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Report of the Planning Group on Northeast Atlantic Pelagic Ecosystem Surveys (PGNAPES)

15–18 August 2006

Reykjavik, Iceland

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

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Contents

Executive Summary

The present report was prepared on the Planning Group on Northeast Atlantic Pelagic Ecosystem Surveys (PGNAPES) in Reykjavik, Iceland 15–18 August 2006 and contains the results of the acoustic, hydrographic, plankton and fish sampling from two international ICES coordinated survey in 2006. The **International blue whiting spawning stock survey** on the spawning grounds west of the British Isles in March-April 2006 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-June 2006 with participation of Denmark (EU coordinated), Faroes, Iceland and Norway. In addition the scientific study of mackerel, herring and blue whiting was performed in the Norwegian Sea in the July-August with the chartered commercial vessels M/V "Libas" and M/V "Endre Dyrøy" with project leader from Institute of Marine Research, Bergen, Norway. 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 2006. 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 2007 are also outlined with descriptions of the relevant protocols, preliminary participants and suggested survey designs.

1 Introduction

1.1 Terms of Reference 2006

The **Planning Group on Northeast Atlantic Pelagic Ecosystem Surveys** [PGNAPES] (Chair: A. I. Krysov, Russian Federation) will meet in Reykjavik, Iceland, from 15–18 August 2006 to:

ITEM	TOR 2006	SECTION
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	3, 4 and 5
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	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	3.6
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 2007	5.1
	ii) the international coordinated survey on Norwegian spring-spawning herring, blue whiting and environmental data in May-June 2007	5.2
	iii) Russian investigations on pelagic fish and the environment in May-July 2007	5.2
	vi) Icelandic investigations on pelagic fish and the environment in June-July 2007	5.2
	v) Norwegian investigation on pelagic fish and the environment in August 2007	5.2
e)	Finalise and adopt the proposed protocol to ensure standardisation of all sampling tools, procedures and survey gears	6

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.

1.2 List of participants

Jørgen Dalskov	Denmark
Karl-Johan Stæhr	Denmark
Jan Arge Jacobsen,	Faroe Islands
Leon Smith,	Faroe Islands
Asta Gudmundsdottir	Iceland
Hjalmar Vilhjalmsson	Iceland
Guðmundur Oskarsson	Iceland
Sveinn Sveinbjørnsson,	Iceland
Thorsteinn Sigurdsson,	Iceland
Ciaran O'Donnell,	Ireland
Sytse Ybema	Netherlands
Jens Christian Holst,	Norway
Mikko Heino,	Norway
Kjell Arne Mork,	Norway

Øyvind Tangen,	Norway
Alexander Krysov (Chair),	Russia

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

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 south-westward shift has continued in 2004 and 2005, and especially in 2006 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.

Two other large stocks in the Northeast Atlantic are the blue whiting and the mackerel are using the Norwegian Sea during their feeding migration during summer. The main spawning areas of the blue whiting 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 was 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 2004 the "Planning Group on Surveys of Pelagic fish in the Norwegian Sea" (PGSPEN) was renamed to the "Planning Group on Northeast Atlantic Pelagic Ecosystem Surveys" (PGNAPES), including also the blue whiting spawning survey during spring.

In 2006 a series of surveys were carried out by vessels from Denmark, Faroe Islands, Iceland, Norway, Ireland, the Netherlands, and Russia (only in the March-April), coordinated by the PGNAPES, resulting in a relatively good coverage of the areas and relevant species. In May-June 2006, as 2005, the coverage included the Barents Sea (except EEZ RF) and the Norwegian Sea enabling a full synoptic coverage of Norwegian spring spawning herring. In addition the Norwegian Sea was covered during July and partly in August 2006. Unfortunately in 2006 Russia was not able to execute its planed surveys on pelagic fishes in the Barents and the Norwegian Seas in May-July due to financial reason.

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 2006:

a) on the blue whiting spawning grounds west of the British Isles;

b) 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 Norwegian Spring Spawning herring, blue whiting, zooplankton and hydrography. In addition the Norwegian Sea was covered during July-August 2006 on a national basis:

(Norway, Section 3.3);

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.* 2006a, Internet http://www.imr.no/__data/page/6264/Nr.2_2006_International_blue_whiting_spawning_stock_survey_spring2006.pdf in Annex 2 in the present report.

1.3.1 Joint NISE – PGNAPES meeting

A joint Workshop between the "Norwegian – Iceland Seas Experiment" (NISE) and PGNAPES was held on Wednesday afternoon 16 August 2006. The NISE project was initiated in Reykjavík, Iceland in March 2004 with the aim to combine observational and modelling evidence to provide more extensive descriptions of the physical conditions and their changes in the Norwegian and Iceland Seas. The ultimate aim has been to provide a tool that can be used, not only by physical oceanographers, but also by biologists and fisheries scientists to quantify the effects of changing physical conditions on fish and other living organisms.

At the Workshop six presentations were given (see below) on topics of mutual interests with the following underlying question: "How can the cooperation between biologists and physical oceanographers be strengthened?"

- Bogi Hansen: Background and purpose of the NISE Project.
- Helge Drange: The NISE model.
- Hjálmar Hátún: Simulated and observed hydrography west of the British Isles – recent regime shifts and possible effects on blue whiting distribution and abundance.
- Mikko Heino: Covariability in recruitment of blue whiting in the Northeast Atlantic.
- Jan Arge Jacobsen: Herring distribution and SST/plankton distribution in the Norwegian Sea, with focus on the recent changes in herring distribution during summer.
- Hjalmar Vilhjálmsson: Distribution of the 2°C isotherm north and east of Iceland in the 1950s and 1960s in relation to the herring distribution.

This stimulated a lively discussion on scientific questions and on the relationship between NISE and PGNAPES, and it is anticipated that collaboration between participants from the two groups will be a reality in the near future.

1.3.2 Accessibility of the PGNAPES reports

The PGNAPES reports are available on the Internet (http://www.imr.no/PGSPFN/) as PDF files free to download. In the near future the national survey reports will also be made available on this website.

1.4 Recommendation

1.4.1 Practical achievements

A new acoustic manual is under construction combining both existing PGHERS and PGNAPES formats. This draft manual is to be reviewed by all participants before final submission and review at the PGHERS meeting in 2007. The draft version is to be sent for review to participating members of both planning groups for comments prior to the PGHERS 2007 meeting. Eckhard Bethke (Germany) is nominated for the final update of the manual.

A table of vessel details of participant countries in the following surveys has been inserted in the draft version of the new acoustic survey manual and at the end of Chapter 1.

- Blue whiting survey
- North east Atlantic ecosystem survey

Species lists used in Ireland, the Faroes, the Netherlands, Norway, Germany and Denmark are being compared in order to get a complete species list with their taxonomical numbers (TSN) to be used in the international PGNAPES database.

Reporting structure: nationally and internationally.

Old situation:

Norwegian Sea herring and blue whiting survey

- Cruise reports do not follow a standardized format
- Cruise reports appear as appendix in the international report

International Blue whiting spawning stock survey

- Cruise reports aren't used internationally.
- Cruise reports are not included in the combined report

Suggested situation:

All surveys

- Cruise reports should be produced following a standardized format
- National cruise reports are not included in the combined report but
- Pre-defined links refer to the national reports on the PGNAPES website (http://www.imr.no/PGSPFN/)
- Only combined cruise reports from the main surveys should be attached to the main report
- Comparison of results should be automated directly from the international databases.

Suggestions:

At the 2006 meeting the Faeroes highlighted a need for additional manpower during the blue whiting survey in 2007. Two members of the blue whiting exploiting EU countries will be allocated to the Faeroes next year.

Survey planning requirements for 2007:

The temporal progression of the blue whiting survey in 2006 met the pre-agreed survey design requirements only partly. The area along the shelf edge stretching from south Porcupine bank to the Faeroes was covered with well matching overlaps. However, all overlapping area with the Russian vessel 'AtlantNIRO' were covered with time gaps up to two weeks and transect spacing inconsistent with the remaining vessels, making direct comparisons between vessels more difficult.

It should be stressed that pre-agreed survey design and transect resolution format should be adhered to wherever possible.

Agreements:

Data submission deadlines for all participant countries need to be established for uploading of herring and blue whiting acoustic data to the PGNAPES database. At present not all countries submit data in the required format on a pre-agreed timescale. In some cases data from previous years is still outstanding. It is therefore suggested that a deadline be determined with a person responsible in each country. It will then be the responsibility of this nominated person to submit the data in the agreed format on the pre-agreed timescale within 1 week of survey completion unless pre-agreed with PGNAPES database coordinator. After the deadline all responsible persons for the individual surveys will send an update of their data submission.

In 2002 ICES officially declared ITIS, the Integrated Taxonomic Information System, as the standard species list for ICES. It is therefore decided that this species coding be adopted for PGNAPES surveys to aid the flow of data within the group and for common databases.

During the PGNAPES meeting EU effort allocation is to be planned for the coming year's survey program. To date no scientific personnel or financial contributions to the EU International blue whiting survey has been received, as required by the DCR. In order to allocate effort more efficiently, request emails for participation of Spain, Germany, France and UK will be sent directly after the PGNAPES meeting.

Acoustic log interval distance in the exported data is set to 1 nautical mile.

The next post-meeting of the International Blue whiting spawning stock survey will be held in the Netherlands.

All countries agreed on performing hydrographic CTD downcasts down to a maximum depth of 1000m.

2 Material and methods

The PGNAPES is planning two international planned surveys and in addition results from a various number of additional surveys in the area are reported. Technical details on all the participating vessels are given in Table 2.

International Blue whiting spawning stock survey. The surveyed area (cruise tracks) in March-April 2006 is shown in Figure 2.1. Five vessels participated, the Dutch RV "Tridens", the Irish RV "Celtic Explorer", the Russian RV "AtlantNIRO", the Faroese RV "Magnus Heinason" and the Norwegian RV "G. O. Sars" (Table 2.1). More details are given in the combined cruise report (appendix 2).

International North East Atlantic Ecosystem Survey. The surveyed area (cruise tracks) in May-June 2006 is shown in Figure 2.2. Six vessels participated, the Danish RV "Dana", the Norwegian RVs "G.O. Sars", "Håkon Mosby" and "Johan Hjort", the Icelandic RV "Árni Fridriksson" and the Faroese RV "Magnus Heinason" (Table 2.2). Technical details are given in the combined technical survey report (appendix 3). Hydrographic data from a survey carried out by the Icelandic RV "Bjarni Sæmundsson" were in addition included from the areas north of Iceland. Map showing area I to III used in the acoustic estimate of herring and blue whiting is shown in Figure 2.3.

Other relevant surveys. A survey with the aim of carrying out an ecological study on mackerel, herring and blue whiting in the Norwegian Sea was conducted in the period 15 July – 6 August 2006 by two chartered Norwegian commercial vessels M/V "Libas" and M/V "Endre Dyrøy" (Table 2.3). The area covered at this survey is shown in Figure 2.4. Details of the sampling are given in the cruise report from this survey.

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 2006 are shown in Tables 2.1 – 2.3. 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 Tables 2.1 and 2.3. During the International ecosystem survey in the North East Atlantic in

2006 a total of 359 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 Faroese and the Norwegian vessels the samples for dry weight were size fractionated before drying. Additional samples were collected at the survey carried out by the Icelandic RV "Bjarni Sæmundsson". Only 0–200 m. samples (116 stations) were included in the analysis. All data obtained by WP2 are presented as g dry weigh m^2.

During the Norwegian survey of the Norwegian Sea in July–August a total of 117 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.

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.

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]. 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 ($\square_A$) 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. Biomass estimation 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 subareas.

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 2006. Five research vessels participated in the survey: "Atlantniro", "Celtic Explorer", "G. O. Sars", "Magnus Heinason" and "Tridens". This is the third 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.*, 2006a) reproduced as Appendix 2 in this report, as well as in national reports from individual vessels (Celtic Explorer: Mullins *et al.*, 2006; G. O. Sars: Heino *et al.*, 2006b; Magnus Heinason: Jacobsen *et al.*, 2006, Tridens: Ybema *et al.*, 2006).

3.1.1 Hydrography

CTD stations are shown in Figure 2 of Appendix 2 for all vessels except for "Magnus Heinason". Figures 9–19 in Appendix 2 summarise the hydrographic observations. In general, temperature was warmer and salinity slightly higher than in 2005. The time series from west of the Porcupine Bank shows the highest mean temperature and salinity in record (Appendix 2 Figure 19).

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, with smaller high density pockets close to the banks south of the Faroes and west of Rockall. Limits of the distribution were reached in the north whereas in the western and southern areas were not clear because of the patchy distribution of blue whiting. In south and north densities were generally very low. Schematic distribution of acoustic backscattering densities for blue whiting is shown in Figure 4 of Appendix 2. The distribution was rather typical, with the largest concentrations close to the shelf break.

Blue whiting spawning stock estimate based on the international survey is 10.3 million tonnes and 105 x 10^9 individuals, a marked increase from estimated 7.6 million tonnes and 83 x 10^9 individuals in 2005 but still lower than in 2004. The age-disaggregated total stock estimate is presented in Table 3 of Appendix 2, showing that the stock is now dominated by blue whiting of 4 years in age (2002 year class). Blue whiting of ages 3–4 years made up 60% of spawning stock biomass whereas the previously dominating 2000 year class is greatly reduced in abundance (SSB share of 11%). There is some variability in the age structure between different areas with the highest mean age observed in the Hebrides and Rockall subareas.

Until recent years, the time series from Norwegian blue whiting spawning stock surveys was the only regularly updated survey time series used in blue whiting stock assessment at

WGNPBW. 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. Notice that, in contrast to the international survey, this survey indicated a marginal decrease in abundance.

3.2 International ecosystem survey in the Nordic Seas

Like last year, the international coordinated survey in May was carried out with six vessels, one from the Denmark (EU coordinated), one from Faroes, one from Iceland and two from Norway (Table 2.2). In addition hydrographic data from a survey by RV “Bjarni Sæmundsson” were included in the areas north of Iceland. The plan was to cover all of the relevant parts of the Barents Sea, as was done last year to include all of the immature part of the stock. Unfortunately, due to technical and administrative difficulties, the Russian EEZ could not be surveyed in May 2006. Otherwise, the survey coverage was somewhat more extensive than in previous years, especially off NE-Iceland and in the eastern Iceland Sea.

The PGNAPES coordinated survey in May thus continuously covered the western Barents Sea (the Norwegian EEZ), north to about 73°N and the central and eastern Norwegian Sea approximately limited by the Faroe Islands, Iceland, to 75°N to the north and east of the island of Jan Mayen but west of that at 70°N. The Norwegian coast was covered from 71°N to 62°N. The cruise tracks are shown in Figure 2.2.

The first vessels started surveying 27th April while the last vessel ended surveying June 1st (Table 2.2). The weather in May 2006 was unusually good, hardly hampered survey activity of the vessels at all and disturbance of the acoustic data due to aeration by stamping and rolling was therefore less than during practically all May survey of previous years.

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 of the NWAC 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). 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 2006 the NAO index was lower than the long-term average (see Figure 3.2.1.1). Hence, there were weaker southwesterlies in winter 2006 than normal.

Figure 3.2.1.2 shows the temperature and salinity in the Svinøy section for 4–7 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°C. In 2006 the temperatures in the AW were higher than compared to 2005, except for the area over the slope at the shelf (located in the eastern branch of the NWAC). In the middle of the section the water was several degrees warmer in 2006 than for 2005 partly due to a deeper AW there compared to 2005.

Figures 3.2.1.3–3.2.1.8 shows the horizontal temperature distributions at surface, 20, 50, 100, 200, 400 and 500 m depth in May/June 2006. 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. The influence of EIC into the southern Norwegian Sea was stronger in 2006 than compared to 2005. This is seen by comparing the different isotherms for the two years (compare Figures 3.2.1.3–3.2.1.8 from the 2005 and 2006 reports). Difference plots between the two years (2006–2005) are made for easier comparison (Figures 3.2.1.9–3.2.1.14). The largest differences between the two years are found southeast of Iceland. There the difference can be as large as 2°C nearly at all depths. In the western Norwegian Sea the temperature was lower in 2006 compared to 2005 at all depths. The difference there is typical 0.25–0.75°C. However, in the eastern Norwegian the temperature was somewhat larger in 2006 than in 2005. Largest differences are at the largest depths. In the northern areas the eastern Norwegian Sea was colder in 2006 than in 2005 which is opposite of what the case is in the southern areas.

In the western Barents Sea the temperature at the surface was in 2006 higher than in 2005 over the whole area. The maximum difference was about 0.75°C. At deeper depths the difference between the two years was less. At 100 m depth, south and west of the Bear Island the water was warmer in 2006 than in 2005 with maximum difference of 0.5°C near the Bear Island. In the southern part the temperature was for 2006 about similar as for 2005.

3.2.2 Zooplankton

3.2.2.1 International ecosystem survey in the Nordic Seas

As usual the zooplankton biomass was highest in the cold water of the East Icelandic current (Figure 3.2.2.1). High biomass was also observed along the Arctic front of the western Norwegian Sea, and in the Northern Norwegian Sea. The sampling stations were fairly evenly spread over the area, and increased ship time compared to previous years facilitated good coverage of most oceanographic regions. Average biomass of zooplankton in May 2006 was lower than in 2005, and the lowest measured since 1997 (Table 3.2.2.1). The zooplankton biomass in the two areas west and east of 2°W equalled the mean for the time series in the western region, and was record low for the eastern region (Table 3.2.2.1).

3.2.2.2 July/August –central Norwegian Sea and Faroese EEZ

During July-August biomass was generally lower than in May (Figure 3.2.2.2). Biomass was higher in the west than in the east, and highest biomass was observed in the southwestern parts of the Norwegian Sea. The change in biomass is related to seasonal development of zooplankton stocks, mortality and descent to overwintering depths.

3.2.3 Norwegian spring spawning herring

Like last year, the international coordinated survey in May was carried out with six vessels, one from Denmark (EU coordinated), one from Faroes, one from Iceland and two from Norway (Table 2.2). In addition hydrographic data from a survey by RV "Bjarni Sæmundsson" were included in the areas north of Iceland. The plan was to cover all of the relevant parts of the Barents Sea, as was done last year to include all of the immature part of the stock. Unfortunately, due to technical and administrative difficulties, the Russian EEZ could not be surveyed in May 2006. Otherwise, the survey coverage was somewhat more extensive than in previous years, especially off NE-Iceland and in the eastern Iceland Sea.

The PGNAPES coordinated survey in May thus continuously covered the western Barents Sea (the Norwegian EEZ), north to about 73°N and the central and eastern Norwegian Sea approximately limited by the Faroe Island, Iceland, to 75°N to the north and east of the island of Jan Mayen but west of that at 70°N. The Norwegian coast was covered from 71°N to 62°N. The cruise tracks are shown in Figure 2.2.

The first vessels started surveying 29th April while the last vessel ended surveying June 9th (Table 2.2). The weather in May 2006 was unusually good, hardly hampered survey activity of the vessels at all and disturbance of the acoustic data due to aeration by stamping and rolling was therefore less than during practically all May survey of previous years.

Herring were recorded throughout most of the surveyed area as shown in Figure 3.2.3.1. The distribution was in many ways similar to that of 2005, a figure of which is included for comparison (Figure 3.2.3.2). Thus, the lowest concentrations were recorded in the central Norwegian Sea, with the highest values in the Faroese EEZ and at the eastern edge of the cold waters of the East Icelandic Current. High concentrations were also recorded in the westernmost Barents Sea, between Bear Island and the north coast of Norway, as well as northwest of Lofoten. The southern displacement is further reflected in a more southern centre of gravity of the acoustic recordings in 2006 as compared to 2005 (Figure 3.2.3.3).

The amount of herring in the westernmost area was considerably higher in 2006 than in 2005. The total acoustic herring estimate from the Nordic Seas and the Barents Sea in May 2006 is 10.3 million tonnes. The details of the estimate are given in Table 3.2.3.1. Age and length distributions are shown in Figure 3.2.3.4. The estimate of 10.3 million tonnes is about 3 million tonnes higher than that obtained in May 2005 (7 million tonnes, ICES 2003/D:10). The reasons are probably twofold, i.e. especially good weather conditions in 2006 and the large numbers (biomass) of the 2002 year class which has now completed its migration in the process of migrating west out of the Barents Sea.

There was a clear structure in size of herring throughout the area of distribution. The smallest fish are found in the northeastern area. Size and age increased to the west and south. (Figure 3.2.3.5).

3.2.4 Blue whiting

Blue whiting were observed in most of the survey area with the highest densities off north-western Norway and in the south, between the Faroes and Norway and the Faroes and Iceland. The distribution of the stock is broadly similar to last year's survey apart from a wedge of blue whiting free zone extending south-east from North-East Iceland as far as 1–2°W (Figure 3.2.4.1). There is a tendency of the mean length to increase away from the Norwegian coast towards west, north-west and north (Figure 3.2.4.2). The age structure of the stock is different in that much less 1 group fish is recorded than in 2005.

Stock estimate for the total survey area is given in Table 3.2.4.1. Blue whiting of age 2 and 3 years dominate the stock (about 32% each) followed by 4 year old fish (19%). The 3 year old fish dominate in terms of biomass (33%) followed by 2 and 4 year old (24% and 23%

respectively). The stock biomass estimate of 6.2 million tonnes is 6% lower than in 2005 (6.6 million tonnes) and about 40% lower than in 2004 (10.4 million tonnes) The stock numbers are decreased from $120*10^9$ in 2005 to $73*10^9$ in 2006. This dramatic reduction in numbers is entirely due to much smaller number of 1 year old fish as 2 years and older are more numerous in 2006 than 2005.

For the standard survey area that has been covered each year (between 8°W–20°E and north of 63°N) the estimate is 3.5 million tonnes, down by almost 26% from 4.7 million tonnes measured in 2005, and down 46% from 5.4 million tonnes measured in 2004. The stock estimate in numbers at $43*10^9$ is much lower than in 2004 and 2005 due to low numbers of 1 year old fish. As seen in Figure 3.2.4.3 the proportions of large and old blue whiting are somewhat 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.

The mean length of blue whiting in the standard area is for age groups 1–5 years are higher in 2006 than in 2005 but generally lower for older age groups. By comparison, the mean weight of the blue whiting year classes between the years 2005 and 2006 is more variable. There is a negative relationship between strength of year classes and the size at age 1 year that is statistically significant for length but not for weight (Figure 3.2.4.4).

The results of the survey by subareas shown in Figure 2.3 are summarized in Table 3.2.4.3. The results for the standard area are shown for comparison.

3.2.4.1 Blue whiting off the southern Icelandic coast

As last year, in the beginning of the Icelandic survey a special survey for blue whiting was conducted in the area from the Dohrn Bank between Iceland and Greenland along the shelf to the south-east coast. The aim of this additional coverage was to extend the coverage of the blue whiting distribution and obtain information about the biomass and age/maturity of the blue whiting at this time of the year in this area.

The highest densities were recorded between Iceland and the Faroes (Figure 3.2.4.5). From about 28°W to 16°W the total biomass of blue whiting was 350 thousand tonnes (Table 3.2.4.4) and both the maturity and the age distribution were different from the fish further east (Figure 3.2.4.6). About 61% of the fish west of 16°W were at age 1–2 whereas about 80% were of age 3–5 further east and only about 13% of age 1–2. Nearly all the fish at west and south Iceland were immature contrary to the fish in south-east where most were post-spawners.

3.3 July-August –Norwegian Sea

The results of this survey are preliminary as the survey was ended short time before the compilation of this report.

3.3.1 Norwegian spring spawning herring

The herring was distributed over large areas in the Norwegian Sea, 15 July – 6 August 2006 (Figure 3.3.1). In the northeastern part of the Norwegian Sea, there was relatively small herring, dominated by the 2001-, and 2002-year classes. Larger herring belonging to the 1998-, 1999-, and also 1992-year classes were mainly found in the western and southwestern part of the Norwegian Sea. The feeding herring was mainly located in frontal regions and in Arctic water masses, while migrating herring was predominantly swimming in Atlantic water masses. The herring migration pattern was typically length-dependent with the largest and oldest individuals migrating furthest to the west and southwest. The herring migrated mainly in an eastern and southeastern direction with a speed of 0.5–1.0 knots, based on sonar-tracking data of a large number of individual herring schools. The herring had finished their most intensive feeding season and ate relatively little, except for krill and amphipods in western areas during the short night.

3.3.2 Mackerel

The mackerel (*Scomber sombrus*) was also distributed over substantial areas in Atlantic water masses in the Norwegian Sea, although not to the same scale as for herring. Mackerel was recorded in the central basin of the Norwegian Sea and along the eastern part of the frontal zone (Figure 2.4). The mackerel had also a pronounced length-dependent with the largest and oldest individuals migrating furthest to the north. The 2001-, 2002-, and 2004-year classes dominated the biological samples with more than 70% of the collected individuals. The mackerel was still in an active feeding period, where the prey was dominated by copepods (*Calanus finmarchicus*) and *Limacina retroversa*.

3.4 Young herring

3.4.1 May/June – Young herring in the Barents Sea

Young herring were observed throughout the surveyed area in the Barents Sea with the largest concentrations found in the westernmost area around 20ºE and in the eastern areas along the Norwegian-Russian EEZ border. The Russian zone was not covered and the estimate of young herring is a definite underestimate, in particular with regard to the 2004 and 2005 year classes.

