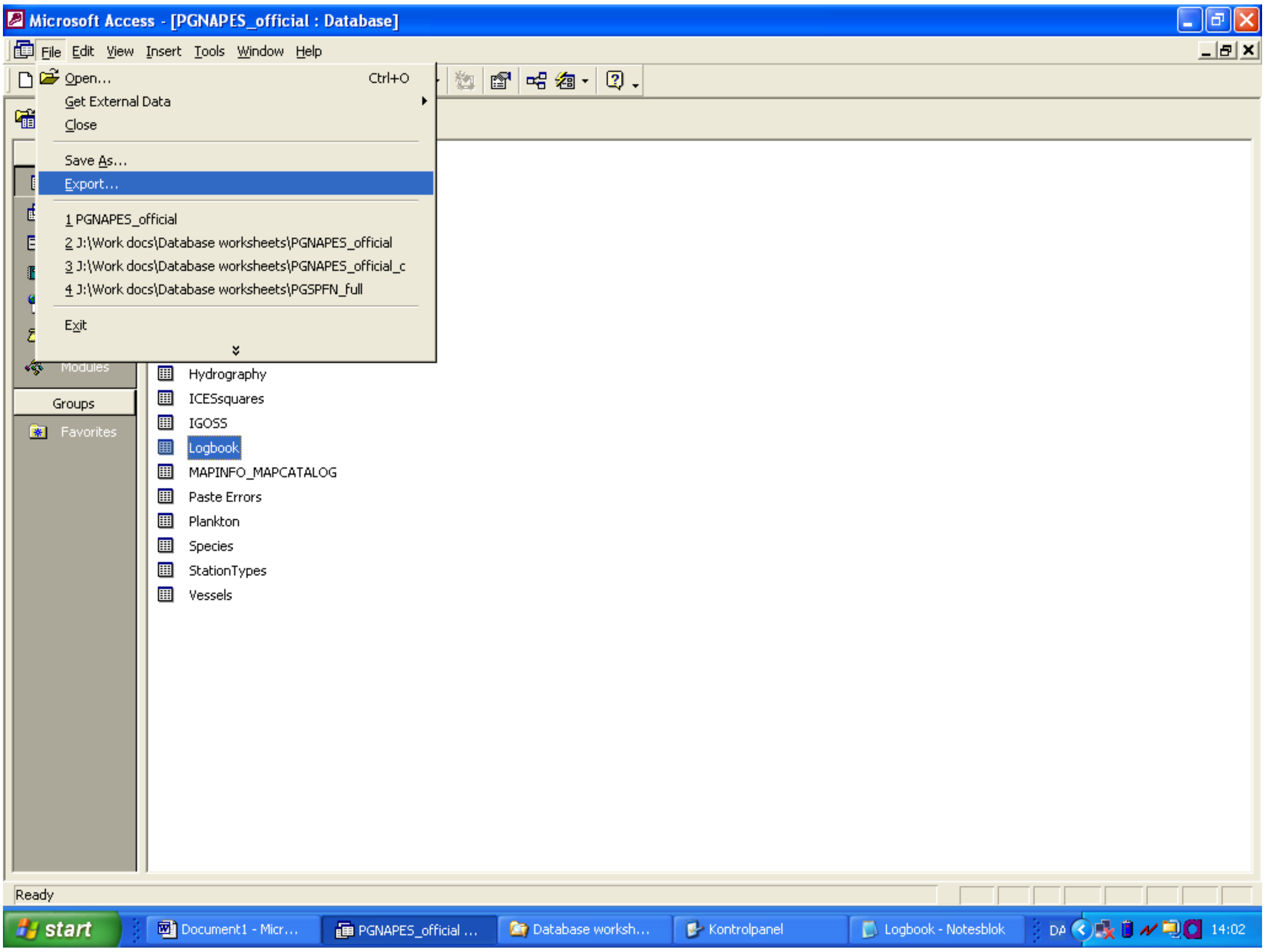
Is important to have the structure of the database in mind when exporting and supplying other participants with exported data.

Exporting data from access:

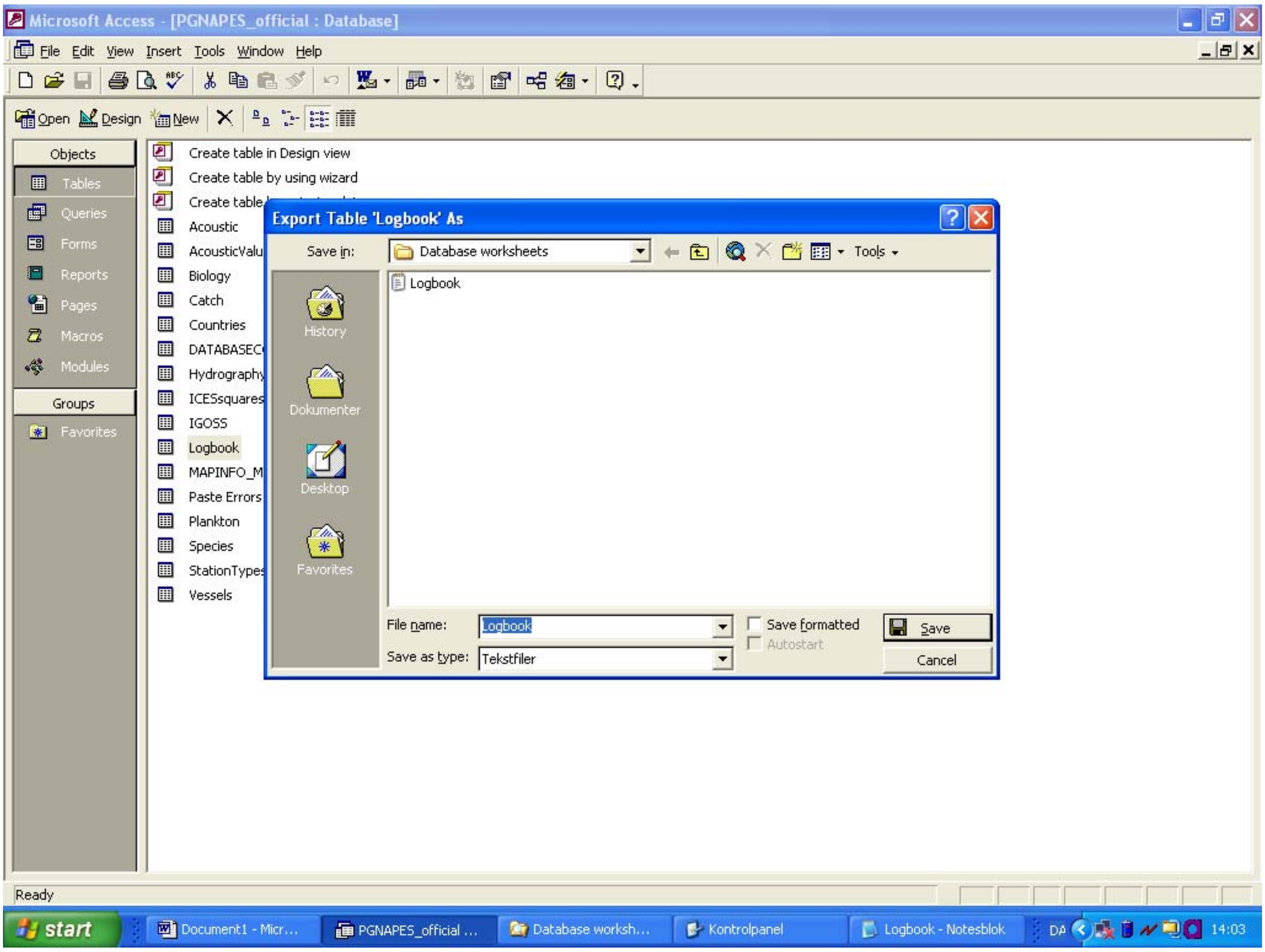
Mark the table you want to export:



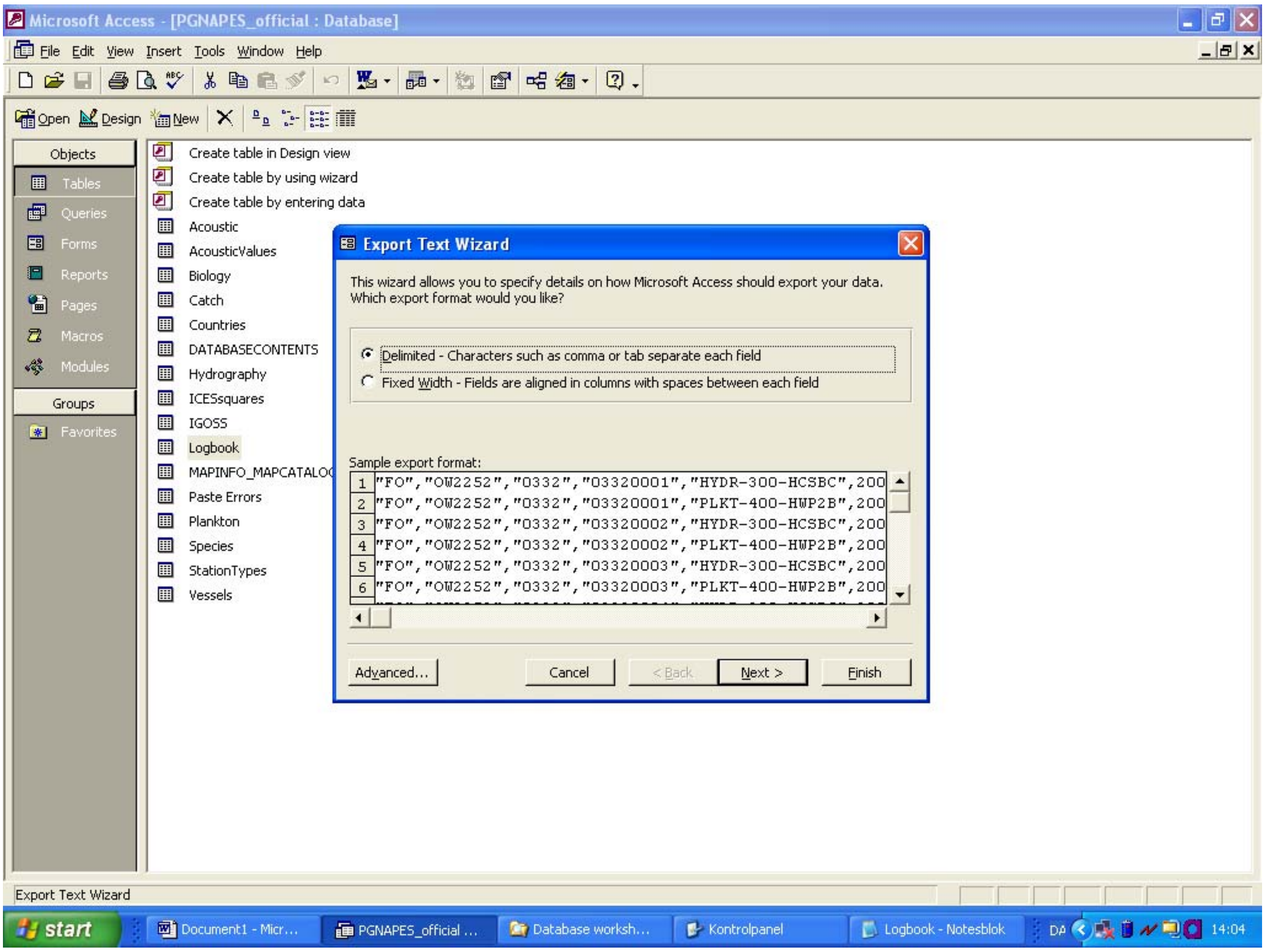
Go to File/export



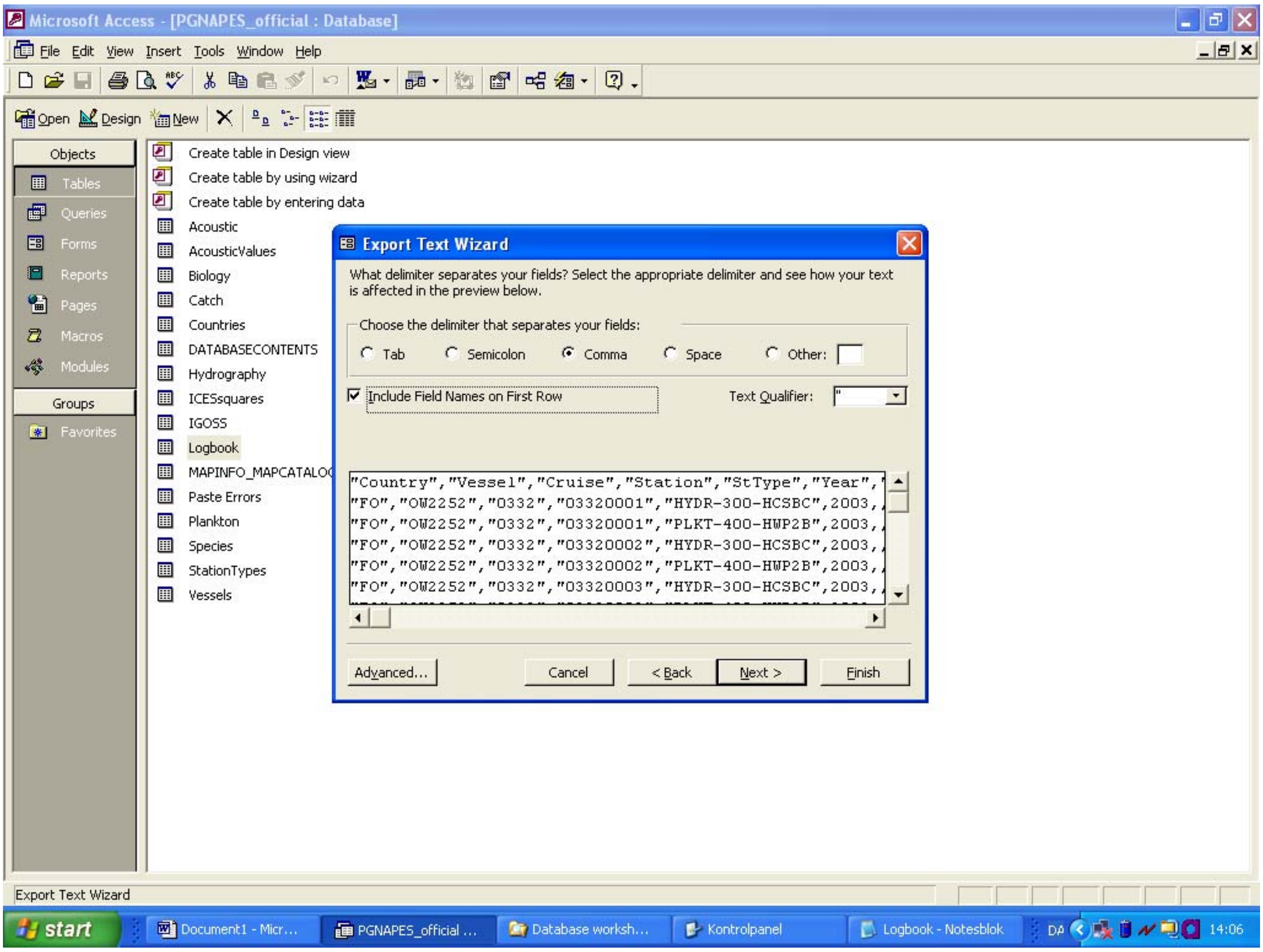
Save as "TEXT format, supply file name



Save as delimited


Microsoft Access - [PGNAPES_official : Database]
File Edit View Insert Tools Window Help
Open Design New
Objects
Tables
Queries
Forms
Reports
Pages
Macros
Modules
Groups
Favorites
Create table in Design view
Create table by using wizard
Create table by entering data
Acoustic
AcousticValues
Biology
Catch
Countries
DATABASECONTENTS
Hydrography
ICESsquares
IGOSS
Logbook
MAPINFO_MAPCATALOG
Paste Errors
Plankton
Species
StationTypes
Vessels
Export Text Wizard
This wizard allows you to specify details on how Microsoft Access should export your data. Which export format would you like?
Delimited - Characters such as comma or tab separate each field
Fixed Width - Fields are aligned in columns with spaces between each field
Sample export format:
1 "FO","OW2252","0332","03320001","HYDR-300-HCSBC",200
2 "FO","OW2252","0332","03320001","PLKT-400-HWP2B",200
3 "FO","OW2252","0332","03320002","HYDR-300-HCSBC",200
4 "FO","OW2252","0332","03320002","PLKT-400-HWP2B",200
5 "FO","OW2252","0332","03320003","HYDR-300-HCSBC",200
6 "FO","OW2252","0332","03320003","PLKT-400-HWP2B",200
Advanced...
Cancel
< Back
Next >
Finish
Export Text Wizard
start
Document1 - Micr...
PGNAPES_official ...
Database worksh...
Kontrolpanel