The herring in the Barents Sea was composed of the four year classes 2002, 2003, 2004 and 2005. The 2004 year class was by far the dominant year class and constituted approximately 75% of the herring tonnage east of 20ºE. The survey indicates that this is a strong year class with 35 billion individuals in the Barents Sea, but with the important Russian zone not covered a trustworthy evaluation is not possible. The same applies to the 2005 year class. The 2003 year class seems weak with only 5 billion individuals. The year class is also small in the Norwegian Sea with only 0.3 billion individuals in sub area II. A small tonnage of the strong 2002 year class was still present in the westernmost part of the Barents Sea.

There was a strong gradient in the mean length of the herring between approximately 17º–20ºE, where the mean length decreased from 28 cm to 20 cm eastwards. The gradient demonstrates the geographic interface between the strong year classes 2002 and 2004.

3.5 Information from the fishery for Norwegian spring spawning herring

Because of the poor market prospects and low prices for herring for human consumption, the Icelandic fishery has been much less intense than in previous years and in mid-August the total catch was only about 50 thousand tonnes as compared to 120 thousand tonnes at the same time in 2005.

As in 2005, the Icelandic fishery began in mid-May and like then the May catch was mainly taken in the Faroese EEZ and on either side of the division line between Faroes, Iceland and the International area (Figure 3.5; based on about 30 thousand tonnes). In 2005, Iceland took a good part of their catch in the first half of June in Icelandic waters off the central east coast. However, around mid-June these herring suddenly start migrating east and northeast. After that practically no more catches were taken inside the Icelandic EEZ and the whole fleet shifted to the international area ENE of Jan Mayen and, later, to the Svalbard zone.

Looking at the catch figure (Figure 3.5) it seems that the herring migrated farther north and west inside the Icelandic EEZ than in 2005. However, of most interest in this context is the fact that the Icelandic fishery continued off Northeast Iceland until around 10 August when it stopped suddenly and the whole fleet shifted northeast to continue their fishing in the international zone E and NE of Jan Mayen. Whether the herring had migrated out of Icelandic water by 10 August or simply became temporarily too scattered for efficient fishing is not known.

It is of interest to note that the catch in the autumn 2005 fishery for Icelandic summer spawning herring east of Iceland was somewhat mixed with large Norwegian spring spawners. However, the ratio of Norwegian herring was generally very low or about 1–2% by number and 3% by weight. From surveys east of Iceland in January/February 2006 it is known that these Norwegian herring did not leave to spawn at Norway, but seemed to follow the Icelandic summer spawners when they started migrating to the south and west for their spring feeding south of Iceland.

3.6 Aerial surveys

In 2006 there was no accessible information on aerial surveys.

4 Discussion

4.1 Hydrography

The influence of the EIC was stronger in May 2006 compared to May 2005 that resulted in a colder western Norwegian Sea in May 2006 compared to May 2005. After the warm years 2003 and 2004 with a relatively large western extension of AW in the Norwegian Sea the western Norwegian Sea has been colder the last two years. This cannot be explained by the NAO index since it has been near or less than normal the last years. However, a closer look in the monthly surface pressure maps for the region show that there was strong southwesterlies during January 2005 that might explain the stronger influence of EIC in 2006. The lower temperatures in the core of the western branch of the NWAC, seen at the Svinøy section, for 2006 compared to 2005 is probably due to lower temperature in the inflowing AW through the Faroe-Shetland Channel. There a temperature reduction for 2005 is observed. However, at larger depths (400–500 m) a large warming from 2005 to 2006 is observed in the eastern Norwegian Sea probably due to a more vertical extension of the AW there.

4.2 Plankton

From 2004 to 2005 there was no change in zooplankton biomass in the Norwegian Sea as measured in May. In 2006 average biomass decreased in the total area and the eastern Norwegian Sea. In the region west of 2°W, zooplankton biomass increased slightly, equalling the long term mean. Biomass in the eastern Norwegian Sea was record low for the time series. The overall distribution pattern of zooplankton biomass during the three years was similar, including high biomass in the cold water of the EIC. In 2006 the elevated biomass usually observed off Troms of the northwestern Norwegian Sea had disappeared (Figure 3.2.2.1). Although biomass of the cold water western regions was not higher than the long term mean, an eastward extension of the EIC in 2006 may have caused a wider distribution of waters with relatively high biomass.

From May to July-August a normal decrease in zooplankton biomass was observed. This decrease is related to the seasonal development of zooplankton stocks involving development into younger stages after recruitment, descent to overwintering depths and mortality due to feeding by predatory zooplankton, fish and others.

4.3 Norwegian Spring Spawning Herring

It was again decided not to draw a migration map for the herring in 2006. The early season migration seems fairly well understood but the late summer migration and wintering areas are uncertain at the moment.

The Norwegian spring spawning herring is still in a state characterized by large changes in the migration pattern. By the autumn of 2005 the wintering area of the Ofotfjord and Tysfjord in northern Norway has been almost abandoned, with only about 700.000 tonnes out of a spawning stock at about 6.4 million tonnes wintering in the fjords during last winter. Only about 3 million tonnes was measured in the new oceanic wintering area outside Vesterålen/Troms in northern Norway. There were consequently missing about 3 million tonnes in the wintering area estimate obtained in November 2006. Whether this deficiency is due to a major underestimate in the wintering areas or that a third, new and undiscovered oceanic wintering area has been established is not known.

The spawning in 2006 had a northerly distribution with relatively small concentrations spawning at Møre. Some of this behaviour could be explained by the large amount of the recruiting 2002 year class spawning for the first time with an expected northerly distribution due to a short spawning migration from the Troms wintering area. Warm ocean climate could possibly also partly explain a northerly spawning.

After spawning in early March the herring migrated northwest and west into the Norwegian Sea. According to individual size and spawning position, the herring spread in the normal size/age structured manner with two major separate concentrations to the southwest and northeast. In between these two areas were much lower concentrations than observed only some years ago when the stock had a more northerly distribution. The southwestern concentration was situated in the southern part of the Jan Mayen zone, the eastern part of the Icelandic zone, the northern part of the Faroese zone and the southwestern part of the international zone. This concentration consisted of older herring in particular of the 1998 and 1999 year classes, but also with a significant number of the recruiting 2002 year class and the old outgoing 1992 year class. The mean weight in this area (III) was 274 grams and the mean length 33.4 cm. The total biomass estimated for this area in May was 4.3 million tonnes, somewhat above 50% of the expected spawning stock biomass in the coming winter. The northeastern concentration was totally dominated by the 2002 year class both in terms of numbers and biomass. In addition the 1998 and 1999 year classes were represented in significant numbers. The mean weight in this area (II) was 199 grams and the mean length 30.4 cm

By late July the southwestern herring concentration had moved further to the west as demonstrated in the Norwegian ecosystem survey in July-August (Figure 3.2.3.1.). The western migration in June-July is further confirmed in the Icelandic fisheries data, where significant fisheries took place west to about 16º west northeast of Iceland (Fig 3.5). Tracking of herring in the southwestern area during the July-August survey showed an easterly migration at 0.5–1 knots. By the middle of August the Faroese fleet left the southwestern fishing area and moved north and east to the northeastern herring concentrations to fish in the international zone. The same was experienced by the Russian fleet which moved eastward in the middle of August. These observations indicate that the herring moved eastwards from around early August, thus ending the main feeding period.

With regard to wintering areas in 2006 it is expected that the northeastern concentrations of young herring, mainly the 2002 year class, will winter off Troms like in the last winter. The situation for the southwestern feeding concentrations seems more uncertain. Last winter the largest herring from this feeding area migrated into the Ofotfjord and Tysfjord. The wintering concentrations in the fjords have decreased yearly with about 500.000 tonnes since 2002. Last winter the amount was down to about 700.000 tonnes which makes 200.000 tonnes a guess for the wintering tonnage in the fjords the coming winter if this trend continues. Whether the remaining southwestern concentrations will winter off Troms or further out in oceanic waters remains unclear and remains to be seen.

Herring of the 1998, 1999 and some 2002 year classes, feeding in the southwestern Norwegian Sea during summer 2006, experienced by far the highest plankton concentrations within the feeding areas of the herring as a whole. However, average zooplankton biomass did not exceed long term average concentrations, indicating that the western distribution of herring was not related to enhanced feeding conditions of this region. Rather, very poor feeding conditions as indicated by the low zooplankton biomass of the eastern Norwegian Sea may have induced the western migration route observed recent years. Increased distribution of waters with higher zooplankton biomass, as indicated by an eastward extension of the EIC, may also have caused improved feeding conditions for the western component of herring. In August herring of the southwestern areas still showed a westerly distribution, while elevated zooplankton concentrations seemed to have a slightly more easterly distribution compared to May. This may explain the eastward track of the herring at that time.

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 were very similar in 2004–2005 (differences in totals ≤6%). However, in 2006 the results diverged (differences in totals ~20%): while the Norwegian survey indicated a marginal decrease in abundance, the international survey indicated a marked increase. This discrepancy raises some questions.

First, why the Norwegian and the international survey gave different results, and which one is likely to be closer to the truth? Obviously, the coverage in the Norwegian survey is more limited. In particular, the Norwegian survey did not cover western areas (Rockall) where sometimes fairly high densities of blue whiting were registered by other vessels. Indeed, the major part of the difference is coming from the Rockall subarea, whereas in the Hebrides subarea, the traditional core spawning area, the difference is minor. Norwegian coverage in Rockall has never been extensive, such that this “miss” does not compromise the internal consistency of the time series. Thus, in a way both estimates are “correct”. Nevertheless, the international survey represents much larger survey effort with wider coverage, denser network of cruise tracks and larger number of trawl stations than the Norwegian survey. The international survey is thus expected to give a better and more precise estimate of the total stock.

Second, how can the large increase in abundance suggested by the international survey be explained? The largest part of the increase originates from the Rockall subarea, and almost as much from the Hebrides. Coverage in these areas was similar in both 2005 and 2006, such that the change may well be real. Also the sentiment in the fishery supports this conclusion: in 2005, the fishery during the latter half of the season was perceived as poor, whereas in 2006 the perception remained more positive. The increase in the estimate is largely due to two year classes, those from 2002 and 2003. In both the Norwegian and the international survey, year class 2002 appeared as moderate or strongest at age 2 years but as rather weak at age 3 years. There are several possible explanations, either biological (late maturation of the bulk of the cohort, or a significant proportion of the cohort maturating already at age 2 years but then skipping the second spawning season) or a mere sampling effect (year class underrepresented in the samples). Very little of the year class 2003 matured at age 2 years and this year class is still recruiting to the spawning stock. Currently it looks like being of moderate strength; the increase in age class 3 from 2005 to 2006 reflects more the low abundance at that age in 2005 rather than the numbers in 2006 being high.

Age structure of blue whiting spawning stock has changed drastically from last year. During the period 2002–2005, year class 2000 dominated the spawning stock numerically. In 2006, it is reduced to rank four. While this may reflect low catchability of large blue whiting with survey trawls, it is also indicative of high total mortality. None of the later year classes appear to have strength anywhere close to that of the 2000 year class. In particular, numbers of young blue whiting (1–2 years) continue to be very low. While this survey covers only small parts of the distribution area of immature blue whiting, this is not worrisome as such. However, similar signals are seen in other areas.

The distribution of blue whiting was rather typical. The greatest concentrations were recorded close to the shelf edge from northern Porcupine Bank to the Hebrides. However, a larger proportion of the stock resided in the Rockall area than in earlier years.

The two surveys provide complementary information on blue whiting spawning stock. Results from the Norwegian survey are needed to assess the development of the blue whiting spawning stock before the conception of the international survey; only the time series from the Norwegian survey has been used in WGNPBW in tuning blue whiting assessment. However, the international survey provides better coverage and is therefore likely to be less affected by changes in distribution within the spawning area. While the time series is still very short (3 years), it would be advisable to incorporate also information from this survey in the assessment.

4.4.2 Norwegian Sea May survey

Estimates in 2000–2006 are available both for the total survey area and for the "standardised" survey area (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 well as in the west where large blue whiting occur. As these variations reflect non-biological 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 total stock estimate in numbers is greatly (by >50%) reduced from the relatively stable of 2003–2005. Reduction in the total biomass is somewhat less drastic (~26%) in comparison to 2005 but larger in comparison to earlier years. The change from 2005 is almost entirely due to very low abundance of age group 1 year — abundance (both in biomass and numbers) actually slightly increased for all the older age groups combined. In fact, age group 1 year (2005 year class) is the smallest one on record, being by one order of magnitude weaker than the previous minimum. Reflecting the paucity of age group 1 year blue whiting, mean age in the stock reached a new record, 2.8 years (earlier range 1.3–2.1 years). The 2004 year class that was strong in 2005 appears now as being below average. Older age groups appear as moderate in comparison to surveys in 2000–2005 (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).

The performance of this survey in predicting recruitment is not yet known, as the overlap with the assessment estimate is limited and the latter in general is plagued by uncertainties that reflect scarcity of data on the most recent year classes. However, the result is in line with the recruitment index from the Barents Sea where the index in 2006 was the lowest one since 1999.

Distribution observed this year looks broadly similar to that observed in earlier years.

4.4.3 Concluding remarks

In summary the two surveys targeting blue whiting provide somewhat different outlooks on the stock as they cover partly different stock components. Stock numbers and biomass in the

Norwegian Sea survey are rather stable except for exceptionally low abundance of 1 year (2005 year class) old blue whiting. Abundance of young blue whiting (1–2 years of age) was also low in the spawning area. However, spawning stock abundance appears to be increasing. Both surveys suggest an overall decrease in comparison to the period 2002–2004.

5 Planning

5.1 Planned acoustic survey of the NE Atlantic blue whiting spawning grounds in 2007

In 2004–2005, 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 surveys in spring 2005 and 2006. Based on experiences gained, the overall timing of the survey (from mid-March to mid-April) appears appropriate. We follow the target areas as suggested in 2005 (Figure 5.1.1):

1. Core area spawning area: northern Porcupine-Hebrides shelf edge
2. a. western Porcupine
   b. Rockall and Hatton Banks
   c. southern Faroes
3. 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 possibly as many as six parties will contribute to the blue whiting survey in 2007. Norway 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 high research effort in the core survey area as well coverage of the Porcupine slope spawners and aggregations to the southwest, whilst avoiding double counting. Russia (PINRO and AtlantNIRO) may participate. It was also suggested that participation by Iceland in target area 3b 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 survey dates	Primary target area [secondary]
Celtic Explorer	EU (Ireland)	21	18	28/3–17/4	1 [2b]
G. O. Sars	Norway	30	25	15/3–13/4	1 [2c]
Magnus Heinason	The Faroes	15	11	28/3–11/4	2c
Tridens	EU (Netherlands)	18	14	5/3–23/3	2a [3a]
F. Nansen/Smolensk	Russia		30	15/3–13/4	1 [2c]
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 and trawl intercalibrations.

The results of the cruises will be collated at a two-day meeting in the Netherlands (Amsterdam), 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 2007

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 2007. 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: 62°00'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 2007 Øyvind Tangen, Norway has been appointed. Detailed cruise lines for each ship will be provided by the coordinator as soon as final vessel availability and dates has been decided.

It is proposed that the Danish vessel start its survey in the beginning of May. 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 November 2006) 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 north of 62°N (mainly the Faroese area). 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 2006 survey. Therefore, effort should be put into this task at the 2007 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. 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" (PGNAPES report 2005).

Norway plan to hire two commercial vessels on a three-week survey in the northern herring areas in the Norwegian Sea in July-August 2007.

Iceland will apply for vessel time for three weeks in June-July 2007 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 2007 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	34	27	28/4 – 31/5
Johan Hjort	Norway	30	25	20/5 – 15/6
RV	Russia	15	15	15/5 – 30/5
Dana	Denmark (EU)	30	23	1/5 – 30/5
Magnus Heinason	Faroes	14	12	2/5 – 16/5
Arni Fridriksson	Iceland	26	23	4/5 – 31/5
RV	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 2006.

The following investigations should be targeted:

- 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 codend 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 2007 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 (PGNAPES report 2005).

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)

At the PGNAPES meeting in 2005 a survey 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, was presented and adopted by the group.

Some issues have been mentioned by the participants were the national procedures are different from the manual or where protocol or standardizations should be revised.

A new acoustic manual is under construction combining both existing PGHERS and PGNAPES formats. This draft manual is to be reviewed by all participants before final submission and review at the PGHERS meeting in 2007. The aim of producing a single updated manual is to streamline the content and update to include developments in user equipment and survey methodology.

The draft version is to be sent for review to participating members of both planning groups for comments prior to the PGHERS 2007 meeting. Eckhard Bethke (Germany) is nominated for the final update of the manual.

6.1 Biological sampling procedure

In the manual it is stated that of herring and blue whiting samples of 100 fish per species should be used for data collection of length, weight, sex, maturity and age per individual. Some nations do only use samples of 30 or 50 individuals for this sampling. For herring it has been found that these small samples are not representative for the length distribution in the total catch.

As a general role the group recommends a minimum of 50 fish for blue whiting and 100 fish for herring.

6.2 Plankton sampling

In the manual it is specified to take zooplankton samples by the use of a WP2 net in a vertically haul from 200 m or the bottom to the surface at a speed of 0.5 m/s. There are indications that krill will escape with a hauling speed of 0.5 m/s and the hauling speed should be increased to 0.75 – 0.8 m/s. The group recommends that this question is raised for plankton specialists.

In order to check the accuracy of the plankton splitter, displacement volumes of the resulting partitionings were determined at four selected stations of the RV “Dana” survey. The total plankton volume at those selected stations varied between 11 and 44 mL. The splitter was never able to divide the sample into equal halves. Depending on whether the larger or the smaller partitioning was selected the deviation was between 13.3 and 42.9% (mean = 28.4%, SD = 15.6%) or 15.4 and 75.0% (mean = 44.9%, SD 31.6%), respectively. Therefore, it is recommended that at future cruises the displacement volume of all partitionings should be determined. See Figure 6.2.1.

A Folsom splitter might be a good alternative. Its usefulness has been tested. However, it is mandatory for this splitter to be placed on a horizontal plane which hardly can be achieved on a constantly moving ship. It is therefore recommend that the displacement volumes of the splitting results is determined are recorded for each plankton sample taken.

6.3 Trawling

Problems catching larger schools have occurred for some participants in the acoustic surveys on Norwegian spring spawning herring in the Norwegian Sea. Experience gained at the different vessels indicates that problems in catching herring schools can be hampered if the size of the gear is too small. It is therefore recommended by the group that each vessel should use a trawl with the highest practical vertical net-opening as possible in order to get a representative catch (i.e. sample) for herring schools. (See text table Section 1).

6.4 PGNAPES exchange format

There has still been uncertainty about species codes to be used during the exchange of data from the surveys. It is recommend that all caught species should be reported, as this is an "ecosystem" survey. Instead of different three-letter codes it is recommend that TSN (Taxonomical Serial Number) codes are used. TSN is the numbering system provided by ITIS (Integrated Taxonomic Information System, www.itis.usda.gov). A TSN number links to a species name and its hierarchical classification. TSN also handles taxonomical niceties like synonymy and subspecies. Furthermore it has codes for higher levels like genera, families etc. ITIS is updating and maintaining the system (in contradiction to the NODC-system, that is now outdated).

6.5 A comparison of ageing the Norwegian spring-spawning herring between Iceland and Norway

In order to test consistency in age reading of Norwegian Spring Spawning herring a comparison in age readings between age readers in Iceland and in Norway has been carried out (WD: Òskarsson, G. J. "Short notes on a difference between Iceland and Norway in aging the Norwegian Spring Spawning herring). The comparison was done on total 300 samples from three different stations collected on board of RV "Árni Friðriksson" in a survey conducted in May 2006.

The results of the age comparison were similar for the three stations. In the text table below the results of a comparison of ageing of NSSH between the Norwegian and the Icelandic age reader for three different stations ($X_{\text{Norway}} - X_{\text{Iceland}}$) are shown.

	St. 217	St. 224	St. 240	Total
No difference (%)	84.2	85.1	87.1	85.5
+1 year difference (%)	9.5	2.3	4.3	5.5
-1 year difference (%)	6.3	12.6	7.5	8.7
More difference (%)	0.0	0.0	1.1	0.4
Number of fish	95	87	93	275

Overall, 86% of the fish got the same age by the readers, 14% got difference of one year, while only 0.4% got more difference (one fish with two years difference). Overall, the difference between the two age readers is considered to be within the expected and acceptable level. Furthermore, the results indicate that the difference should not cause a serious biased assessment towards certain year classes. It is suggested that age reading exercises should be carried out in a regular basis among others Institutes dealing with the Norwegian spring-spawning herring.

7 PGNAPES database, ToR (f)

The April-survey west and north of the British Isles: All nations supplied data in the PGNAPES database format. This was very encouraging. This is the first time we have managed to have a complete survey dataset in the PGNAPES database.

The May-survey in the Norwegian Sea: Data have been supplied in the agreed format by FO, and partially by IS and NO. DK, IS, NO will supply data to the database as soon as data are ready. Last year a manual was produced, and an agreement was made that every nation should supply data in the PGNAPES database format to the Faroese Fisheries Lab. before the meeting. It is imperative that the nations are able to supply data in the right format before the meeting to avoid that the members of the group use valuable time fitting data into the database during the meeting. The only way the members can be able to supply flawless data before the meeting is to stress the importance of using the supplied PGNAPES access base actively during the cruise. This will ease the work of the DBA, and further it would guarantee that the data are exported in the correct PGNAPES format. Further this will also ease the work on board the survey vessel.

Once a complete dataset from the surveys are given in the PGNAPES database format, an Oracle database (10g express edition) will be mounted in Faroes Fisheries Laboratory, Tórshavn, and the data collected so far will be loaded. The database will be accessible via the internet.

The group discussed the species table in the PGNAPES database. It was agreed to change the 3- letter codes to TSN (Taxonomical Serial Number) codes. Further the ICES three-letter codes, NODC-code, the STN numbers and scientific name of the species were also added to the species table.

An invitation from PGHERS to attend a 2 day planning meeting around the efforts of Teunis Jansen (DK) to make an internet based assessment application was received in early June, and Leon Smith (FO) attended the meeting to consider the opportunity of cooperation. The PGHERS have already developed an internet portal to collect acoustic and catch data from their members.

As the PGHERS tables were scrutinized and changed during the meeting it was possible to get insight into the underlying PGHERS database, and it was obvious that data easily can be interchanged between the two databases. Teunis Jansen offered us the source code of the system to put up anywhere we wanted to, and an invitation to develop modules for the system. The future aspect is that all research vessels will have on-line internet access and then an online internet assessment application will come to full use.

For the future work it is recommended to continue with our exchange format, having in mind the time it takes to synchronize the output formats from the participating nations.

If we decide to use the future PGHERS internet assessment application, it is easy to upload data from the PGNAPES format to the PGHERS format. We shall not put a great effort in developing a web interface.

8 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 2006 in case the present development in the feeding migration continues.

9 References

Foote, K. G., Knudsen, H. P., Vestnes, G., MacLennan, D. N., and Simmonds, E. J. 1987. Calibration of acoustic instruments for fish density estimation: a practical guide. ICES Coop. Res. Rep. 144: 57 pp.

Heino, M. *et al*. 2006a. International blue whiting spawning stock survey spring 2006. Working Document to the Northern Pelagic and Blue Whiting Fisheries Working Group, Copenhagen, 24–30 August 2006.

Mikko Heino, Henrik Soiland, Martin Dahl, Jaime Alvarez, Valentine Anthonypillai, Kirsti B. Eriksen, Jan de Lange, Elna S. Meland, Ronald Pedersen, Oyvind Tangen & Terje Torkelsen, Alexander Krysov, 2006b. Blue whiting survey during spring 2006. Toktrapport/Havforskningsinstituttet/ISSN.

ICES. 2004. Report of the Planning Group on Surveys on Pelagic Fish in the Norwegian Sea 2004. ICES CM 2004/D:07: 58 pp.

ICES. 2005. Report of the Planning Group on Northeast Atlantic Pelagic Ecosystem Surveys (PGNAPES). ICES CM2005/D:09: 92 pp.

Jacobsen, J. A., Smith, L., and Joensen, M. M. 2006. Cruise Report, cruise no. 0624: Joint investigations on blue whiting south of the Faroes and in the area west of the British Isles, 29 March – 12 April 2006. Faroese Fisheries Laboratory, Tórshavn, the Faroes.

Mullins, E., Johnston G., Power G., Goddijn L., Mackey, M. 2006. Irish Blue Whiting Acoustic Survey Cruise Report. Marine Institute, Ireland.

Toresen, R., Gjøsæter, H., and Barros de, P. 1998. The acoustic method as used in the abundance estimation of capelin (*Mallotus villosus* Müller) and herring (*Clupea harengus* Linné) in the Barents Sea. Fish. Res. 34: 27–37.

Totland, A. and Godø, O. R. 2001. BEAM – an interactive GIS application for acoustic abundance estimation. *In* T. Nishida, P.R. Kailola and C.E. Hollingworth (Eds): Proceedings of the First Symposium on Geographic Information System (GIS) in Fisheries Science. Fishery GIS Research Group. Saitama, Japan.

Table 1.3.1: Organisational frame of the coordinated herring investigations in the Norwegian Sea, 1995–2006.

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 (ICES CM 2005/D:09)
2006	Faroe Islands, Iceland Norway, Russia, EU	14	Galway (ICES CM 2005/D:09) + correspondence	Reykjavik (this report)

Table 2.1: Sampling at the participating vessels during the International Blue whiting spawning stock survey conducted in March–April 2006 in the North Atlantic, targeting blue whiting on the spawning grounds west of the British Isles.

PLATFORM	COUNTRY	SURVEY AREA	PERIOD	LENGTH OF CRUISE TRACK (NM)	TRAWL STATIONS	CTD STATIONS
Celtic Explorer	IR	55°00'N–60°00N, 15°W–10°00W	23.3–8.4	2175	17	28
G.O. Sars	NO	54°00´N-61°00´N 16°00´W-02°00’W	18.3–5.4	3087	24	76
Tridens	NL	51°00N–57°00'N, 17°00W–08°00W	15.3–27.3	1365	10	30
AtlantNIRO	RU	54°00'N–59°00N, 20°00W–14°00W	4.3–29.3	2512	30	46
Magnus Heinason	FA	59°30'N–61°300N, 15°00W–6°00'W	31.3-11.4	1254	14	21

Table 2.2: Sampling at the participating vessels during the International North East Atlantic Ecosystem survey conducted in April–May 2006.

PLATFORM	COUNTRY	SURVEY AREA	PERIOD	LENGTH OF CRUISE TRACK (NM)	TRAWL STATIONS	PLANKTON SAMPLES	CTD STATIONS
Dana	DK	62°00N–72°30'N, 2°00W–15°00E	28.4 – 25.5	3761	44	41	41
Johan Hjort	NO	68°20´N-74°30´N 10°00É-39°30É	23.5 – 11.6	2499	25	35	36
Magnus Heinason	FA	62°N–66°30'N, 9°00W–0°30'W	3.5 – 17.5	1651	12	35	35
G.O. Sars	NO	62°00-75°30´N 05°00W-19°00E	27.4 – 1.6	5233	50	64	83
Arni Fridriksson	IS	62°30`N–69°30'N, 16°00W–4°00W	9.5 – 1.6	3985	45	78	84
Håkon Mosby	NO	61°00´N-75°00´N 02°00W-18°00É	4.5 – 22.5	2090	-	106	76
*Bjarni Sæmundsson	IS	63°00'N–70°30'N, 28°00'W–09°00'E	14.5 – 1.6	N/A			124

***The survey carried out by the RV "Bjarni Sæmundsson" was not a part of the international coordinated survey.**

Table 2.3: Other surveys which are related to the Norwegian spring-spawning herring, blue whiting and mackerel conducted in the Northeast Atlantic in summer 2006.

PLATFORM	COUNTRY	SURVEY AREA	PERIOD	LENGTH OF CRUISE TRACK (NM)	TRAWL STATIONS	PLANKTON SAMPLES	CTD STATIONS
M/V Libas	NO	62°00'N–74°00'N, 17°00'W–17°00'E	15.7– 6.8	4450	68	55	55
M/V Endre Dyrøy	NO	62°00'N–74°00'N, 17°00'W–17°00'E	15.7– 6.8	4300	68	62	62

Table 3.1.2.1: Age- and length-stratified abundance estimate of blue whiting in the spawning area, west of the British Isles, in the Norwegian blue whiting spawning stock survey in March–April 2006. Data from RV "G. O. Sars". Target strength used for blue whiting: 21.8 log L – 72.8 dB.

	AGE IN YEARS (YEAR CLASS)												MEAN	
LENGTH	1	2	3	4	5	6	7	8	9	10+	NUMBERS	BIOMASS	WEIGHT	MATURE
(CM)	2005	2004	2003	2002	2001	2000	1999	1998	1997	-1996	(10^6)	(10^6 KG)	(G)	%
15.0 – 16.0	238	0	0	0	0	0	0	0	0	0	238	4	16.3	0
16.0 – 17.0	1636	0	0	0	0	0	0	0	0	0	1636	32	19.4	1
17.0 – 18.0	1104	6	0	0	0	0	0	0	0	0	1111	26	23.0	4
18.0 – 19.0	857	20	0	0	0	0	0	0	0	0	877	23	26.6	16
19.0 – 20.0	458	222	0	0	0	0	0	0	0	0	680	22	31.8	16
20.0 – 21.0	384	535	0	0	0	0	0	0	0	0	919	37	40.7	51
21.0 – 22.0	113	422	27	0	0	0	0	0	0	0	562	26	46.3	65
22.0 – 23.0	103	372	149	48	0	0	0	0	0	0	672	38	56.6	82
23.0 – 24.0	0	814	1142	840	0	0	0	0	0	0	2796	178	63.7	90
24.0 – 25.0	0	619	3533	2135	0	254	0	0	0	0	6540	457	69.8	100
25.0 – 26.0	0	252	6791	8083	1820	229	0	0	0	0	17175	1314	76.5	100
26.0 – 27.0	0	577	3328	8573	2551	1549	0	0	0	0	16578	1390	83.8	100
27.0 – 28.0	0	0	2689	7740	3683	1025	0	0	0	0	15137	1410	93.2	100
28.0 – 29.0	0	0	895	5446	2862	1600	4	0	0	0	10806	1136	105	100
29.0 – 30.0	0	0	813	2239	2357	1217	401	0	0	0	7027	832	118	100
30.0 – 31.0	0	0	0	867	1408	873	352	156	0	0	3656	489	134	100
31.0 – 32.0	0	0	79	487	328	890	288	0	0	0	2072	299	144	100
32.0 – 33.0	0	0	0	10	845	279	244	17	0	0	1395	231	165	100
33.0 – 34.0	0	0	0	143	90	49	241	264	0	0	786	153	194	100
34.0 – 35.0	0	0	0	7	55	0	42	29	89	0	221	47	214	100
35.0 – 36.0	0	0	0	0	0	201	6	0	7	0	214	48	225	100
36.0 – 37.0	0	0	0	0	0	0	14	0	32	32	78	16	211	100
37.0 – 38.0	0	0	0	0	0	0	0	0	2	8	10	3	248	100
38.0 – 39.0	0	0	0	0	0	0	0	0	0	0	0	0	.	.
39.0 – 40.0	0	0	0	0	0	0	0	0	0	0	0	0	.	.
40.0 – 41.0	0	0	0	0	0	0	0	0	0	0	0	0	.	.
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	35	35	12	356	100
TSN (10^6)	4893	3839	19446	36617	15998	8167	1592	466	129	75	91221			
TSB (10^6 kg)	125	232	1577	3326	1677	917	240	81	26	21	8221			
Length (cm)	17.9	23.2	26.0	27.0	28.3	28.8	31.4	32.5	35.1	39.4	26.6			
Weight (g)	25.5	60.4	81.1	90.8	105	112	151	174	203	281	90.1			
Condition	4.4	4.8	4.6	4.6	4.6	4.7	4.9	5.1	4.7	4.6	4.8			
% mature	10	78	100	100	100	100	100	100	100	100	94.2			
% of SSB	0	2	20	41	21	11	3	1	0	0				

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

YEAR	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	MEAN
Total area	8.2	13.4	10.6	14.2	11.6	13.1	12.4	9.2	9.2	8.9	11.1
Region W of 2°W	9.1	13.4	13.5	15.7	11.4	13.7	14.6	9.8	10.7	12.6	12.5
Region E of 2°W	7.5	14.4	10.2	11.8	8.7	13.6	9	8	8.2	4.8	9.6

Table 3.2.3.1: Age- and length-stratified abundance estimate of Norwegian spring-spawning herring in May-June 2006 for total area and abstract of estimate for Subarea I, II, III and Subarea II+III.

Length	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Number	Biomass	Weight
10	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0	6
11	2071	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2071	18	9
12	1302	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1302	14	11
13	157	0	0	0	0	0	0	0	0	0	0	0	0	0	0	157	2	14
14	144	0	0	0	0	0	0	0	0	0	0	0	0	0	0	144	3	19
15	0	555	0	0	0	0	0	0	0	0	0	0	0	0	0	555	14	25
16	0	3315	0	0	0	0	0	0	0	0	0	0	0	0	0	3315	101	30
17	0	6702	0	0	0	0	0	0	0	0	0	0	0	0	0	6702	231	35
18	0	8743	0	0	0	0	0	0	0	0	0	0	0	0	0	8743	348	40
19	0	10855	0	0	0	0	0	0	0	0	0	0	0	0	0	10855	514	47
20	0	4167	10	0	0	0	0	0	0	0	0	0	0	0	0	4177	235	56
21	0	683	966	0	0	0	0	0	0	0	0	0	0	0	0	1649	110	67
22	0	0	1000	0	0	0	0	0	0	0	0	0	0	0	0	1000	72	72
23	0	0	1361	0	0	0	0	0	0	0	0	0	0	0	0	1361	116	85
24	0	0	1144	105	0	0	0	0	0	0	0	0	0	0	0	1249	123	98
25	0	0	759	156	0	0	0	0	0	0	0	0	0	0	0	915	98	107
26	0	0	219	714	0	0	0	0	0	0	0	0	0	0	0	933	122	131
27	0	0	105	2255	0	0	0	0	0	0	0	0	0	0	0	2360	355	150
28	0	0	0	3510	0	0	0	0	0	0	0	0	0	0	0	3510	573	163
29	0	0	31	4976	60	17	0	0	0	0	0	0	0	0	0	5084	923	182
30	0	0	0	3169	275	28	65	20	0	0	0	0	0	0	0	3557	710	200
31	0	0	0	956	579	630	557	474	0	0	0	0	0	0	0	3196	719	225
32	0	0	0	0	112	635	1921	1217	9	7	0	0	0	0	0	3901	969	248
33	0	0	9	0	9	415	2550	2964	189	50	25	31	0	109	0	6351	1698	267
34	0	0	0	53	0	32	1048	2036	132	115	5	0	76	109	0	3606	1038	288
35	0	0	0	0	0	53	140	560	129	193	20	95	200	106	53	1549	487	314
36	0	0	0	0	0	0	55	69	99	286	94	141	349	187	106	1386	475	343
37	0	0	0	0	0	0	0	32	0	0	15	77	152	247	62	585	210	359
38	0	0	0	0	0	0	0	0	0	0	12	0	30	34	102	178	67	375
39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	425
40																0		
N mill.	**3688**	**35020**	**5604**	**15894**	**1035**	**1810**	**6336**	**7372**	**558**	**651**	**171**	**344**	**807**	**792**	**324**	**80406**	**10342**	

Total herring area																	
Biomass 10^3 t	37	1487.5	497.7	2792.7	230.8	447.7	1664.9	1995.9	166.9	207.6	56.4	115.2	272.4	256.2	113.5		10342.2
Length cm	12.1	18.7	23.7	29.1	31.2	32.4	33.2	33.7	34.7	35.6	36.1	36.2	36.3	36.1	37.8		24.6
Weight g	10	42.5	88.8	175.7	223	247.4	262.7	270.8	299.4	319.1	330.2	335.2	337.1	323.7	360		128.6

Herring area I (Barents Sea)																	
Biomass 10^3 t	37	1486.2	454.1	113	0.1	0.3	1.3	0.9									2092.9
Length cm	12.1	18.7	23.5	26.9	32.5	32.5	32.5	32.5									18.9
Weight g	10	42.5	85.9	129.3	207	207	207	207									46.7
Herring area II (north-east)																	
Biomass 10^3 t		1.3	40.2	2278.9	49.5	162.1	559	695.4	9.5	15.8	6.6	0	7.1	87.4	46.5		3959.3
Length cm		20.6	26	29.1	31.5	32.2	32.9	33.4	34.1	35.3	33.7	.	34.5	35.2	37.5		30.4
Weight g		65.3	132.6	174.5	217.4	234	245.7	253.6	267.2	290.8	257.6	.	275.1	290.3	352.6		199
Herring area III (south-west)																	
Biomass 10^3 t			3.3	400.8	181.1	285.3	1104.6	1299.7	157.5	191.7	49.8	115.2	265.3	168.8	425		4290.1
Length cm			29.5	30	31.2	32.6	33.4	33.8	34.8	35.6	36.5	36.2	36.4	36.6	37.5		33.4
Weight g			201.5	204.7	224.6	255.8	272.4	281	301.6	321.7	342.9	335.2	339.1	344.2	365		274.2

Herring area II and III (NorwegianSea)																	
Biomass 10^3 t		1.3	39.8	2559.6	302.4	496.6	1723.7	1910.8	201.8	227	58.8	135.2	311.4	211.4	85.2		8265
Length cm		20.6	25.9	29.2	31.2	32.4	33.2	33.7	34.6	35.5	36.5	36.1	36.4	36.6	37.5		31.8
Weight g		64.8	130.8	175.8	216.7	246.8	264.3	273.9	296.7	318.1	341.7	332.5	338.2	341.9	360		232.5

Table 3.2.4.1: Age- and length-stratified abundance estimate of blue whiting in the North-east Atlantic Ecosystem Survey in May–June 2006, west of 20°E. Density is 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".

LENGTH (CM)	1	2	3	4	5	6	7	8	9	10	11	12+	NUMBER	BIOMASS	WEIGHT
16	7	0	0	0	0	0	0	0	0	0	0	0	7	0	18
17	36	0	0	0	0	0	0	0	0	0	0	0	36	1	27
18	345	0	0	0	0	0	0	0	0	0	0	0	345	12	35
19	835	34	0	0	0	0	0	0	0	0	0	0	869	36	41
20	1546	886	0	0	0	0	0	0	0	0	0	0	2432	111	46
21	2747	2338	1	0	0	0	0	0	0	0	0	0	5086	259	51
22	1611	5427	358	0	0	0	0	0	0	0	0	0	7396	433	59
23	335	5947	2717	86	0	0	0	0	0	0	0	0	9085	618	68
24	135	1675	6508	582	0	0	0	0	0	0	0	0	8900	723	81
25	124	643	7186	2189	0	0	0	0	0	0	0	0	10142	892	88
26	52	107	4926	3268	537	17	0	0	0	0	0	0	8907	838	94
27	15	3	1436	4475	235	14	8	0	0	0	0	0	6186	652	105
28	0	1	64	2914	866	10	3	0	1	0	0	0	3859	442	115
29	0	0	1	505	1713	48	5	4	0	0	0	0	2276	298	131
30	0	0	1	78	726	275	4	1	2	0	0	0	1087	159	147
31	0	0	0	3	181	286	21	3	0	0	0	0	494	81	163
32	0	0	0	0	45	147	45	1	0	0	0	1	239	41	172
33	0	0	0	0	17	44	129	36	46	0	0	0	272	54	197
34	0	0	0	0	0	35	44	19	0	0	0	0	98	21	211
35	0	0	0	0	0	7	7	7	0	0	0	0	21	4	224
36	0	0	0	0	0	0	7	7	0	0	0	0	14	3	222
37	0	0	0	0	0	0	1	1	0	0	0	0	2	1	346
38	0	0	0	0	0	0	1	1	0	0	0	0	2	1	272
39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.
40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.
41	0	0	0	0	0	0	0	0	0	7	0	0	7	3	401
Number 10^6	7788	17061	23198	14100	4320	883	275	80	49	7	0	1	67762		
Biomass 10^3t	403	1086	1989	1437	546	140	52	16	9.5	2.7	0	0.1		5681	
Length cm	21.4	22.9	25.3	27.1	29.1	31.3	33.2	34.0	33.3	41.1		32.5		25.0	
Weight g	51.8	63.6	85.7	102	126	159	189	203	193	393		172		83.8	

Table 3.2.4.2: Age- and length-stratified abundance estimate of blue whiting in the North-east Atlantic Ecosystem Survey in May–June 2006 for the standard area between 8°W–20°E and north of 63°N. Density is 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".

LENGTH (CM)	1	2	3	4	5	6	7	8	9	10	11	12+	NUMBER	BIOMASS	WEIGHT
16	7	0	0	0	0	0	0	0	0	0	0	0	7	0	18
17	11	0	0	0	0	0	0	0	0	0	0	0	11	0	25
18	179	0	0	0	0	0	0	0	0	0	0	0	179	6	32
19	0	342	0	0	0	0	0	0	0	0	0	0	342	13	39
20	278	1205	0	0	0	0	0	0	0	0	0	0	1483	63	42
21	95	3713	0	0	0	0	0	0	0	0	0	0	3808	189	50
22	0	6131	411	0	0	0	0	0	0	0	0	0	6542	380	58
23	0	5448	2573	83	0	0	0	0	0	0	0	0	8104	550	68
24	0	994	4994	336	0	0	0	0	0	0	0	0	6324	517	82
25	0	437	4899	1299	0	0	0	0	0	0	0	0	6635	618	93
26	0	30	1735	2465	369	54	0	0	0	0	0	0	4653	489	105
27	0	0	653	1663	363	61	38	0	0	0	0	0	2778	328	118
28	0	0	42	542	441	95	31	0	14	0	0	0	1165	153	131
29	0	0	17	144	305	119	92	61	0	0	0	0	738	105	143
30	0	0	0	18	50	31	40	6	19	2	0	0	166	26	156
31	0	0	0	0	7	21	39	3	0	0	0	0	70	12	171
32	0	0	0	0	22	1	6	7	1	0	0	8	45	8	184
33	0	0	0	0	9	2	0	3	0	0	0	0	14	3	197
34	0	0	0	0	0	0	0	0	7	0	0	0	7	2	227
35	0	0	0	0	0	0	0	0	3	0	0	0	3	1	214
36	0	0	0	0	0	0	0	0	1	0	0	0	1	0	339
37	0	0	0	0	0	0	0	0	2	0	0	0	2	1	346
Number 10^6	570	18300	15324	6550	1566	384	246	80	47	2	0	8	43077		
Biomass 10^3t	22.6	1099.4	1330.2	704	197.8	51.3	35.6	12	8.1	0.4	0	1.5		3463	
Length cm	19.9	22.6	25.0	26.7	28.2	28.7	29.6	30.0	31.2	30.5	.	32.5		24.3	
Weight g	39.6	60.1	86.8	108	126	134	145	150	172	156	.	184		80.4	

Table 3.2.4.3: Age-stratified abundance estimate of blue whiting in the North-east Atlantic Ecosystem Survey in May–June 2006 for the subareas shown in Figure 3.2.2. Density is 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".

	1	2	3	4	5	6	7	8	9	10	11	12+	TOTAL
Area I: Barents Sea													
Number 10^6	631	4030	618	53	81	99	20	23	3	0	0	0	5558
Biomass 10^3 t	23	224	46	7	14	16	5.4	5.3	0.9	0	0	0	342
Length cm	19.3	22.2	24.1	27.7	30.1	29.9	33.9	33.8	37.5				22.5
Weight g	36.4	55.5	75.1	131	173	165	263	225	275				61.5
Area II: central Norwegian Sea													
Number 10^6	1151	19139	18692	8476	2117	495	292	110	57	4	0	8	50541
Biomass 10^3 t	46	1169	1644	913	271	67	42	19	8.6	0.7	0	1.4	4181
Length cm	19.7	22.7	25.0	26.7	28.3	28.8	29.5	31.0	30.0	30.5		32.5	24.5
Weight g	39.8	61.1	87.9	108	128	135	144	171	154	165		184.4	82.7
Area III: SW Norwegian Sea and the Icelandic and Faroese EEZs													
Number 10^6	3450	623	4175	5416	2643	665	167	50	21	7	0	0	17217
Biomass 10^3 t	182	46	358	558	344	107	32	11	3.9	2.6	0	0	1644
Length cm	21.4	24.4	26.1	27.6	29.5	31.5	33.6	34.6	33.5	41.5			26.4
Weight g	52.6	73.8	85.7	103	130	161	190	205	185	401			95.5
All areas combined													
Number 10^6	5232	23794	23487	13944	4841	1258	481	185	81	11	0	8	73322
Biomass 10^3 t	250	1439	2048	1478	629	191	80	35	13	3.3	0	1.4	6167
Length cm	20.8	22.7	25.2	27.0	29.0	30.3	31.1	32.4	31.2	37.3		32.5	24.8
Weight g	47.9	60.5	87.2	106	130	151	165	188	167	310		184.4	84.1
"Standard" area													
Number 10^6	570	18300	15324	6550	1566	384	246	80	47	2	0	8	43077
Biomass 10^3 t	23	1099	1330	704	198	51	36	12	8.1	0.4	0	1.5	3462.7
Length cm	19.9	22.6	25.0	26.7	28.2	28.7	29.6	30.0	31.2	30.5		32.5	24.3
Weight g	39.6	60.1	86.8	108	126	134	145	150	172	156		184	80.4

Table 3.2.4.4: Age- and length stratified abundance estimate of blue whiting in Icelandic waters west of 16°W in May-June 2006. Data from RV "Arni Fridriksson". Target strength used for blue whiting: 21.8 logL-72.8 dB.

LENGTH	WEIGHT					N AGE						
(CM)	(G)	1	2	3	4	5	6	7	8	NUMBERS	BIOMASS	TOTAL
17	26.8	13249								13249	354	
18	35.9	99835								99835	3589	
19	41.5	323410								323410	13424	
20	47.1	574859								574859	27063	
21	55.0	495217		1446						496663	27336	
22	62.0	269393		0						269393	16691	
23	73.4	85960	103035	9514						198509	14561	
24	82.1	14854	189164	44014	7154					255185	20950	
25	91.1		256727	248620	0					505347	46040	
26	102.7		107895	375149	24956					507999	52187	
27	116.4		9529	288723	70719	4908				373880	43507	
28	130.9			69376	108045	10765				188187	24632	
29	141.9			0	42071	33055				75126	10657	
30	170.3			4006	11669	55144	20224			91043	15503	
31	170.7					17355	52064			69419	11850	
32	190.1					8677	26032			34709	6596	
33	196.6					3944	12787	7950		24681	4852	
34	219.4						16829	8414		25243	5538	
35	224.2						5259	5259	5259	15777	3537	
36									0	0	0	
37									0	0	0	
38	272.3								3155	3155	859	
Total N (´000)		1876776	666349	1040849	264613	133849	133195	21624	8414	4145669		
Total B ('000 t)		96	59	109	33	21	25	5	2		350	
Average L (cm)		20.4	24.6	26.1	27.7	29.8	31.8	33.9	36.1			23.7
Average W (gr)		51.1	88.0	104.7	126.5	160.2	185.2	212.2	242.2			84.4
% N		45.3	16.1	25.1	6.4	3.2	3.2	0.5	0.2			100.0
Condition(g/dm^3)		6.0	5.9	5.9	6.0	6.0	5.8	5.5	5.1			6.0

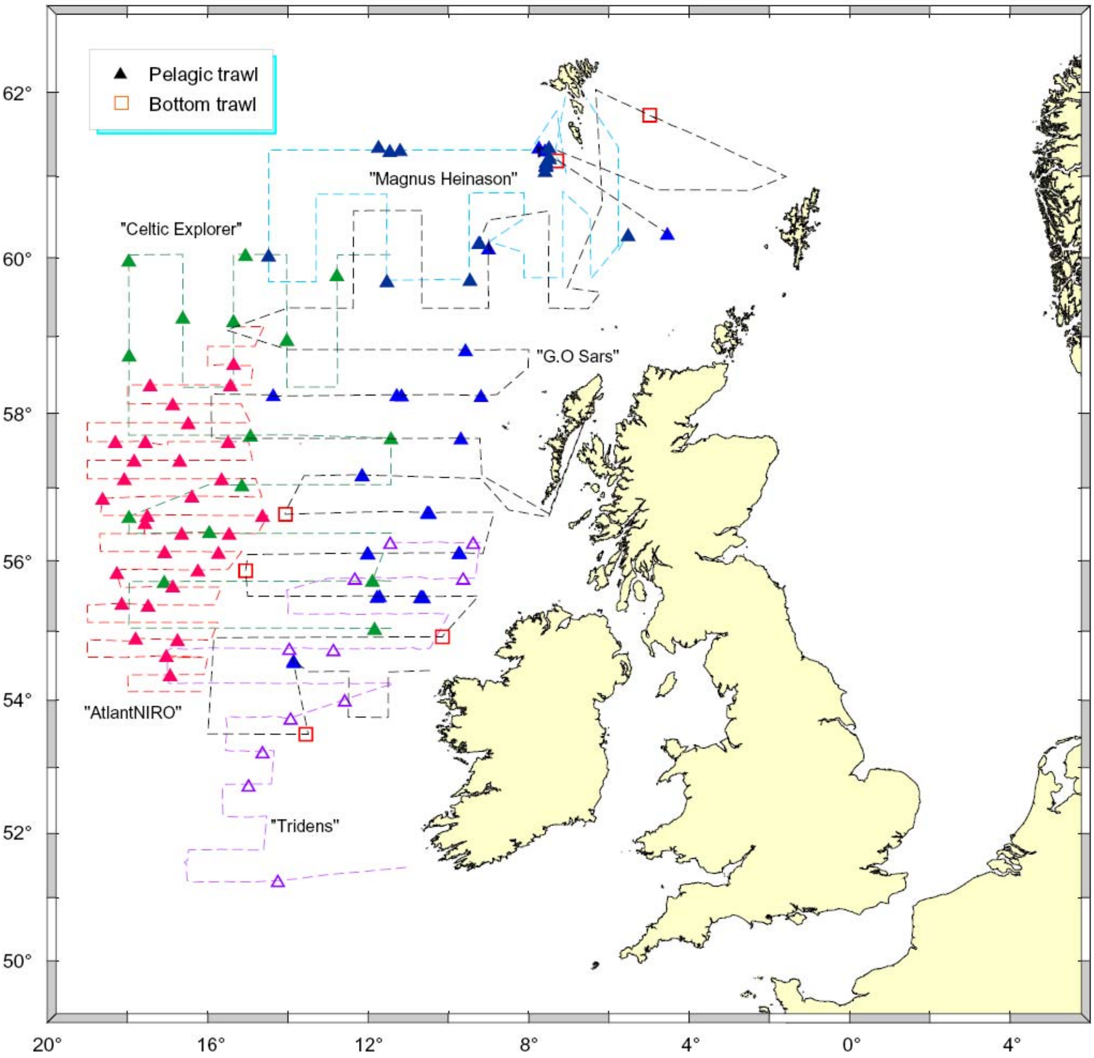


Figure 2.1: Cruise tracks during the International Blue whiting spawning stock in March -April 2006.