Logbook - Notesblok
14:04

Be sure it is comma delimited, and include Fields Names on first row is tagged



Press finish

The fileformat is ordinary ASCII-format. The datavalues within the file are arranged as Comma-Separated-Values (*.csv) as shown in the example below.

"Country","Vessel","Cruise","Station","StType","Year","log","Month","Day","Hour","Min","Lat","Lon","BottDepth","WinDir","Win
Speed"
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"FO","OW2252","0332","03320005","PLKT-400-HWP2B",2003,,5,3,8,3,61.33,-7.90,812,45,15.

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ICES 2002, PGHERS Manual for Herring Acoustic Surveys in ICES Division III, IV and VIa.

Appendix 1

Characteristics of the trawl gear used in the surveys.

Country		
Vessel		
Power (main engine in kW)		
Gear code		
Gear name		
Type (**B**ottom/**P**elagic)		
Panels		
Headline (in meters)		
Groundrope (in meters)		
Sweep length (in meters)		
Length (in meters)		
Circumference (in meters)		
Mesh sice in panels*:	(in mm)	
	(in mm)	
	(in mm)	
	(in mm)	
	(in mm)	
	(in mm)	
	(in mm)	
Codend (in mm)		
Opening hight (in meters)		
Wing spread (in meters)		
Remarks		

* “Mesh sizes in all panels” are listed for panels from the mouth of the net to the cod end; the number of entries is not an indication of the number of panels as adjacent panels may have the same mesh size.