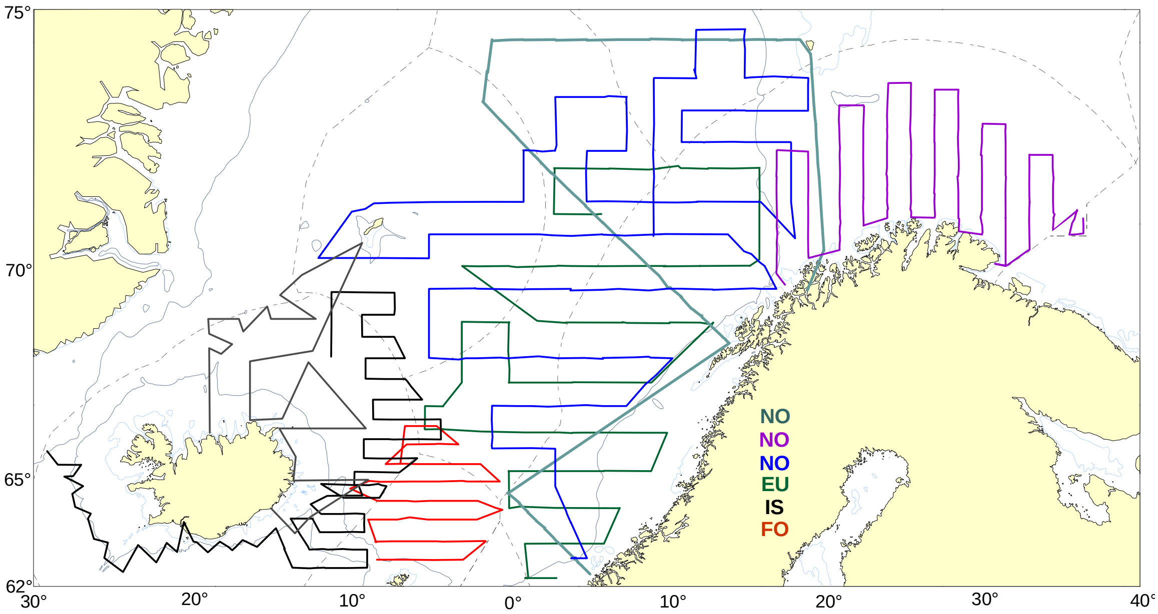


Figure 2.2: Cruise tracks during the International North East Atlantic Ecosystem Survey in April-May 2006.

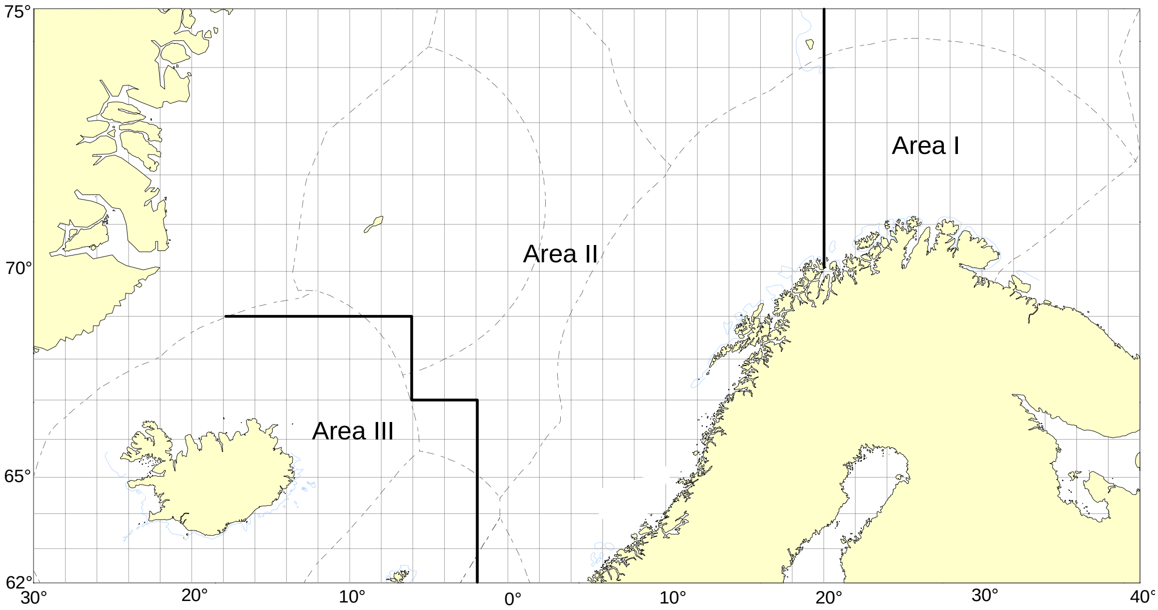


Figure 2.3: Areas defined for acoustic estimation of blue whiting and Norwegian spring spawning herring.

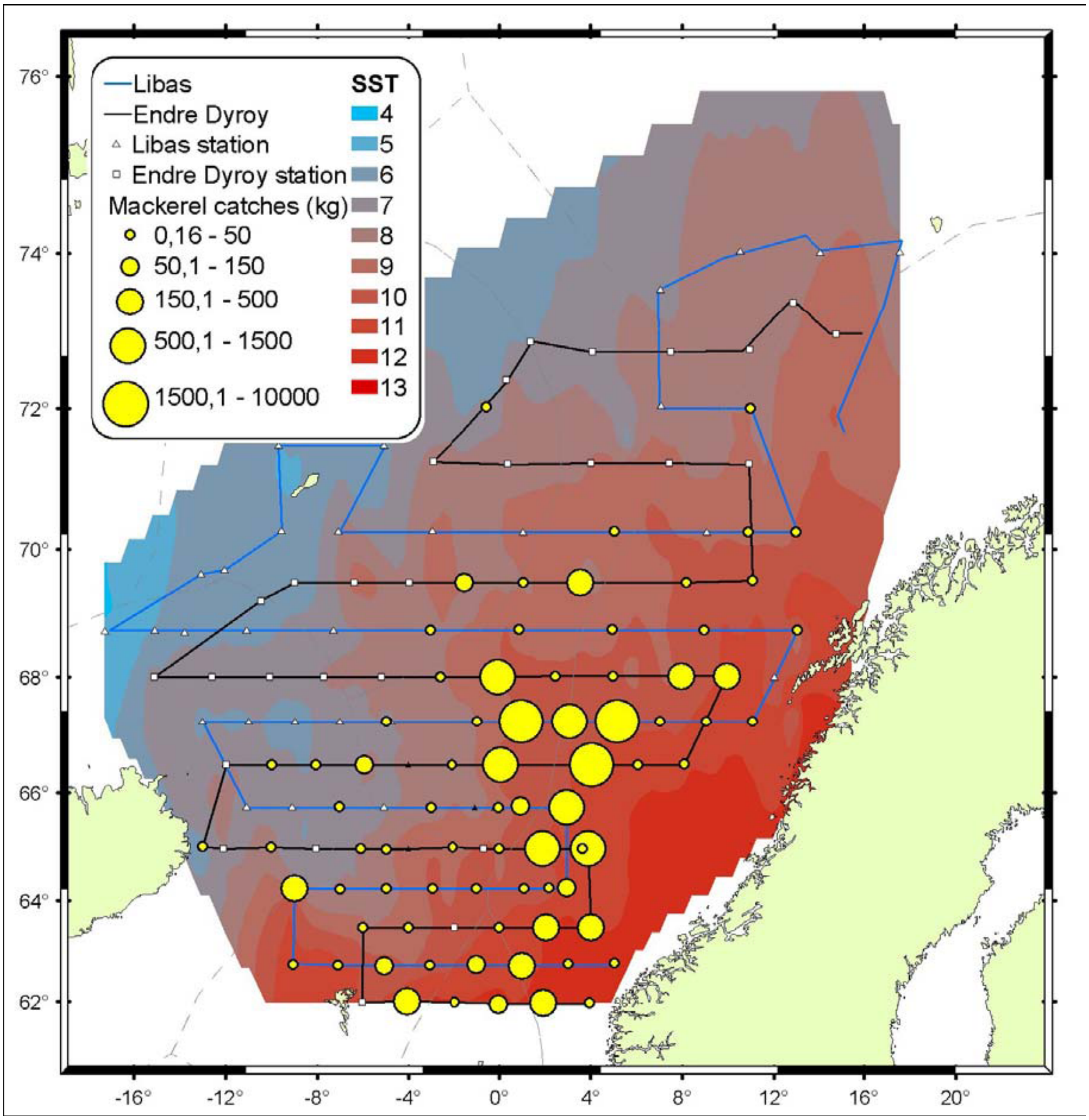


Figure 2.4: Surveys track and mackerel catches shown as kg/n.mi. from “Libas” and “Endre Dyrøy” in the Norwegian Sea, 15 July – 5 August 2006.

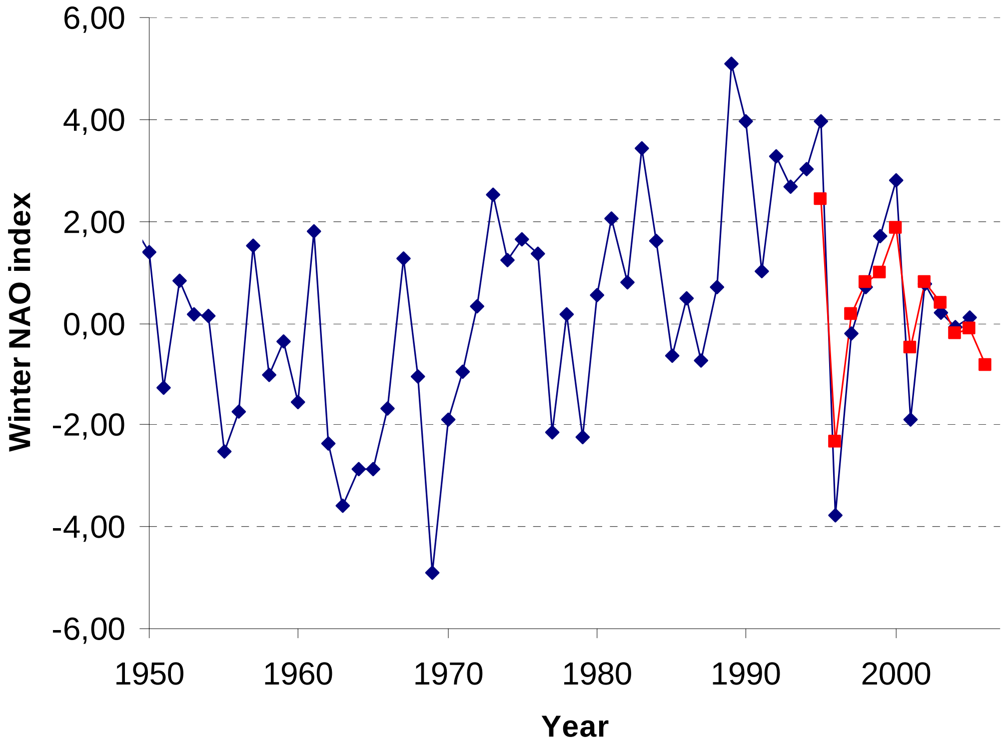


Figure 3.2.1.1: Hurrell's winter (Dec-Mar) NAO index (the difference of normalized sea level pressure between Lisbon, Portugal and Stykkisholmur/Reykjavik, Iceland from 1950 to 2005 (blue line) and Jones winter (Dec-Mar) NAO index (the difference between the normalised sea level pressure over Gibraltar and the normalised sea level pressure over Southwest Iceland) from 1995 to 2006 (pink line).

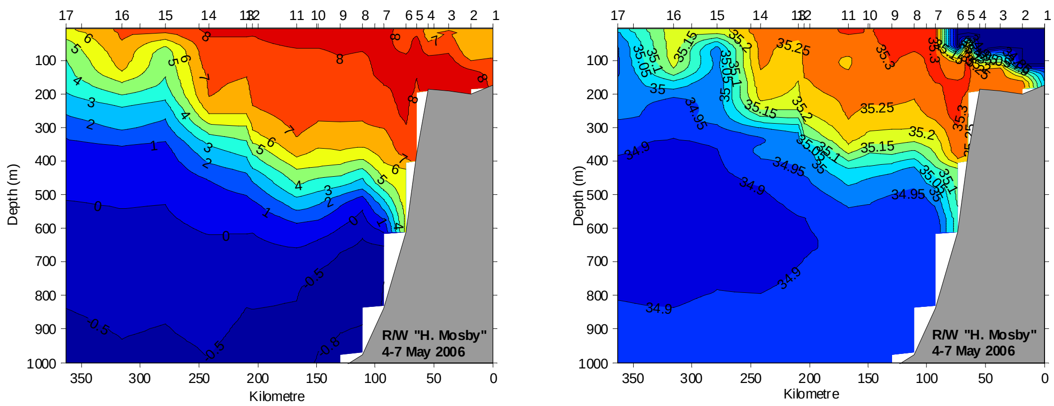


Figure 3.2.1.2: Temperature (left panel) and salinity (right panel) in the Svinøy section 4–7 May 2006.

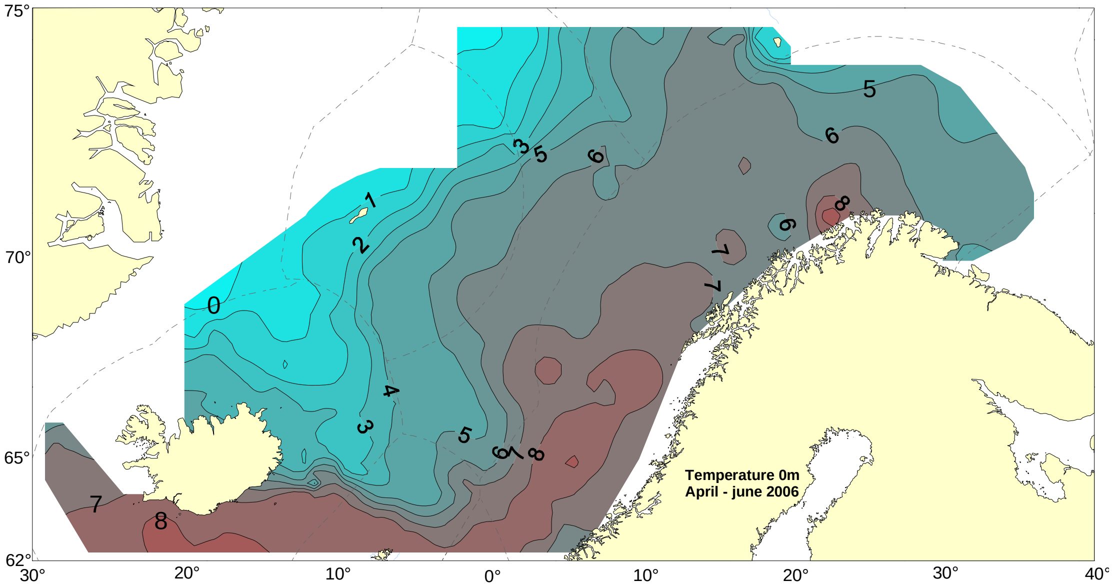


Figure 3.2.1.3: Temperature at the surface in May 2006.

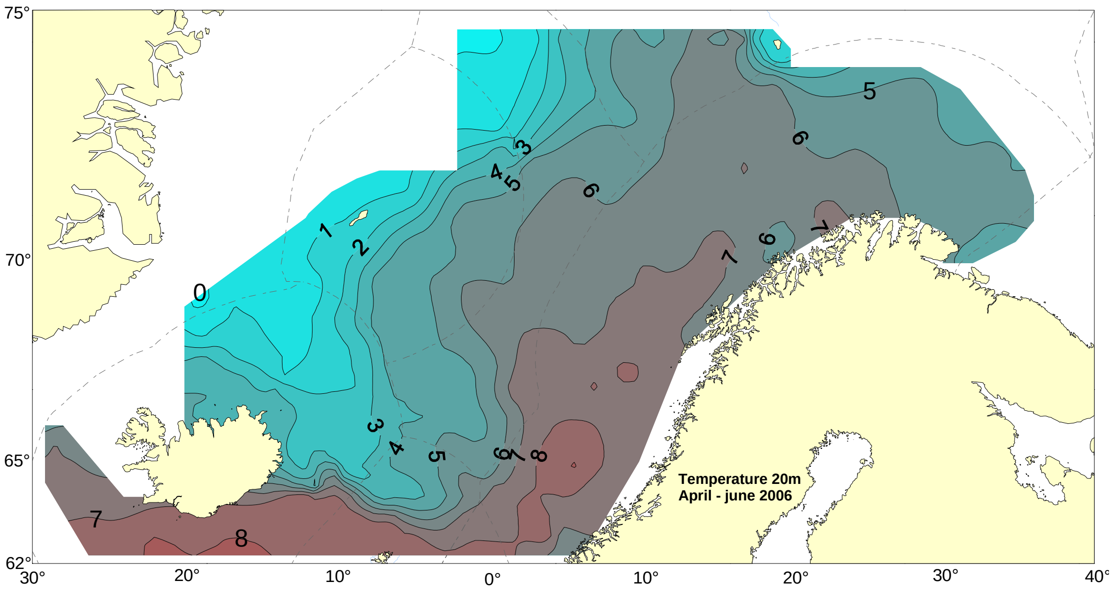


Figure 3.2.1.4: Temperature at 20 m depth in May 2006.

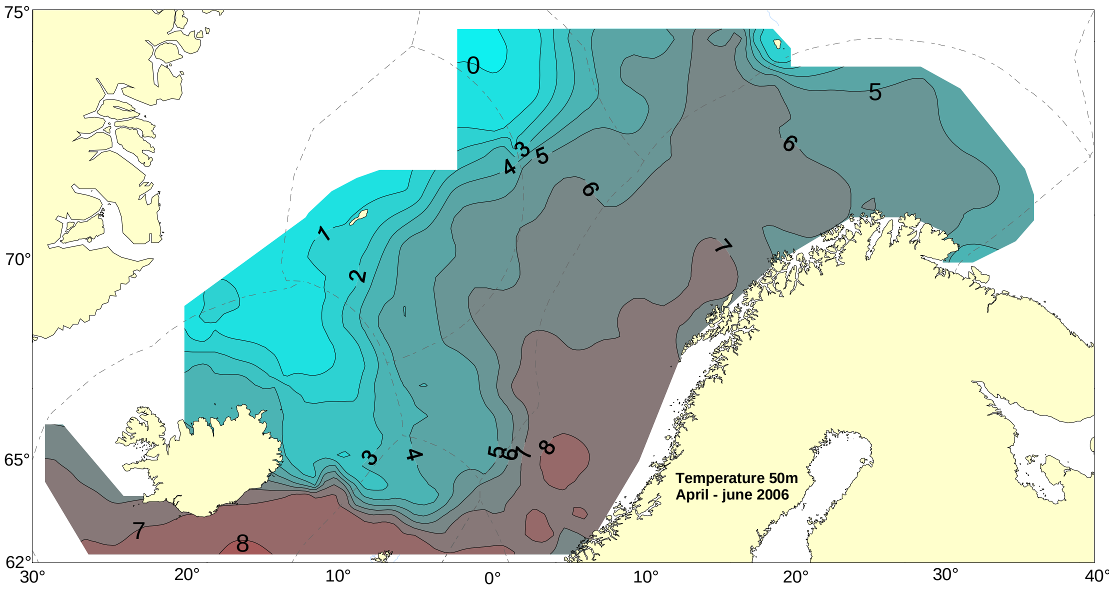


Figure 3.2.1.5: Temperature at 50 m depth in May 2006.

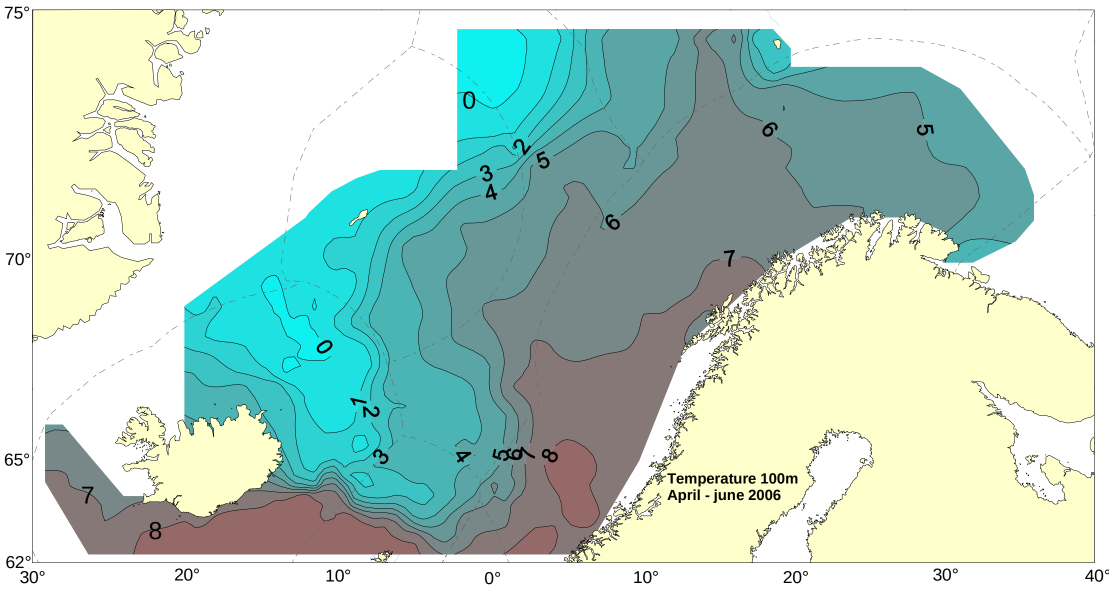


Figure 3.2.1.6: Temperature at 100 m depth in May 2006.

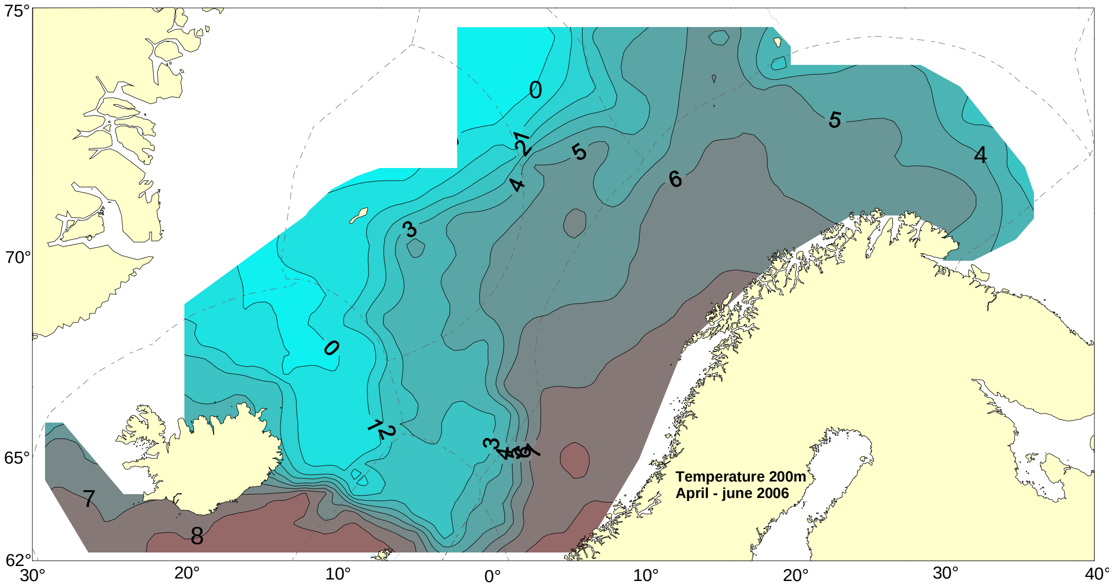


Figure 3.2.1.7: Temperature at 200 m depth in May 2006.

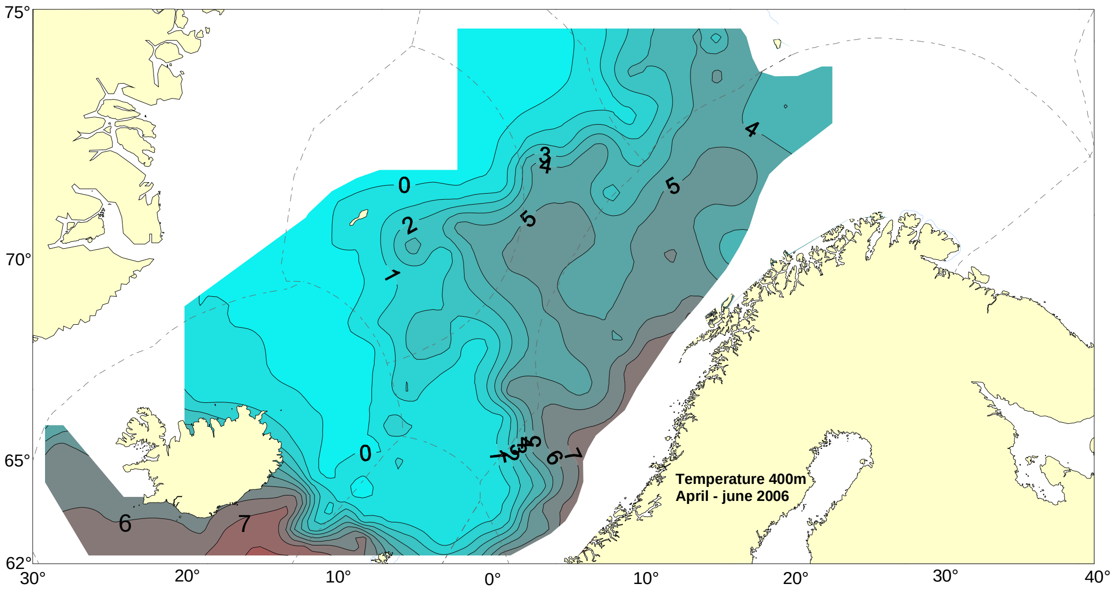


Figure 3.2.1.8: Temperature at 400 m depth in May 2006.

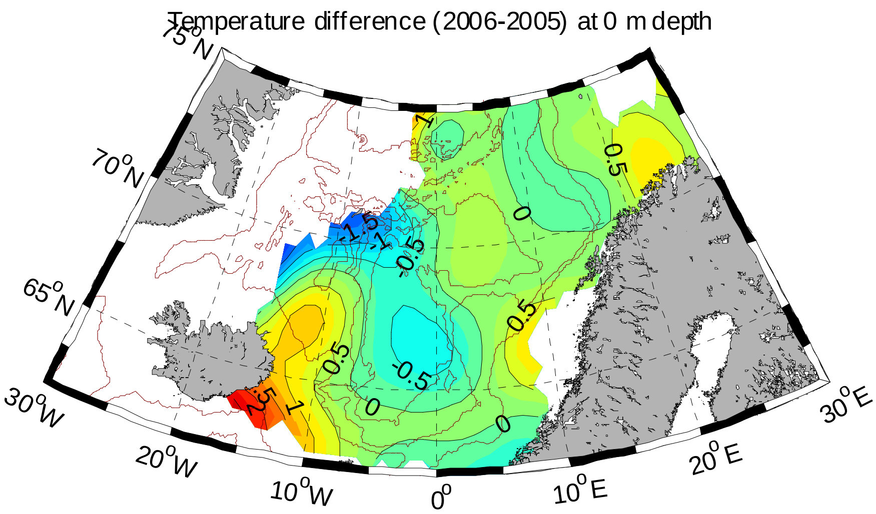


Figure 3.2.1.9: Temperature difference between 2006 and 2005 at the surface in May 2006. Positive value indicates warmer in 2006.

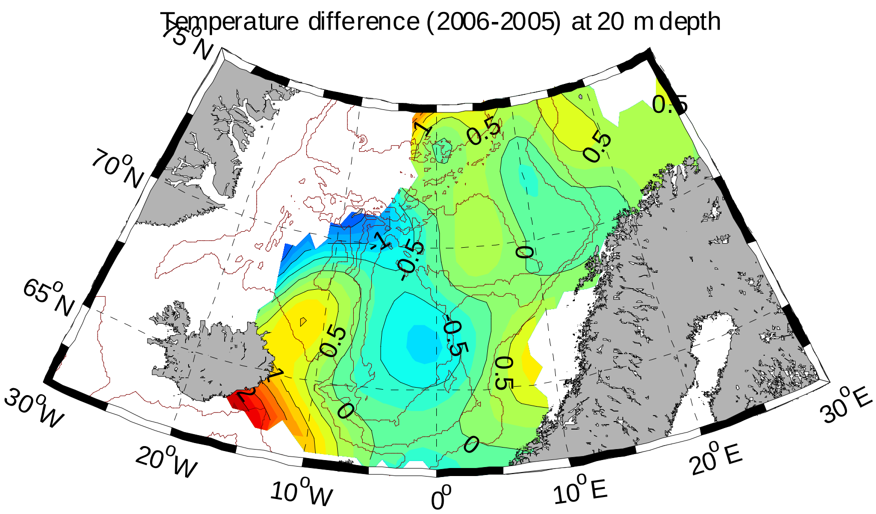


Figure 3.2.1.10: Temperature difference between 2006 and 2005 at 20 m depth in May 2006.

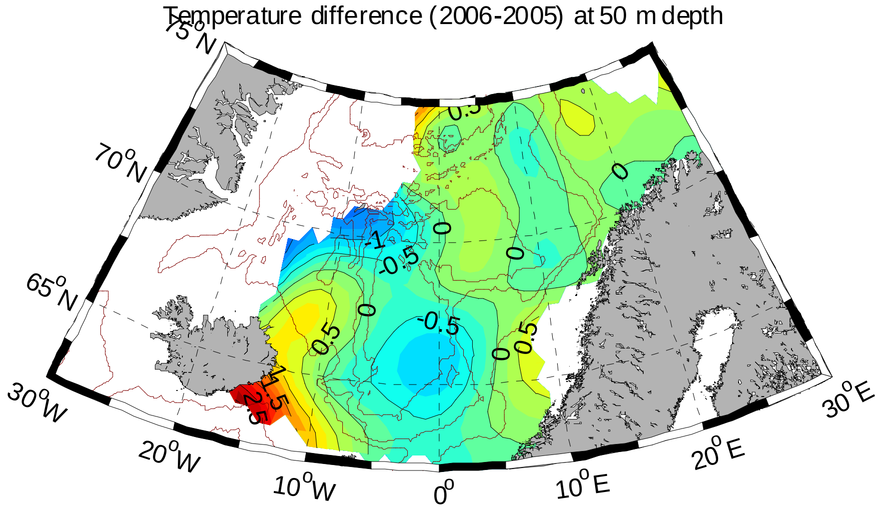


Figure 3.2.1.11: Temperature difference between 2006 and 2005 at 50 m depth in May 2006

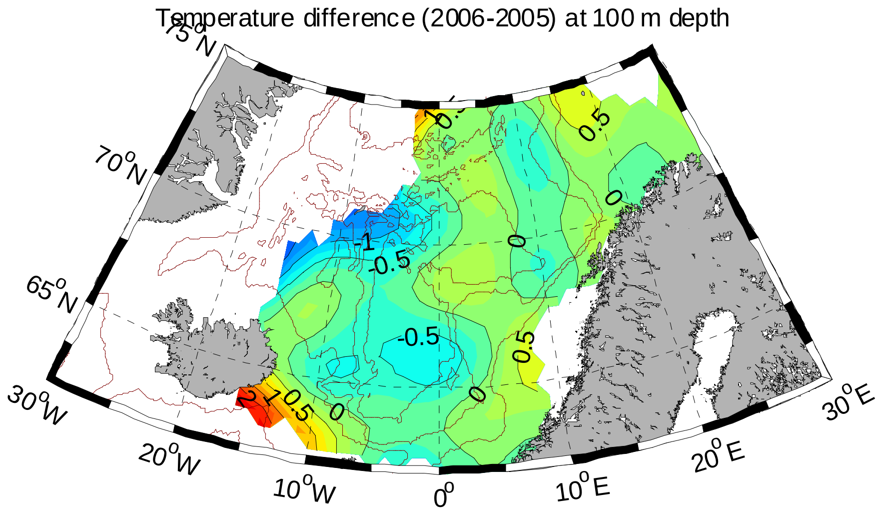


Figure 3.2.1.12: Temperature difference between 2006 and 2005 at 100 m depth in May 2006.

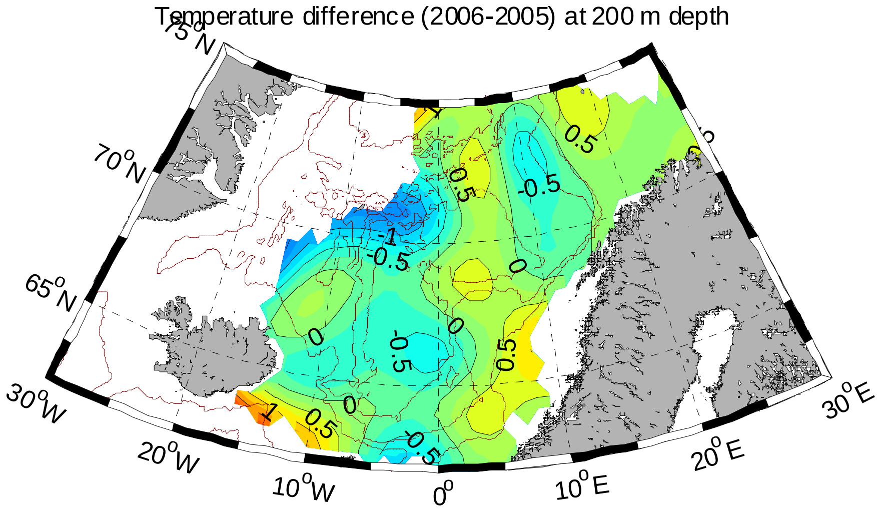


Figure 3.2.1.13: Temperature difference between 2006 and 2005 at 200 m depth in May 2006

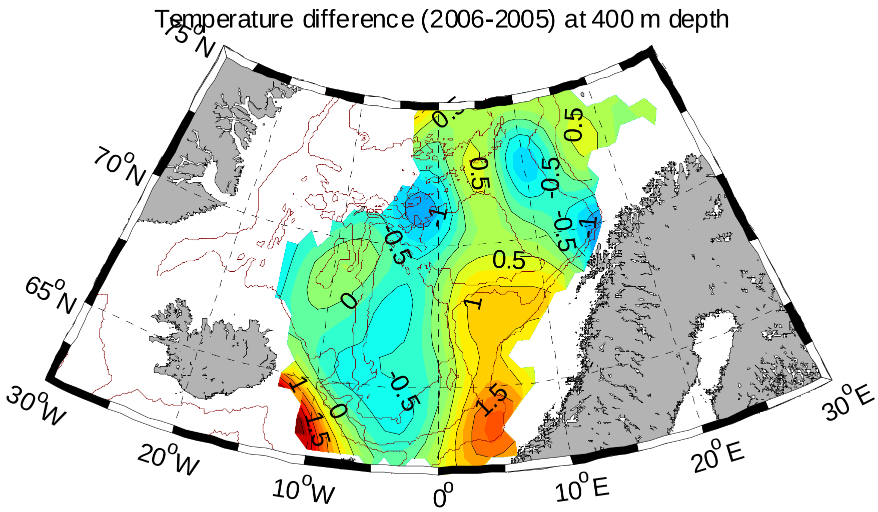


Figure 3.2.1.14: Temperature difference between 2006 and 2005 at 400 m depth in May 2006.

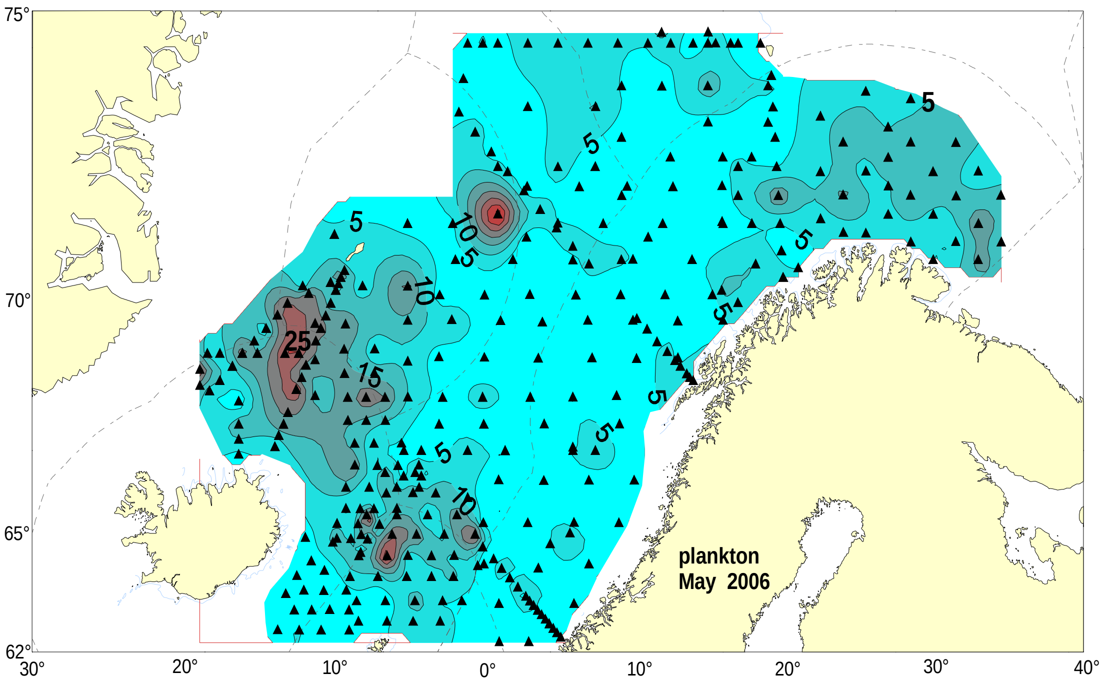


Figure 3.2.2.1: Zooplankton biomass (g dw m^{-2}) (200–0 m) (50–0 m in Icelandic standard sections) in May 2006.

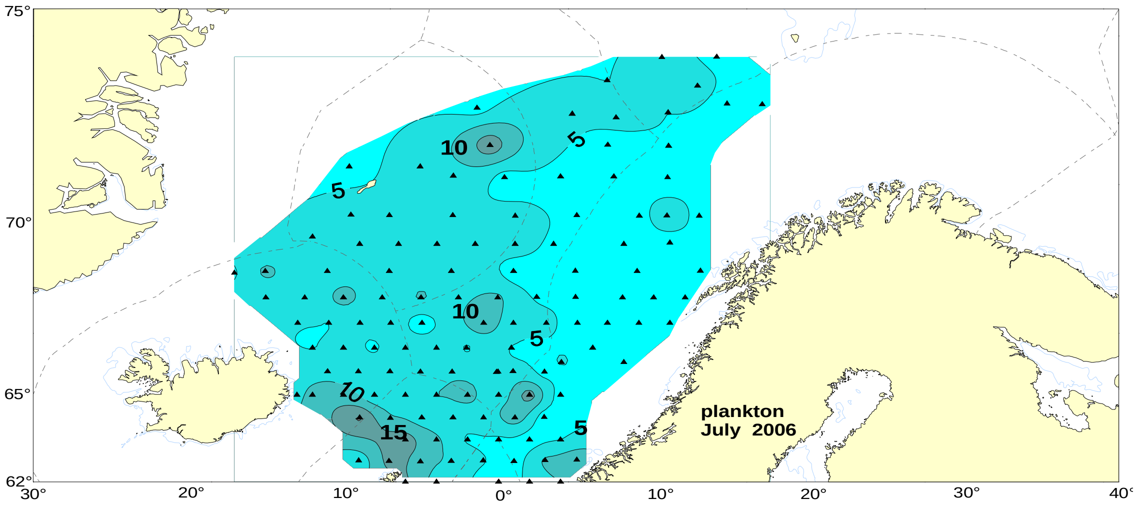


Figure 3.2.2.2: Zooplankton biomass (g dw m^{-2}) (200–0 m) in July-August 2006.

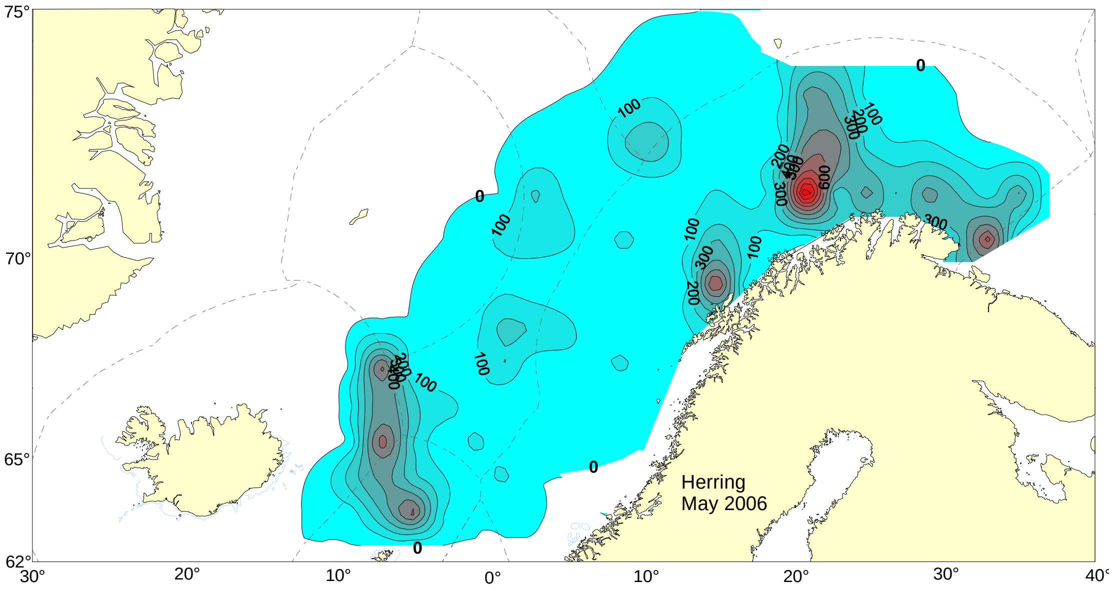


Figure 3.2.3.1: Distribution of Norwegian spring spawning herring as measured during the International survey in April-June 2006.

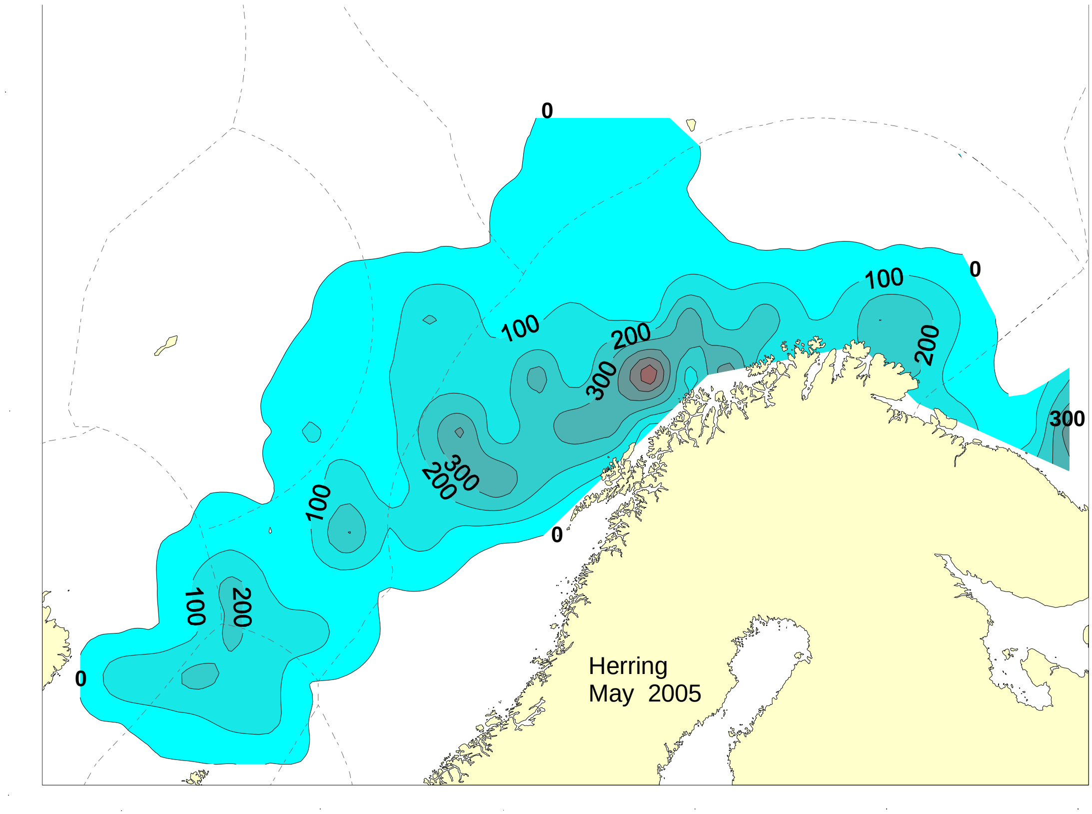


Figure 3.2.3.2: Distribution of Norwegian spring spawning herring as measured during the International survey in April-June 2005.

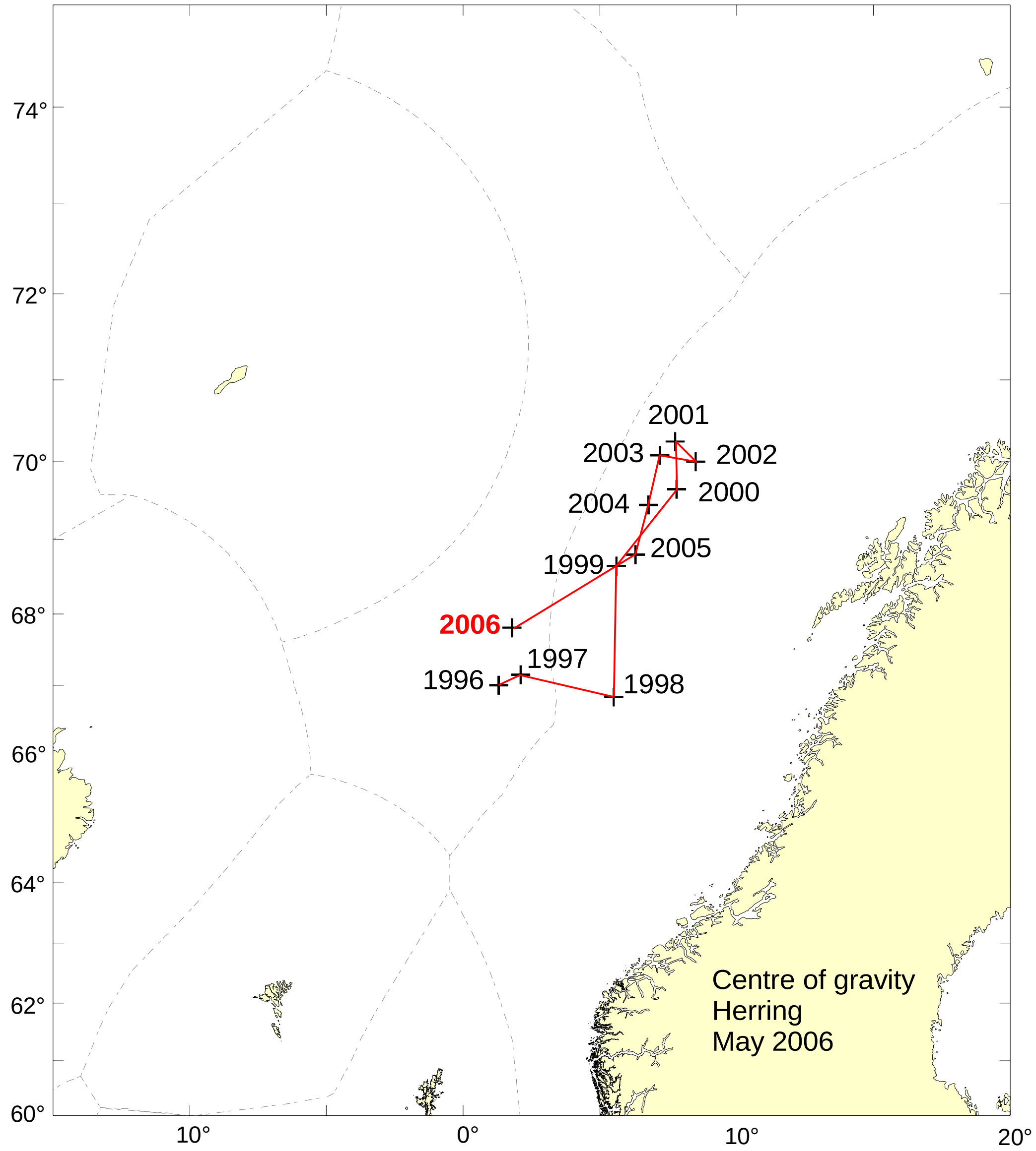


Figure 3.2.3.3: Centre of gravity of herring during the period 1996–2006 derived from acoustic value.

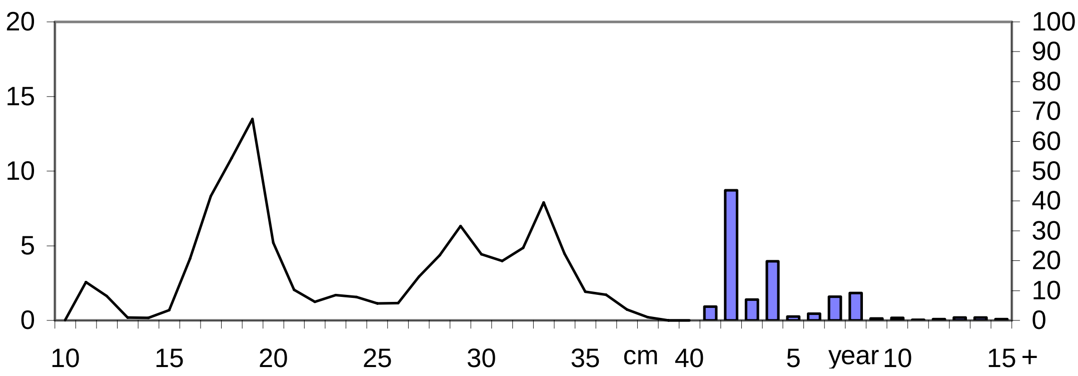


Figure 3.2.3.4: Length and age distribution of Norwegian spring spawning herring in the Norwegian Sea in May 2006.

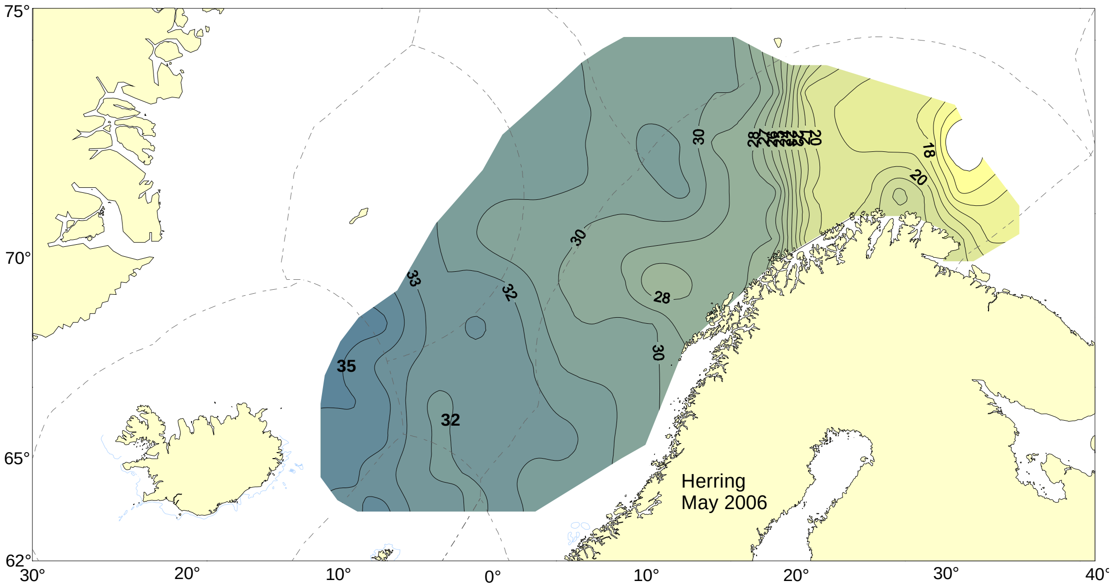


Figure 3.2.3.5: Mean lengths by area of Norwegian spring spawning herring derived from trawl samples in April-June 2006.

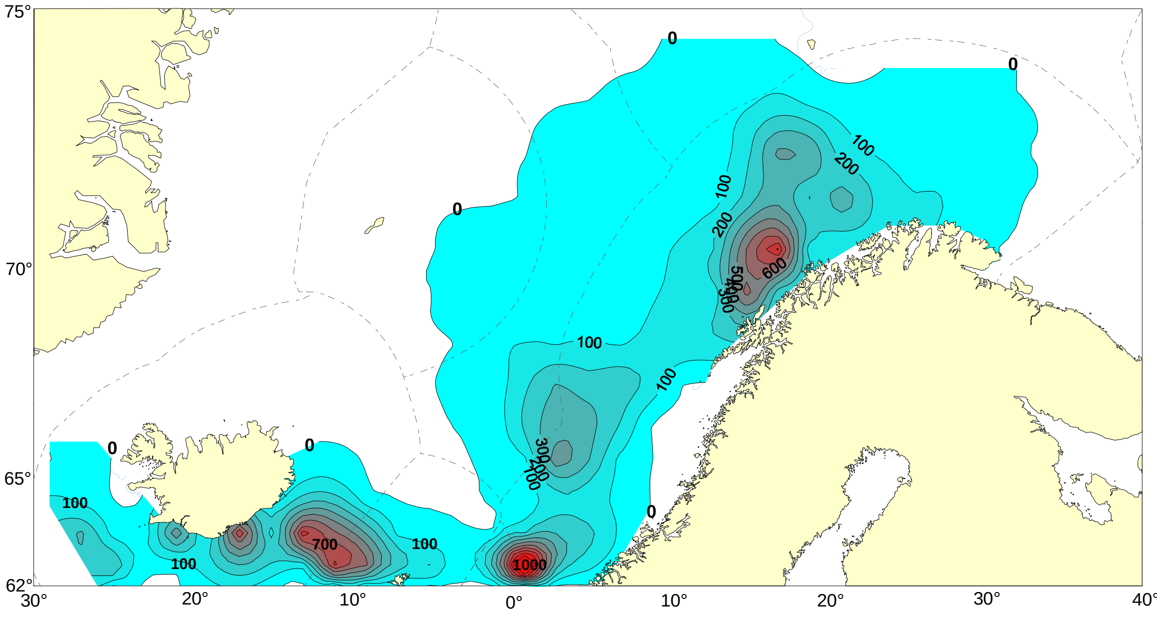


Figure 3.2.4.1: Acoustic density of blue whiting recorded in the North-east Atlantic Ecosystem Survey in May–June 2006. Density is terms of s_A-values (m^2/nm^2) based on combined 5 nm values reported by each of the research vessels “Dana”, “Magnus Heinason”, “Arni Fridriksson”, “Johan Hjort” and “G. O. Sars”.

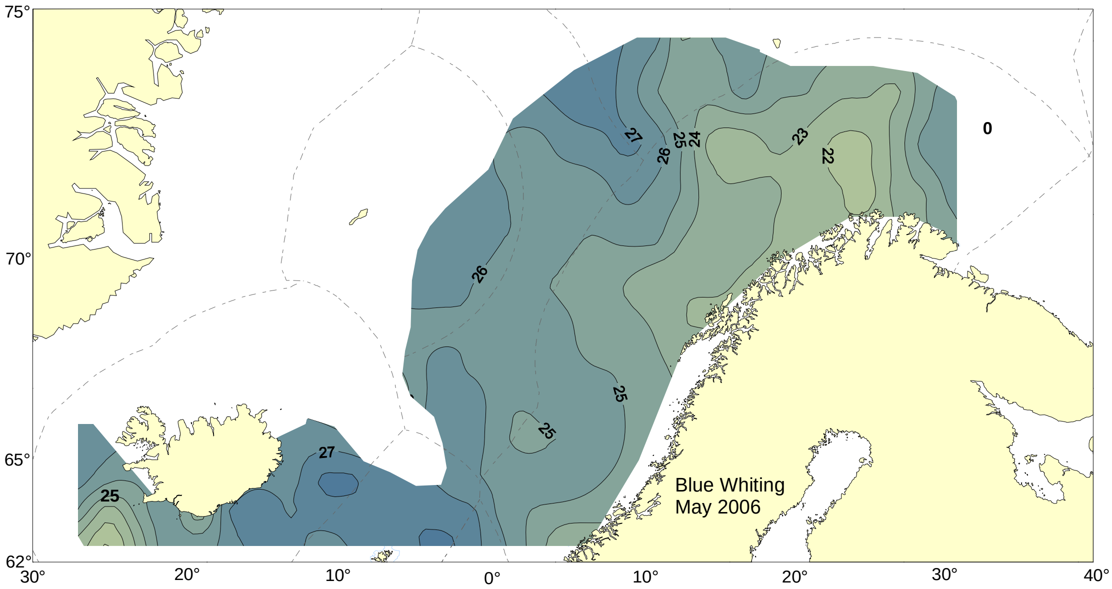


Figure 3.2.4.2: Mean length (cm) of blue whiting recorded in the North-east Atlantic Ecosystem Survey in May–June 2006. Based on trawl samples from RVs "Dana", "Magnus Heinason", "Arni Fridriksson", "Johan Hjort" and "G. O. Sars".

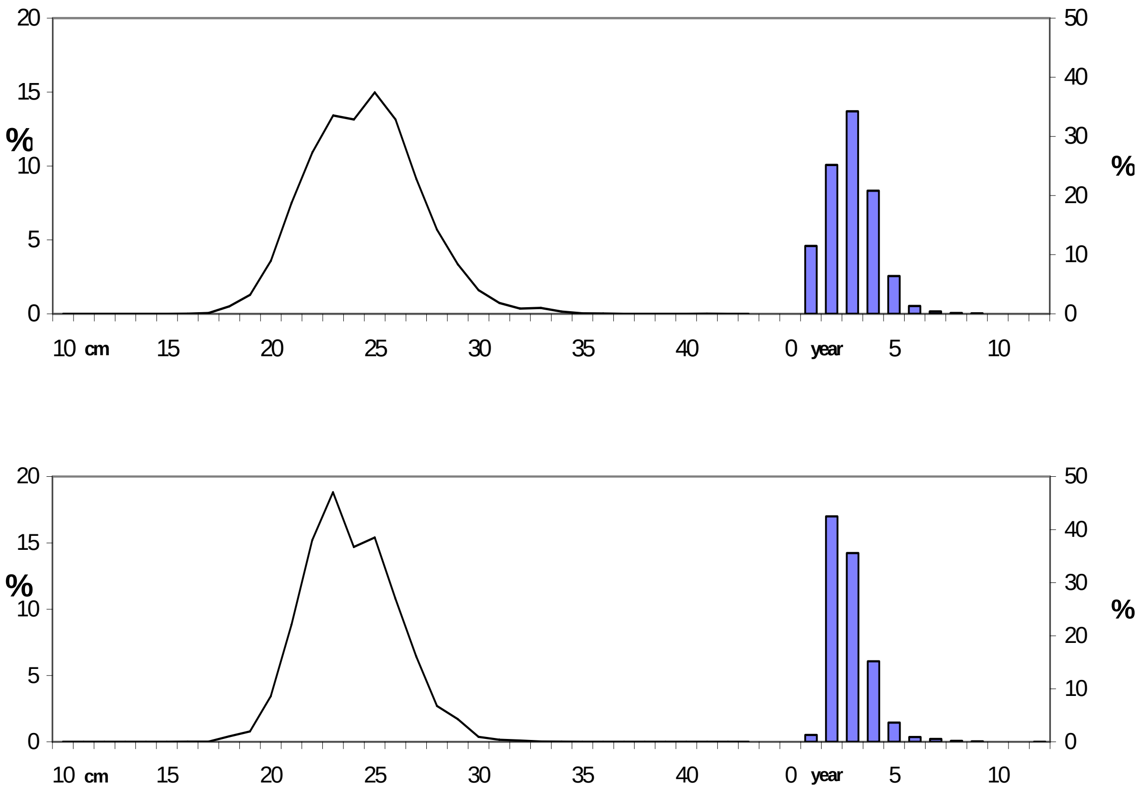


Figure 3.2.4.3: Estimated length and age distributions of blue whiting in the North-east Atlantic Ecosystem Survey in May–June 2006. The upper panel is based on the total survey area as shown in Figure 3.2.4.1; the lower panel is based on the standard survey area between 8°W-20°E and north of 63°N.

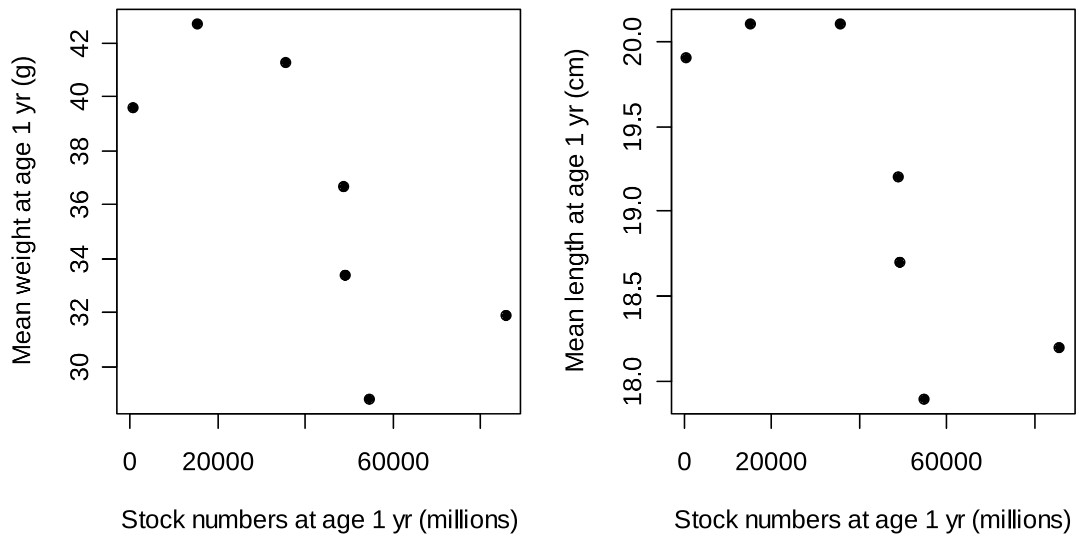


Figure 3.2.4.4: Relationship between size and abundance of blue whiting at age 1 year in the standard survey area in the North-east Atlantic Ecosystem Surveys in 2000–2006. The correlation coefficients are rp=-0.75 (weight) and rp=-0.80 (length), of which only the latter is statistically significant (respectively p=0.054 and p=0.030).

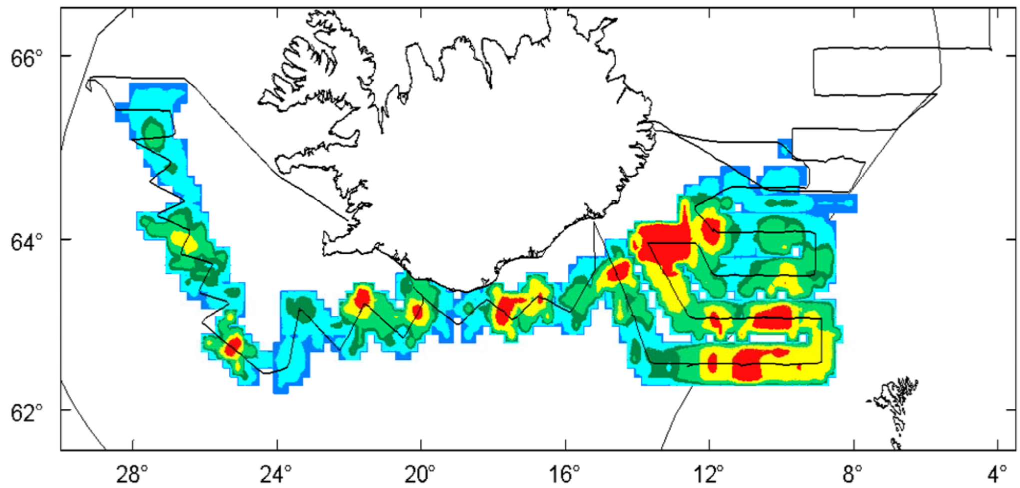


Figure 3.2.4.5: Acoustic density of blue whiting (s_A-values) in Icelandic waters and SW-Norwegian Sea in May–June 2006. The red vertical line demarks 16° W meridian.

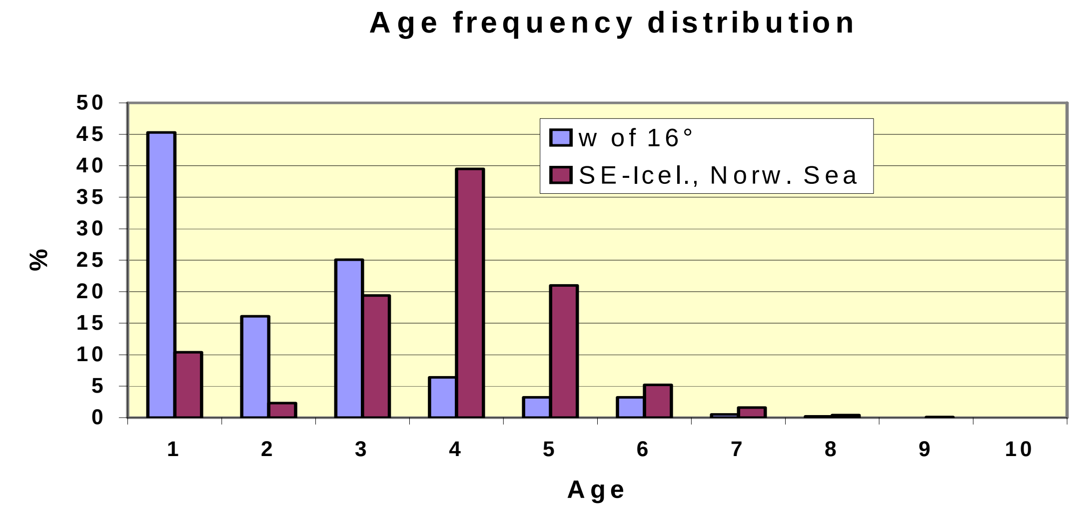


Figure 3.2.4.6: Length frequency distribution of blue whiting in Icelandic area east and west of 16° W in May–June 2006.

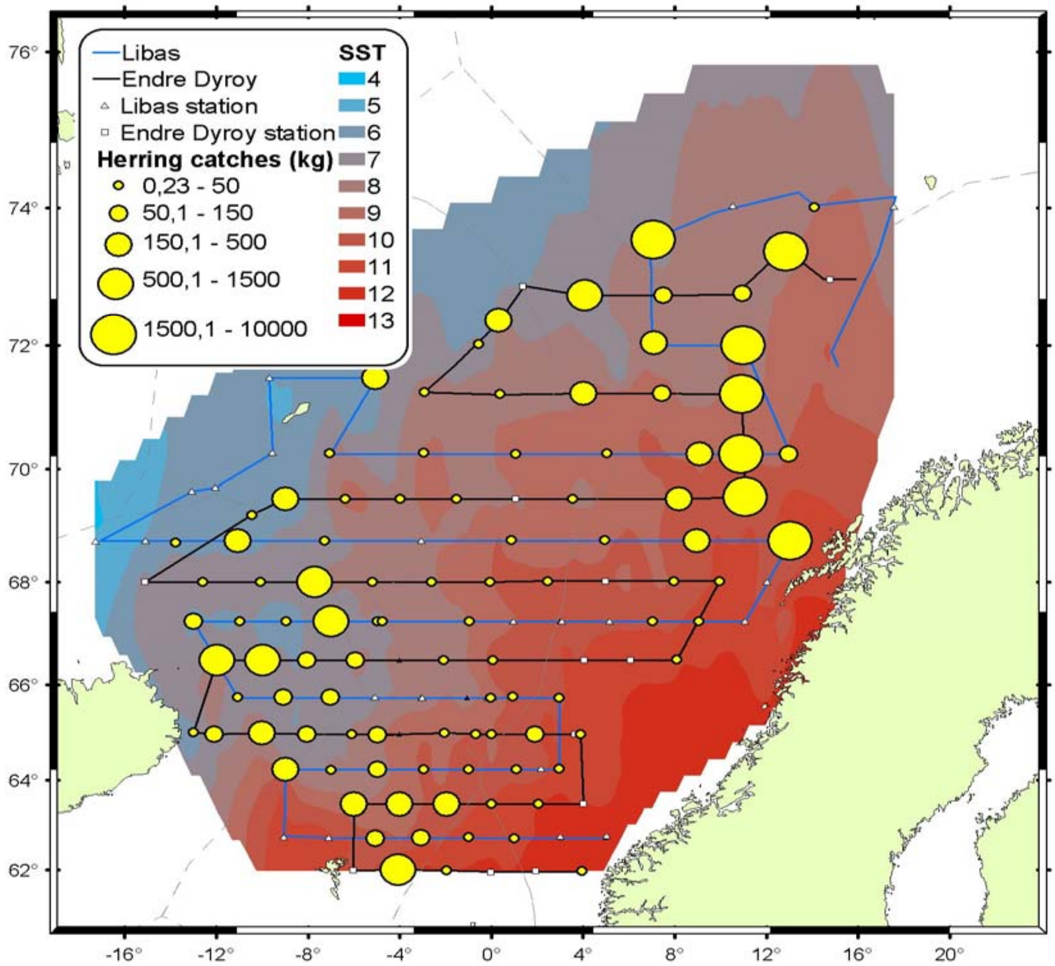


Figure 3.3.1.1: Herring catches shown as kg/n.mi. from "Libas" and "Endre Dyrøy" in the Norwegian Sea, 15 July – 5 August 2006.

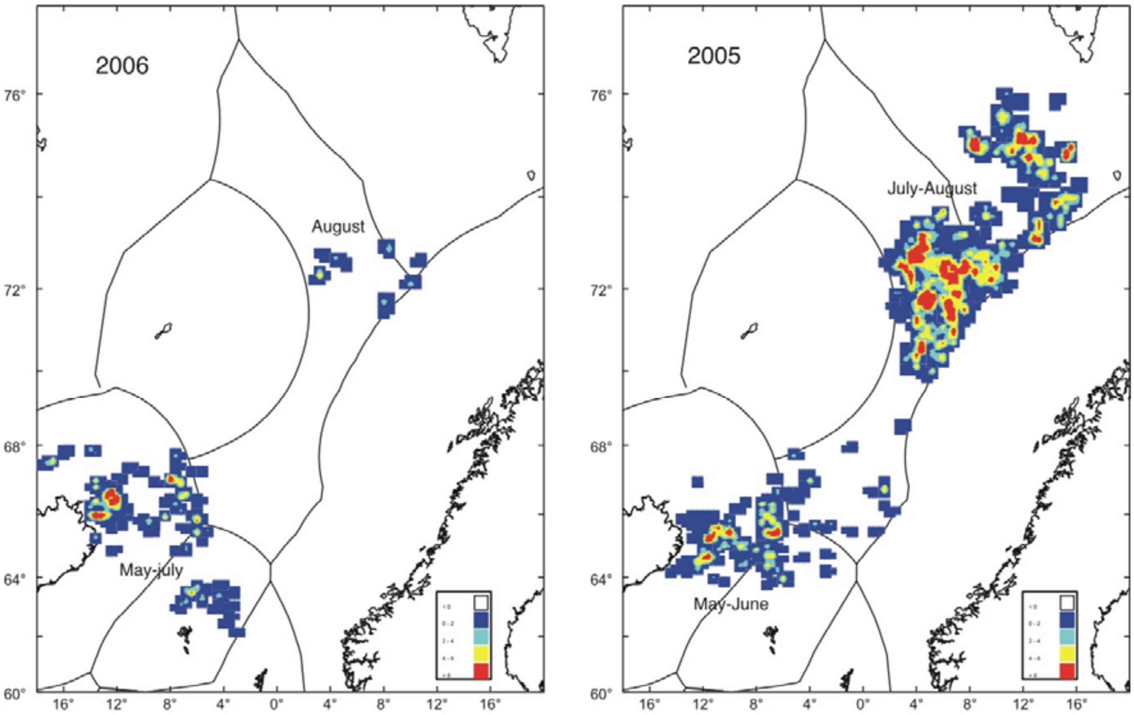


Figure 3.5. Icelandic catches of Norwegian spring spawning herring during 15 May-15 August 2006 and 2005. In 2005 the fishery in the Icelandic and Faroese EEZs ended around 15 June, but lasted until 10 August in 2006.

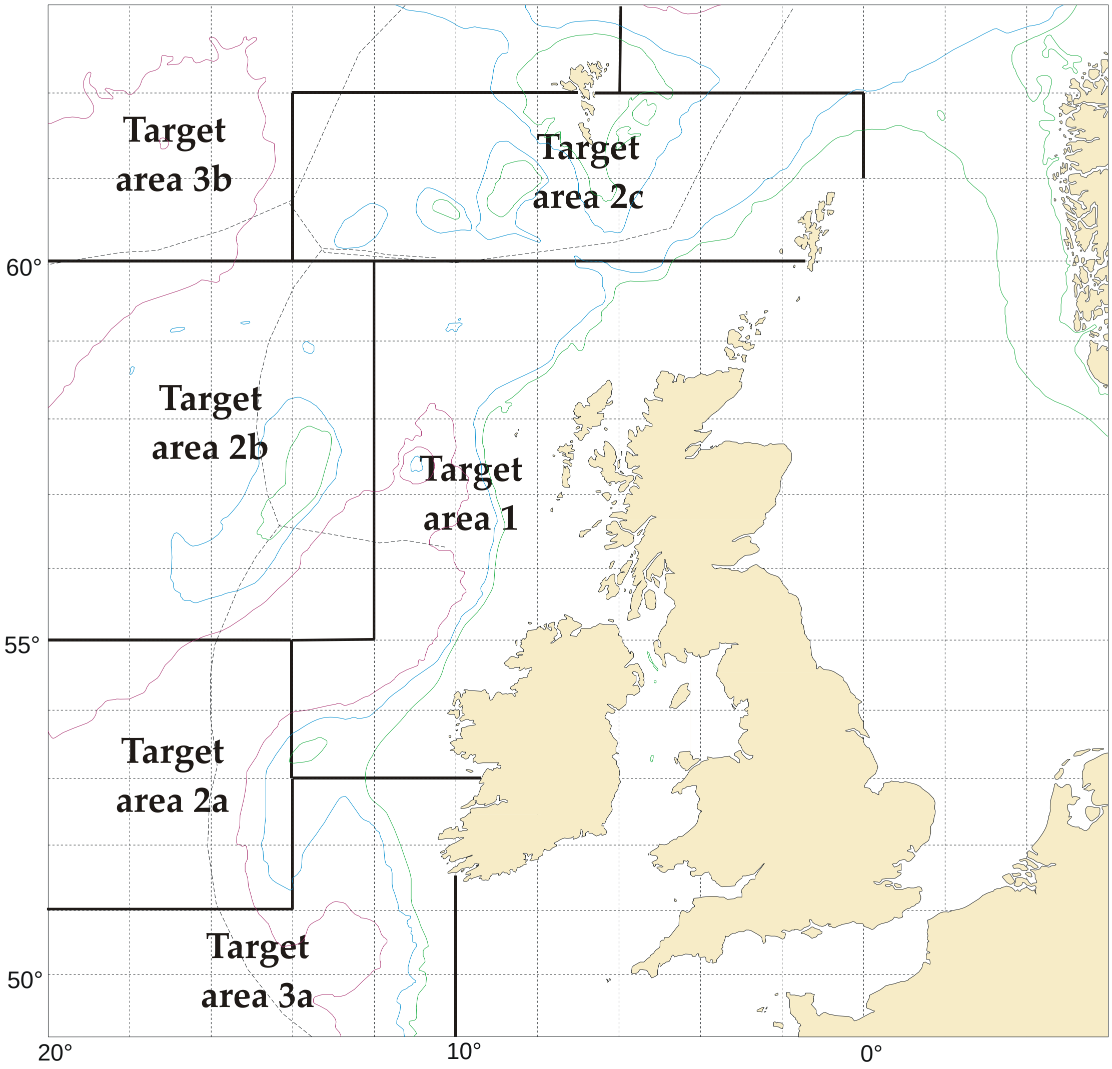


Figure 5.1.1: Planned survey area for the blue whiting spawning survey in March-April 2006.

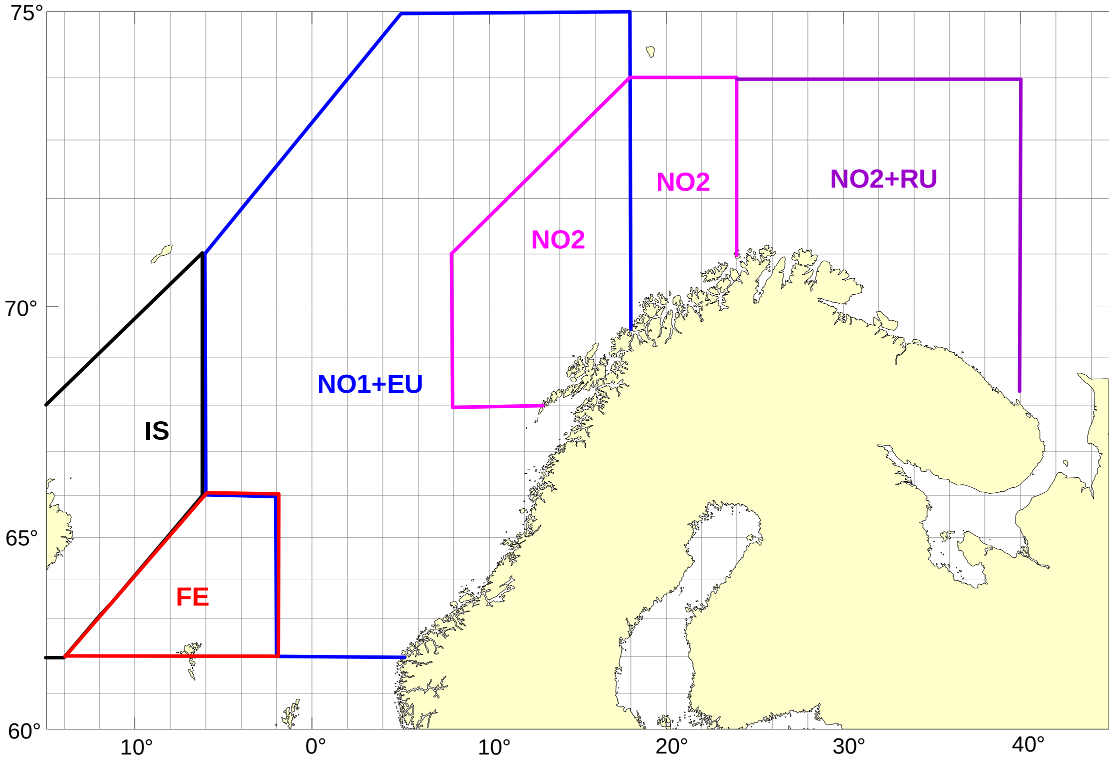


Figure 5.2.1: Planned survey area for surveys in the Norwegian Sea and Barents Sea in May 2005.

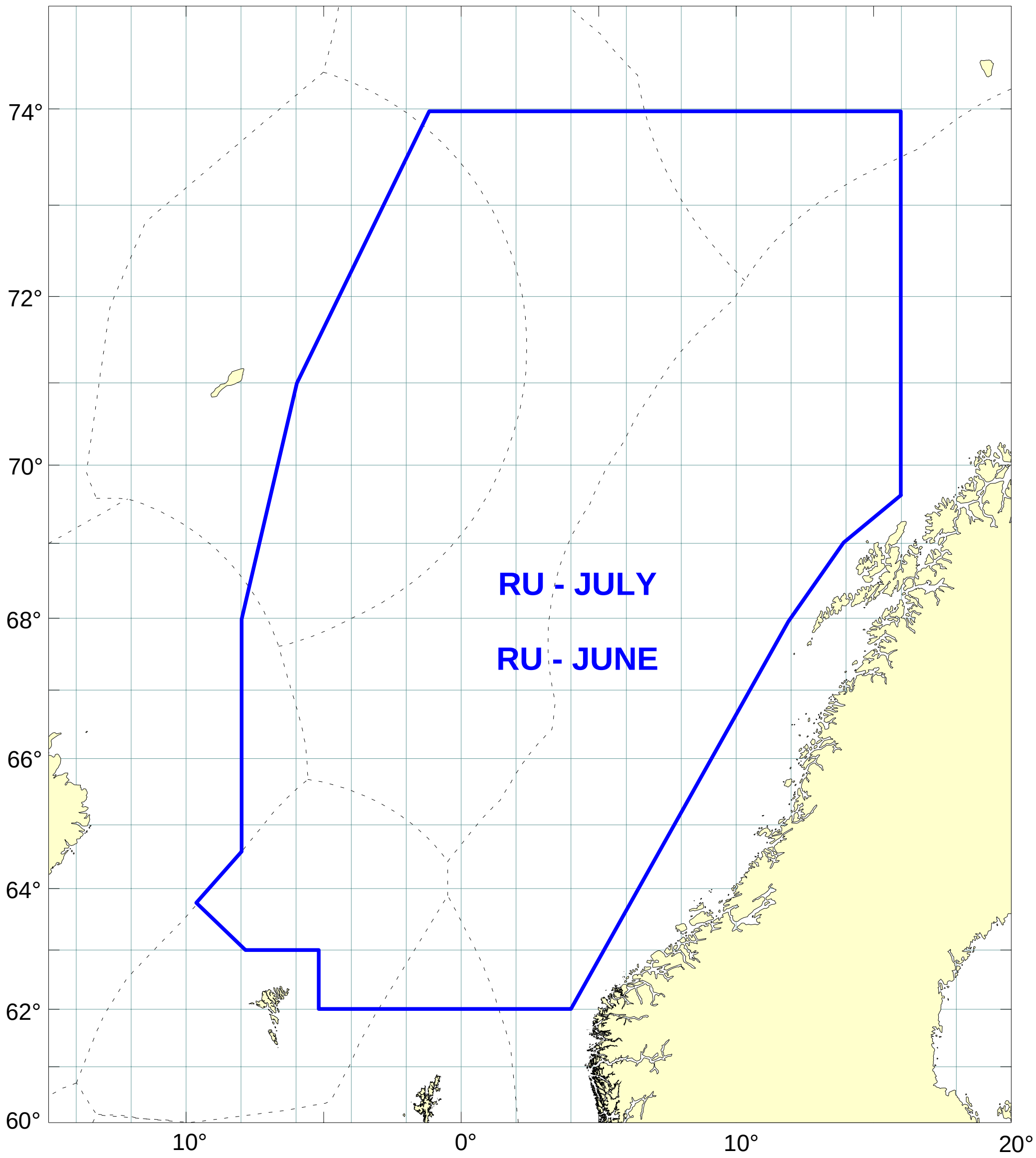
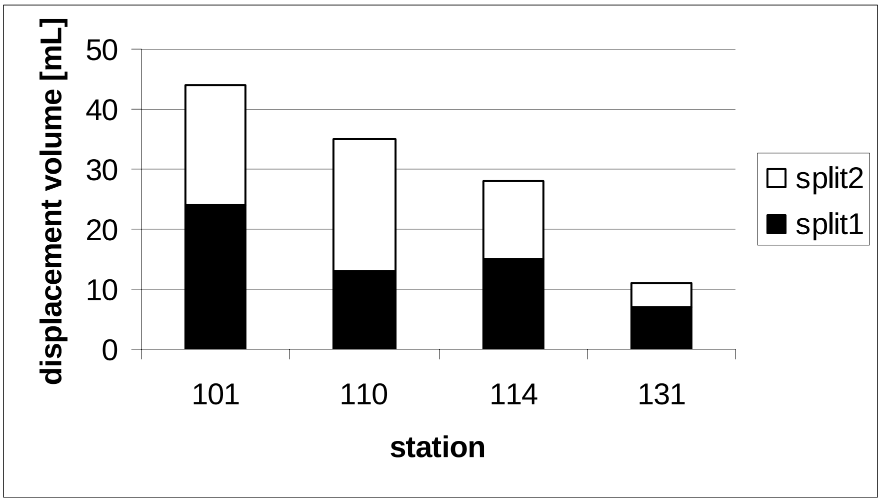


Figure 5.2.2: Planned survey area for the Russian survey in the Norwegian Sea in June-July 2005.



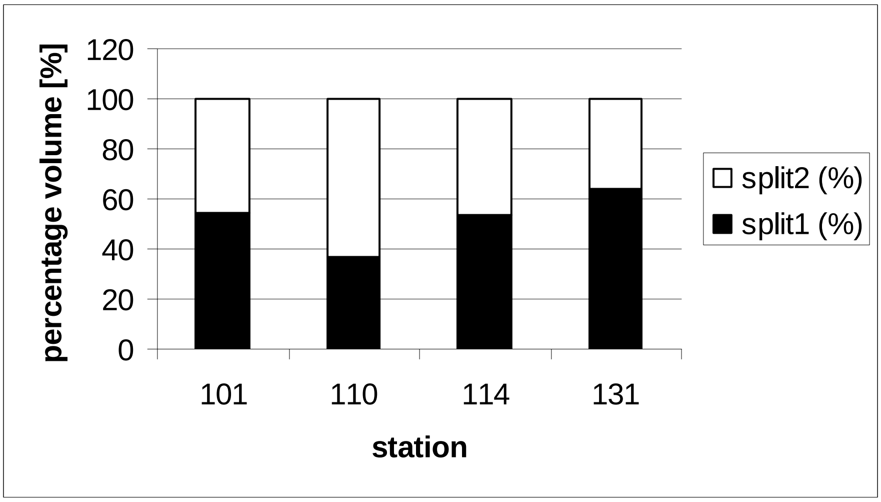


Fig. 6.2.1: Plankton sample partitioning utilizing the plankton splitter onboard RV Dana at 4 selected stations. Top: in mL displacement volume. Bottom: in percentage of total plankton volume (100%).

Annex 1: List of participants of PGNAPES

Planning Group on Northeast Atlantic Pelagic Ecosystem Surveys - Marine Research Institute, Reykjavik, 15 – 18 August 2006

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Annex 2: Survey report in the blue whiting spawning area 2006

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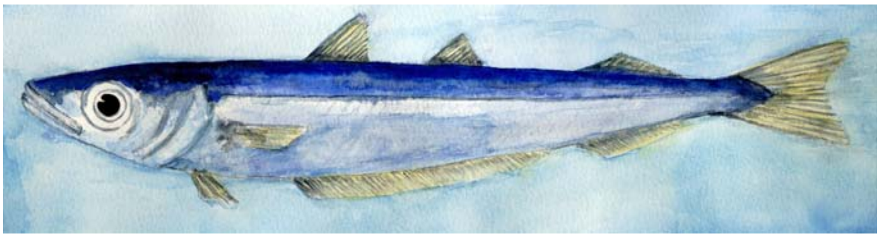
Working Document

Planning Group on Northeast Atlantic Pelagic Ecosystem Surveys

Reykjavik, Iceland, 15–18 August 2006

The Northern Pelagic and Blue Whiting Fisheries Working Group

Copenhagen, Denmark, 24-30 August 2006



INTERNATIONAL BLUE WHITING SPAWNING STOCK SURVEY SPRING 2006

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Introduction

In spring 2006, five 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. 2006; Celtic Explorer: Mullins et al. 2006; G. O. Sars: Heino et al. 2006; M. Heinason: Jacobsen et al. 2006; Tridens: Ybema et al. 2006).

This report is based on a workshop held after the international survey in Tórshavn, 20–21/4/2006, 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 2005 (ICES 2005a), 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	4/3–29/3
Celtic Explorer	Marine Institute, Ireland	23/3–8/4
G. O. Sars	Institute of Marine Research, Bergen, Norway	18/3–15/4
Magnus Heinason	Faroese Fisheries Laboratory, Faroe Islands	31/3–11/4
Tridens	Institute for Marine Resources & Ecosystem Studies, the Netherlands	15/3–27/3

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

Frequent periods of bad weather hampered the survey effort for short periods of time, causing either a reduction in vessel speed, or periods where surveying had to be suspended.

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 (Celtic Explorer, M. Heinason, Tridens, G. O. Sars) and after (Atlantniro) the survey. Salient acoustic settings are summarized below.

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

	Atlantniro	Celtic Explorer	G. O. Sars	Magnus Heinason	Tridens
Echo sounder	Simrad EK 500	Simrad EK 60	Simrad EK 60	Simrad EK 500	Simrad EK 60
Frequency (kHz)	**38**, 120	**38**, 18, 120, 200	**38**, 18, 70, 120, 200	**38**	**38**
Primary transducer	ES38B	ES 38B - Serial	ES 38B - SK	ES38B	ES 38B
Transducer installation	Hull	Drop keel	Drop keel	Hull	Towed body
Transducer depth (m)	5	8.7	8	3	7
Upper integration limit (m)	10	15	15	7	12

Absorption coeff. (dB/km)	10	9.6	9.785	10	9.6
Pulse length (ms)	Medium	1.024	1	Medium	1.024
Band width (kHz)	Wide	2.425	2.425	Wide	2.43
Transmitter power (W)	2000	2000	2000	2000	2000
Angle sensitivity (dB)	21.9	21.9	21.9	21.9	21.9
2-way beam angle (dB)	-20.6	-20.6	-20.8	-20.6	-20.6
Sv Transducer gain (dB)	27.30			27.22	
Ts Transducer gain (dB)	27.64	25.23	25.55	27.35	25.87
s_A correction (dB)		-0.73	-0.65		-0.59
3 dB beam width (dg)					
alongship:	6.9	6.99	7.05	7.02	7.02
athw. ship:	6.8	7.03	7.06	6.86	7.16
Maximum range (m)	750	1000	750	750	750
Post processing software	Sonardata Echoview	Sonardata Echoview	BEI	Sonardata Echoview	Sonardata Echoview

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 3.1) post processing software for the previous days work. Data was partitioned into the following categories; plankton (<120 m depth layer), mesopelagic species, blue whiting and bottom fish. Partitioning of data into the above categories was carried out by two experienced scientists. Adjustments for drop-outs were applied where necessary. In addition, as an experiment, the data were also scrutinised using the Norwegian BEI system by a different scientist.

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. Bubble correction of 10-20% was applied when it was apparent that bubbles associated with heavy seas were dampening registrations; the actual value used was somewhat arbitrary.

On Magnus Heinason, acoustic data were scrutinised every 24 hrs on board using Sonar data's Echoview (V 3.50) 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.

On Tridens, acoustic data were scrutinized every 24 hrs using Sonar data's Echoview (V 3.25) post processing software. Data was partitioned into the following categories plankton (all layers), 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.

On Atlantniro, the Sonar data's Echoview (V 3.20) post processing software was used as the primary post-processing tool for acoustic data. Data was partitioned into the following categories, blue whiting, Eutrigla gurnardus, plankton, mesopelagic species and other species. The acoustic recordings were scrutinized once per day.

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	G. O. Sars	Magnus Heinason	Tridens
Circumference (m)	716	768	586	640	1120
Vertical opening (m)	50	48	25-35	38-48	30-70
Mesh size in codend (mm)	16	50	22	40	±20
Typical towing speed (kn)	3.3-4.0	3.5-4.0	3.0-4.0	3.0-4.0	3.5-4.0

On G. O. Sars, some additional samples were taken with a bottom trawl with 4 x 18 m opening equipped with a Rock-hopper ground gear was used on some shallower areas.

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 (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), 200 (Celtic Explorer), 250 (Tridens, only length) 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 all vessels (Figure 2, Table 1). G. O. Sars, Celtic Explorer, Atlantniro and Tridens are equipped with SBE911 CTDs. 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-calibration between R/V G. O. Sars and R/V Magnus Heinason are summarized in Appendix 1. Acoustic inter-calibrations showed that the performance of Magnus Heinason was very similar to G. O. Sars (which was used as the reference vessel). Bad weather prevented the planned inter-calibration between Celtic Explorer and Tridens, while Atlantniro was too far ahead of G.O. Sars to be within reach for at inter-calibration.

Catchability can vary among the vessels due to the large variety of gear employed (see the text table on page 3). However, the difference during the inter-calibration exercise between G. O. Sars and Magnus Heinason nevertheless suggested rather small differences in size selectivity in mean length relative to G. O. Sars; the mean length from M. Heinason was 0.8 cm lower.

The age readings from the different vessels were comparable with some small inconsistencies, i.e., some fish being aged too old for their size. The age-length key was edited manually before it was used in the assessment, i.e., some missing entries were added manually in those few cases where length measurements were available without corresponding age entries.

Distribution of blue whiting

Blue whiting were recorded in most of the survey area that covered about 170 thousand square nautical miles (Figures 4–6). The highest concentrations were recorded in the area between the Hebrides, Rockall and the banks southwest of the Faroes. In comparison to 2005, the biomass was more evenly and more southerly distributed, with more fish close to the traditional hot spot close 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 vessel-specific estimates of mean acoustic density in each survey stratum (Figure 5). These are often in good agreement, but also big discrepancies occur, which can be attributed to spatial and temporal heterogeneity in abundance of blue whiting.

Stock size

The estimated total abundance of blue whiting for the 2006 international survey was 10.4 million tonnes, representing an abundance of 108×10^9 individuals (Table 2). The spawning stock was estimated at 10.3 million tonnes and 105×10^9 individuals. The geographical distribution of total stock biomass by stratum is shown in Figure 7.

In comparison to the results in 2004–2005, the increase in stock numbers and biomass are substantial:

		2004	2005	2006	Change from 2005 (%)
Biomass (mill. t)	Total	11.4	8.0	10.4	+30
	Mature	10.9	7.6	10.3	+36
Numbers (10^9)	Total	137	90	108	+20
	Mature	128	83	105	+27
Survey area (nm^2)		149 000	172 000	170 000	–1

There was heterogeneity in the temporal trend between the sub-areas, however. There was no change in the southern Porcupine Bank, whereas biomass significantly decreased in the Faroes/Shetland sub-area and increased elsewhere, in particular in the Rockall sub-area:

	Sub-area	Biomass (million tonnes) 2005		2006		Change (%)
			% of total		% of total	
I	S. Porcupine Bank	0.21	3	0.20	2	–5
II	N. Porcupine Bank	0.47	6	0.74	7	+57
III	Hebrides	4.3	54	5.2	50	+22
IV	Faroes/Shetland	1.4	18	0.94	9	–33
V	Rockall	1.6	20	3.3	32	+105

Stock composition

Stock in the survey area is dominated by age classes 4 and 3 years (year classes 2002 and 2003), which make together about 60% of spawning stock biomass (Table 3, Figure 7). This represents a shift to the dominance of young fish from the survey in 2005. The year classes that were dominant in 2005, now at age 5-6 years, make 29% of the remaining spawning stock biomass.

Half of the spawning stock biomass was recorded in the Hebrides sub-area. The age structure of stock in this area resembled that of the total survey area (Figure 8). In the southern and northern areas, younger blue whiting were relatively more abundant. However, in Rockall, significant numbers of large, old blue whiting were measured, and the age distribution was more spread than elsewhere.

Almost all fish older than one year in age were mature. The proportion of juvenile fish was highest in the Faroes/Shetland sub-area (Table 2), whereas almost all fish were mature in the northern Porcupine and Hebrides sub-areas. In the Porcupine Bank, no sampling on the slopes of the bank (where juvenile usually occur) was conducted, contributing to the relative of paucity of young fish in the stock estimate.

Hydrography

The horizontal distribution of temperature and salinity at 10, 200, 400 and 600 meters depths are shown in Figures 9–16. The maps are based on CTD data collected on board G. O. Sars, Atlantniro, Celtic Explorer and Tridens (Figure 2). 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 8°C. At the Porcupine section (Figure 17) the temperature is quite homogeneous (11-11.5°C) down to about 500m with a gradual change in the thermocline between 500m and 1000m. Weak stratification is typical for the area, and in the northern part of the Rockall Channel the mixed layer was 600–700m deep. 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 18, 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 9-12). Due to a northward flowing shelf edge current, the warmest and most saline water is found in a narrow band along the shelf edge.

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.

On the Faroe-Shetland section (Figure 18) 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 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 in the core of the Atlantic water are about the same as last year, but colder and less saline than seen in 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 has 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 19. 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. In the period 2002-2004 the temperature was above 10.5°C, with 2004 the warmest on record (~10.8°C). Last year we saw a drop to ~10.4°C. This year a new record has been set with 11.3°C, i.e. 0.5°C warmer than the previous record. Similar changes are seen in the other boxes, indicating that the box discussed above is representative for the region along the continental slope south of the Wyville Thompson ridge.

The mean salinity in the box off Porcupine Bank is 35.51 this year. This is the highest value in the more than 20 years long time series.

Concluding remarks

Main results

- The effort by five 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.
- The third international blue whiting spawning stock survey shows a clear increase in stock numbers and biomass (~20–36%), in comparison to the survey in 2005. The estimates are still lower than in 2004. The area surveyed was the same as in 2005, but 15% larger than during the 2004 survey.
- Considering total stock biomass in those survey strata that were covered in both 2005 and 2006, and adjusting for changes in the proportional coverage within each stratum, suggests an increase of about 22%, that is, somewhat lower than the estimates from the total survey areas.
- Most of the increase in the stock estimate comes from the Rockall sub-area, in particular from its western part. This area was covered earlier in season this year than in 2005; also the surveyed area was greater. Hebrides and northern Porcupine sub-areas, which had similar coverage in 2005 and 2006, showed more moderate increases.
- The stock in the survey area is dominated by age classes 4 and 3 years (year classes 2002 and 2003), which make together about 60% of spawning stock biomass. This represents a shift to the dominance of younger fish from the survey in 2005. The year classes that were dominant in 2005, now at age 5-6 years, make 29% of the remaining spawning stock biomass.
- Dealfish (*Trachipterus arcticus*) occurred in unprecedented frequency in the trawl catches. Also some commercial vessels reported very high proportions of dealfish in their catch.

Interpretation of the results

- 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, Pedersen et al. 2006). 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 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.
- The lower biomass in the northern region indicates that the northern migration of post-spawning blue whiting was delayed in 2006 compared to last year. There seem to be a delay of about two weeks in the northern migration into the Faroese EEZ. This was clear from the low abundance in the Faroese area (northern part of Sub-area IV), as well as from the fact that the Faroese commercial vessels were waiting in the Faroese area by 12 April, because their quota was finished in EU waters. In 2005 the fishery in the Faroese area started around 1 April.

Practical experiences and lessons for the future surveys

- Data exchange during and after the survey was relatively smooth due to improved adherence to the PGNAPES data format. Further improvements to the data exchange and database format were discussed. It was agreed that proposed changes of data formats will be sent in before the start of the survey in order for all vessels to use the most up to date format for data exchange. An important change in the database format was to switch from common PGNAPES species naming to the use of the standard three-letter species code used by ICES. All 2006 data will be imported into the database shortly and made available for the survey participants on the web.
- Fish sampling procedures were discussed and it was suggested that Tridens would use a similar procedure as Celtic Explorer and G.O. Sars: take up to 50 samples for biological measurements and up to another 200 for length measurements. Furthermore Tridens should consider using 7 maturity stages, following the standards for this survey.
- Cruise tracks were planned and executed more consistent than in 2005; transect directions were now parallel and shallow waters (less than 200m) were generally not included in the acoustic data that were used in the stock estimate.
- Tridens is still not able to do trawling samples at night. 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.
- The age reading workshop in Hirtshals in 2005 revealed no surprising disagreements between Norwegian and Dutch age readers. Thus, so far, no cause could be found for discrepancies in age readings during the 2005 intercalibration between G.O. Sars and Tridens.
- We recommend sharing expertise (e.g., in scrutinizing echograms) through exchange of scientific personnel. Exchange calls should be made as soon as possible, preferably not later than during the PGNAPES meeting in August 2006.
- It is suggested that all vessels should be capable to do CTD downcasts up to 1000m.
- It was agreed that during the survey participants may send observations of the acoustic survey in the form of aggregated distribution maps to their contacts in the national fleets to increase cooperation.
- The survey area south of Porcupine Bank was covered after the majority of the international fishing fleet had left this area while the most northern survey area was covered before the fleet arrived.

References

Anon. (Monstad et al.), 1982. Report of the International acoustic survey on blue whiting in the Norwegian Sea, July/August 1982. ICES CM 1982/H:5.

Foote, K. G., Knudsen, H. P., Vestnes, G., MacLennan, D. N., and Simmonds, E. J. 1987. Calibration of acoustic instruments for fish density estimation: a practical guide. ICES Coop. Res. Rep. 144: 1–57.

Foote, K. G., Knudsen, H. P., Korneliussen, R. J., Nordbø, P. E. and Røang, K. 1991. Postprocessing system for echo sounder data. J. Acoust. Soc. Am. 90:37–47.

Godø, O. R., Heino, M., Søiland, H., Alvarez, J., Dahl, M., de Lange, J., Gullaksen, O., Tangen, Ø. & Torkelsen, T. 2002. Blue whiting survey during spring 2002. Working Document to The Northern Pelagic and Blue Whiting Fisheries Working Group, Vigo, Spain, 29 April–8 May 2002. 27 pp.

Heino, M., Godø, O. R., Søiland, H., Nygaard, J. E., Alvarez, J., de Lange, J., Drivenes, L., Gullaksen, O., Tangen, Ø. and Torkelsen, T. 2003. Blue whiting survey during spring 2003. Working Document to The Northern Pelagic and Blue Whiting Fisheries Working Group, Copenhagen, 29 April–8 May 2003.

Heino, M. , Søiland, H., Dahl, M., Pedersen, G., Alvarez, J., Anthonypillai, V., Hovland, T., de Lange, J., Meland, E. S., Myklevol, S., Svendsen, B. V., Tangen, Ø., Torkelsen, T., Stowasser, G. and Varne, R. 2005. Blue whiting survey during spring 2005. Toktrapport/Havforskningsinstituttet/ISSN 1503-6294/Nr. 5 – 2005.

Heino, M. , Søiland, H., Dahl, M., Alvarez, J., Anthonypillai, V., Eriksen, K. B., de Lange, J., Meland, E. S., Pedersen, R., Tangen, Ø. and Torkelsen, T. 2006. Blue whiting survey during spring 2006. Toktrapport/Havforskningsinstituttet/ISSN 1503-6294/Nr. 3 – 2006.

ICES 2005a. Report of the Northern Pelagic and Blue Whiting Fisheries Working Group. ICES CM 2006/ACFM:05.

ICES 2005b. Report of the Planning Group on Northeast Atlantic Pelagic Ecosystem Surveys (PGNAPES). ICES CM 2005/D:09, Ref.: G, ACFM, ACE.

Jacobsen, J. A., Smith, L.,. and Joensen, M. M. 2006. Joint investigations on blue whiting south of the Faroes and in the area west of the British Isles. 29 March - 12 April 2006. r R/V Magnus Heinason OW2252. Cruise no. 0624. Faroese Fisheries Laboratory, Tórshavn, the Faroes.

Monstad, T., 1986. Report of the Norwegian survey on blue whiting during spring 1986. ICES CM 1986/H:53.

Mullins, E., Johnston, G., Power, G., Goddijn, L. and Mackey, M. 2006. Irish Blue Whiting Acoustic Survey Cruise Report, ICES Divisions VIa & VIb. Marine Institute, Ireland.

Pedersen, G., Pedersen, R. and Torkelsen, T. 2006. *In situ* target strength measurements of blue whiting. Appendix 7 in Heino et al. 2006.

Shnar, V et al. 2006. Report of the Russian survey on blue whiting during spring 2006.

Toresen, R., Gjøsæter, H. and Barros de, P. 1998. The acoustic method as used in the abundance estimation of capelin (*Mallotus villosus* Müller) and herring (*Clupea harengus* Linné) in the Barents Sea. Fish. Res. 34: 27–37.

Totland, A. and Godø, O.R. 2001. BEAM – an interactive GIS application for acoustic abundance estimation. In T. Nishida, P.R. Kailola and C.E. Hollingworth (Eds): Proceedings of the First Symposium on Geographic Information System (GIS) in Fisheries Science. Fishery GIS Research Group. Saitama, Japan.

Ybema, S., Bol, R., Bakker, K. and Tjoe-Awie, P. 2006. Cruise report hydro acoustic survey for blue whiting (*Micromesistius poutassou*), 13 March–31 March 2006. Institute for Marine Resources & Ecosystem Studies, IJmuiden, The Netherlands.

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	3/3–29/3	2512	30	46	371	371*
Celtic Explorer	23/3–8/4	2175	17	28	730	2961
G. O. Sars	18/3–15/4	3087	24	76	865	2368
Magnus Heinason	31/3–11/4	1254	14	21	365	1111
Tridens	15/3–27/3	1365	10	30	400	400*

* Used in the stock estimate. The actual number was higher but combining all data was not straightforward.

Table 2. Assessment factors of blue whiting, spring 2006.

Sub-area			Numbers (10^9)			Biomass (10^6 tonnes)			Mean weight	Mean length	Density
		n.mile^2	Mature	Total	%mature	Mature	Total	%mature	g	cm	ton/n.mile^2
I	S. Porcupine Bank	13268	2.18	2.18	100	0.20	0.20	100	93.4	26.9	15
II	N. Porcupine Bank	24841	8.51	8.51	100	0.74	0.74	100	87.3	26.7	30
III	Hebrides	34916	55.1	57.1	96.4	519	5.24	99.1	91.7	26.9	150
IV	Faroes/Shetland	32439	9.82	10.3	95.5	0.92	0.94	98.3	91.0	26.3	29
V	Rockall	64355	29.5	29.9	98.7	3.27	3.28	99.7	109.5	27.2	51
Tot.		169819	105	108	97.3	10.3	10.4	99.3	96.3	26.9	61

Table 3. Stock estimate of blue whiting, spring 2006.

	Age in years (year class)										Num-	Bio-	Mean	Prop.
Length	1	2	3	4	5	6	7	8	9	10+	bers	mass	weight	mature*
(cm)	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	(10^6)	(10^6 kg)	(g)	(%)
15.0 – 16.0	132	0	0	0	0	0	0	0	0	0	132	2	16.8	0
16.0 – 17.0	795	0	0	0	0	0	0	0	0	0	795	15	19.4	0
17.0 – 18.0	971	0	0	0	0	0	0	0	0	0	971	23	23.4	1
18.0 – 19.0	444	28	0	0	0	0	0	0	0	0	472	14	29.5	17
19.0 – 20.0	364	296	0	0	0	0	0	0	0	0	660	24	36.4	48
20.0 – 21.0	288	833	0	0	0	0	0	0	0	0	1121	48	42.9	80
21.0 – 22.0	106	867	106	0	0	0	0	0	0	0	1079	55	50.9	93
22.0 – 23.0	61	558	711	161	0	0	0	0	0	0	1491	85	57.2	100
23.0 – 24.0	0	1164	1964	766	0	0	0	0	0	0	3894	247	63.5	100
24.0 – 25.0	0	806	5184	2275	102	154	0	0	0	0	8520	597	70.1	100
25.0 – 26.0	0	746	10441	8070	1369	210	0	0	0	0	20838	1605	77.0	100
26.0 – 27.0	0	238	7620	7965	2345	957	0	16	0	0	19141	1624	84.9	100
27.0 – 28.0	0	3	4317	8932	3015	658	0	0	0	0	16925	1598	94.4	100
28.0 – 29.0	0	0	1094	6901	2798	1088	49	0	0	0	11931	1279	107	100
29.0 – 30.0	0	0	649	2631	2861	1229	272	0	53	0	7694	923	120	100
30.0 – 31.0	0	0	25	847	1766	913	391	89	0	0	4032	554	137	100
31.0 – 32.0	0	0	86	305	805	995	468	80	0	0	2738	429	157	100
32.0 – 33.0	0	0	0	20	908	516	181	60	0	0	1685	288	171	100
33.0 – 34.0	0	0	0	60	350	322	251	8	0	0	990	206	208	100
34.0 – 35.0	0	0	3	8	274	472	139	8	48	0	952	221	233	100
35.0 – 36.0	0	0	0	0	16	225	331	232	94	0	897	237	264	100
36.0 – 37.0	0	0	0	0	0	221	192	39	43	0	495	140	282	100
37.0 – 38.0	0	0	0	0	0	12	112	113	21	0	259	79	305	100
38.0 – 39.0	0	0	0	0	0	0	54	54	0	0	108	40	373	100
39.0 – 40.0	0	0	0	0	0	0	14	14	0	0	27	8	307	100
40.0 – 41.0	0	0	0	0	0	0	1	61	25	0	88	37	420	100
41.0 – 42.0	0	0	0	0	0	0	0	10	4	0	14	5	356	100
42.0 – 43.0	0	0	0	0	0	0	5	6	5	7	24	8	353	100
TSN (10^6)	3162	5540	32201	38942	16608	7972	2459	791	293	7	107975			
TSB (10^6 kg)	87	329	2598	3603	1896	1104	495	206	73	3	10393			
Mean length (cm)	18.0	22.9	25.8	27.0	28.7	30.0	32.9	35.2	35.2	42.5	26.9			
Mean weight (g)	27.6	59.5	80.7	92.5	114	139	201	260	249	337	96.3			
Condition (g/dm^3)	4.7	5.0	4.7	4.7	4.8	5.1	5.6	6.0	5.7	4.4	4.9			
% mature*	13	97	100	100	100	100	100	100	100	100	97.3			
% of SSB	0	3	25	35	18	11	5	2	1	0				

* Percentage of mature individuals per age or length class

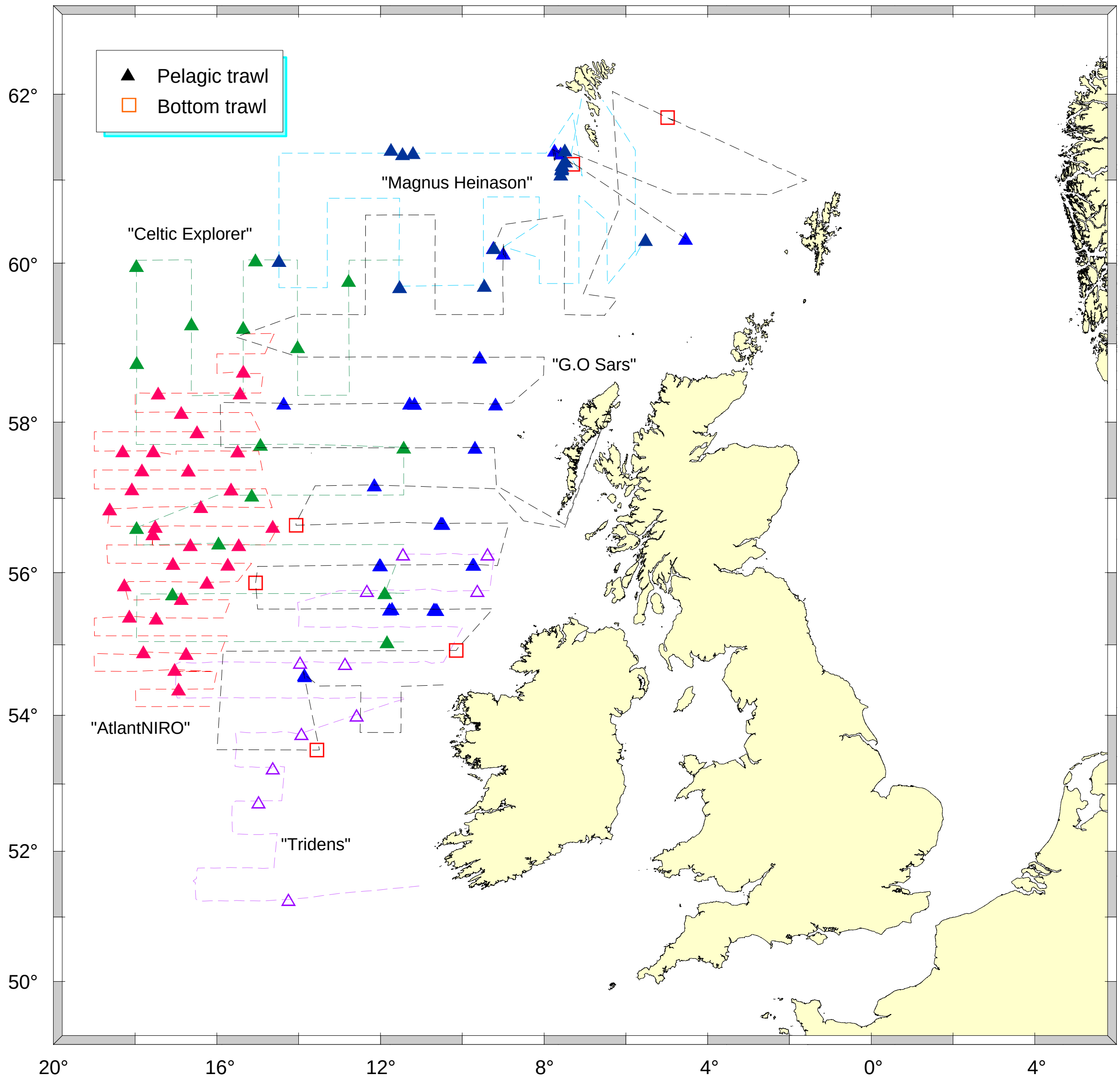

Figure 1. Cruise tracks and trawl stations during the International Blue Whiting Spawning Stock Survey in spring 2006. The figure shows all survey activity; in Figure 4, only the cruise tracks from which acoustic data were used in the stock estimate are shown.

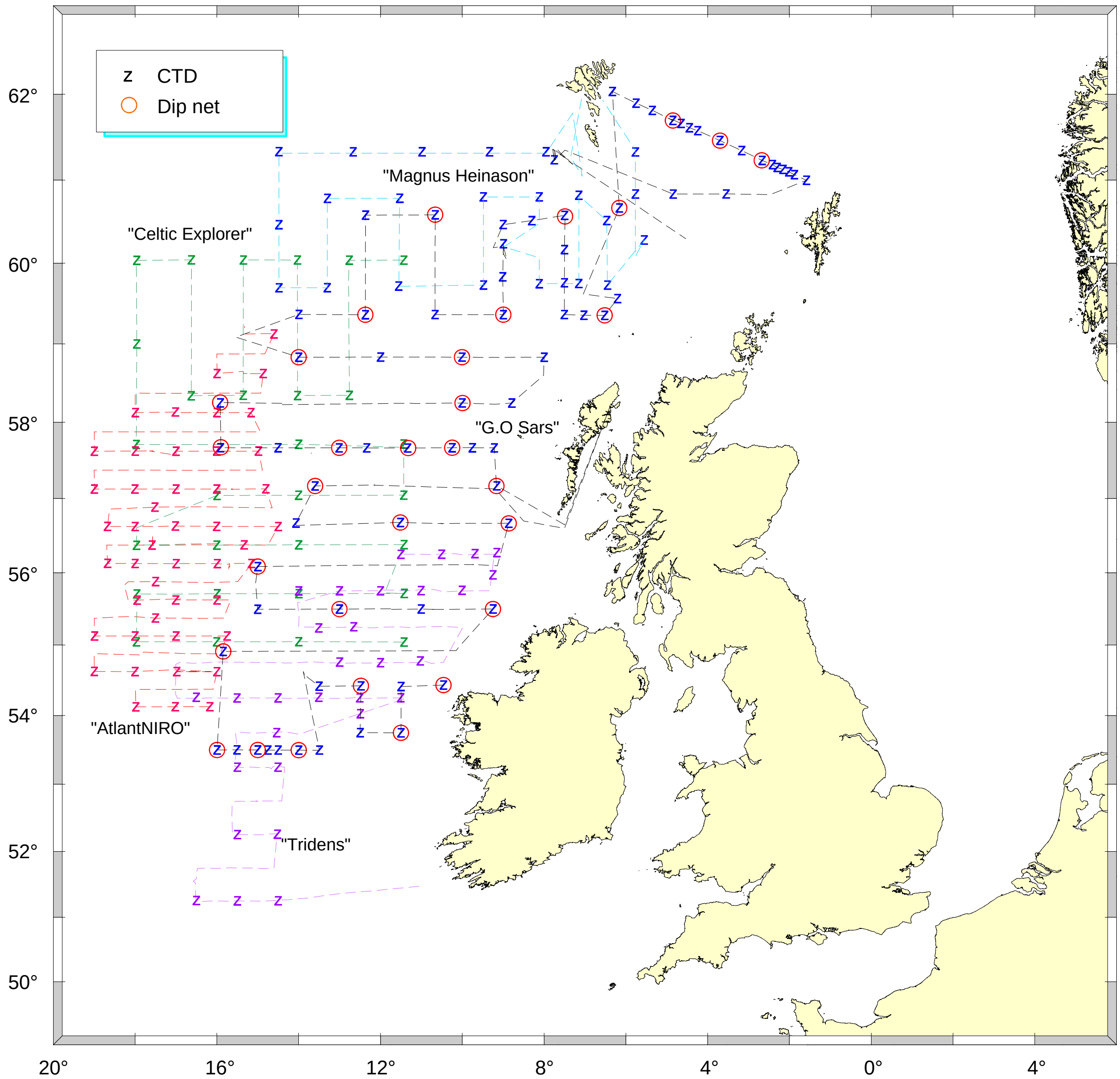

Figure 2. CTD stations for R/V Atlantniro, R/V Celtic Explorer, R/V G. O. Sars, and R/V Tridens in March-April 2006.

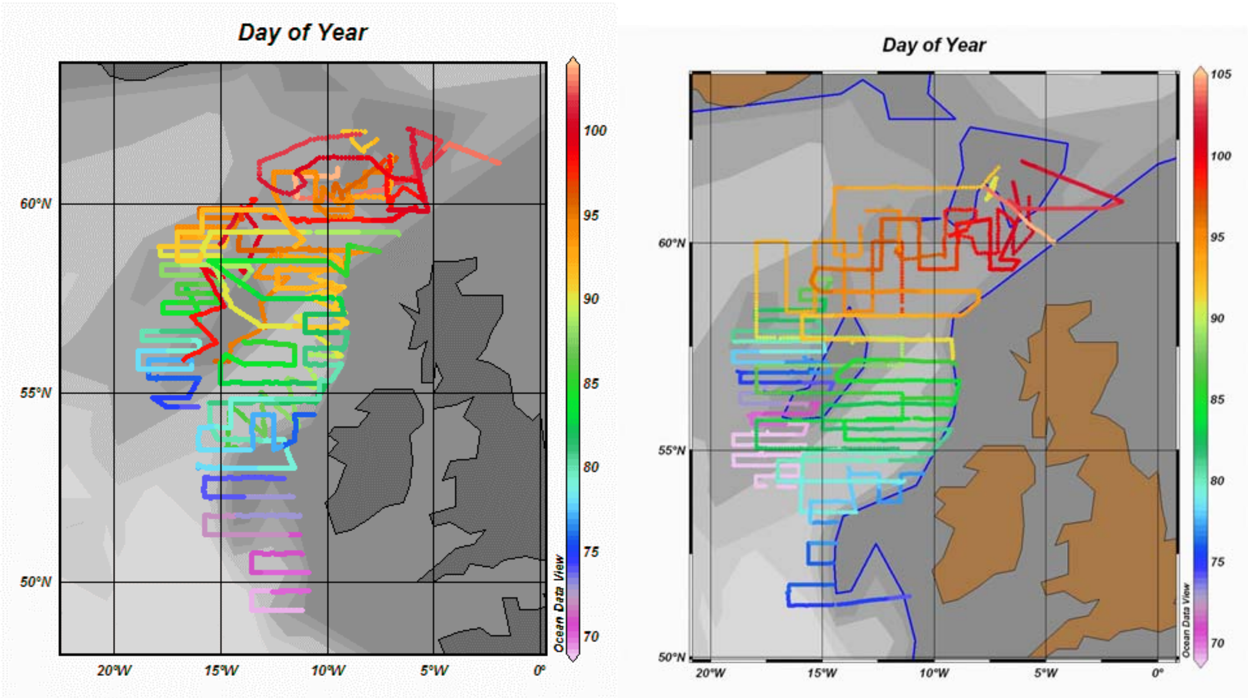

Figure 3. Temporal progression of the survey, 10 March–14 April 2005 (left) and 3 March–15 April 2006.

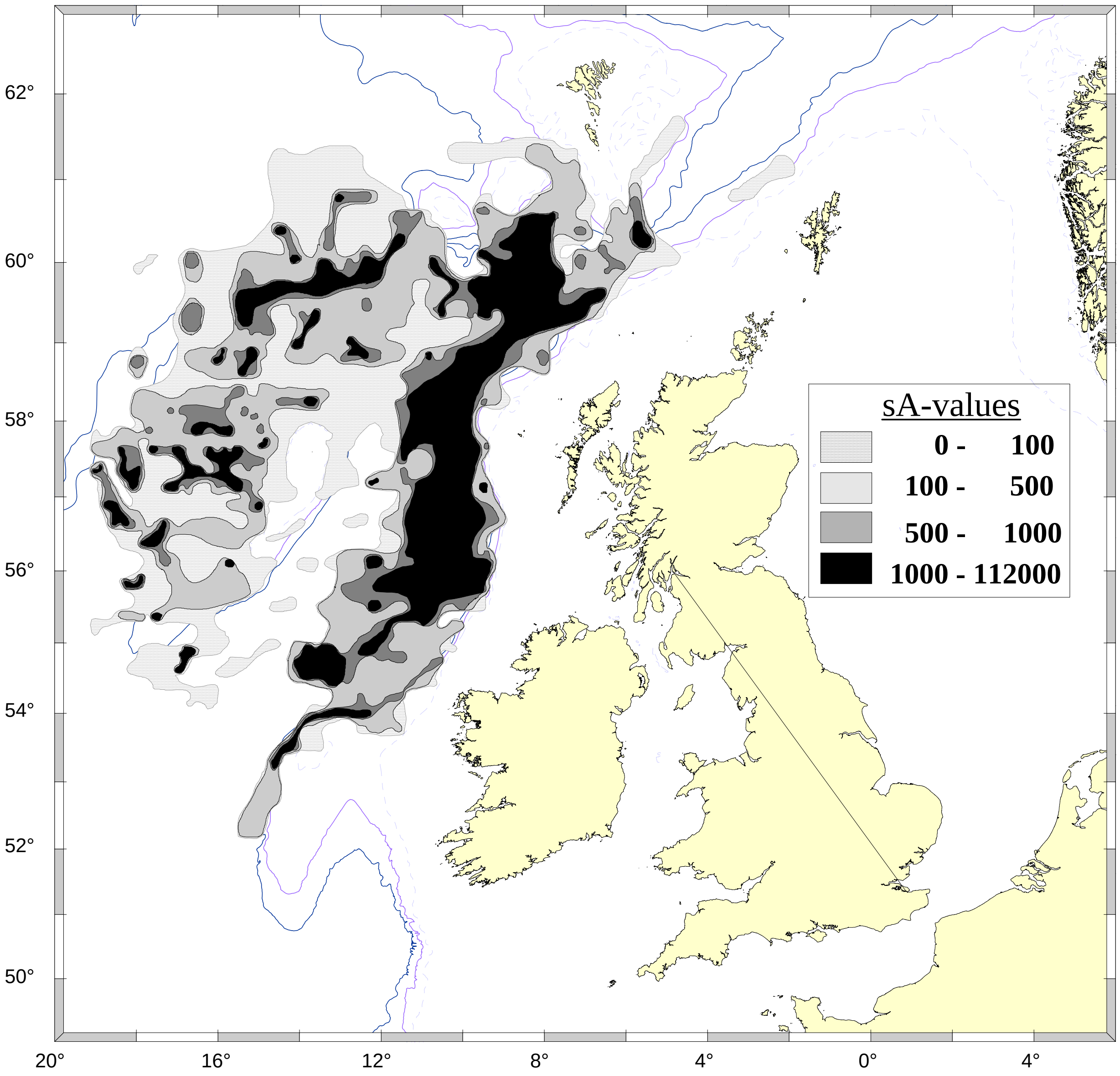

Figure 4. Schematic map of blue whiting acoustic density (s_A, m^2/nm^2) in spring 2006.

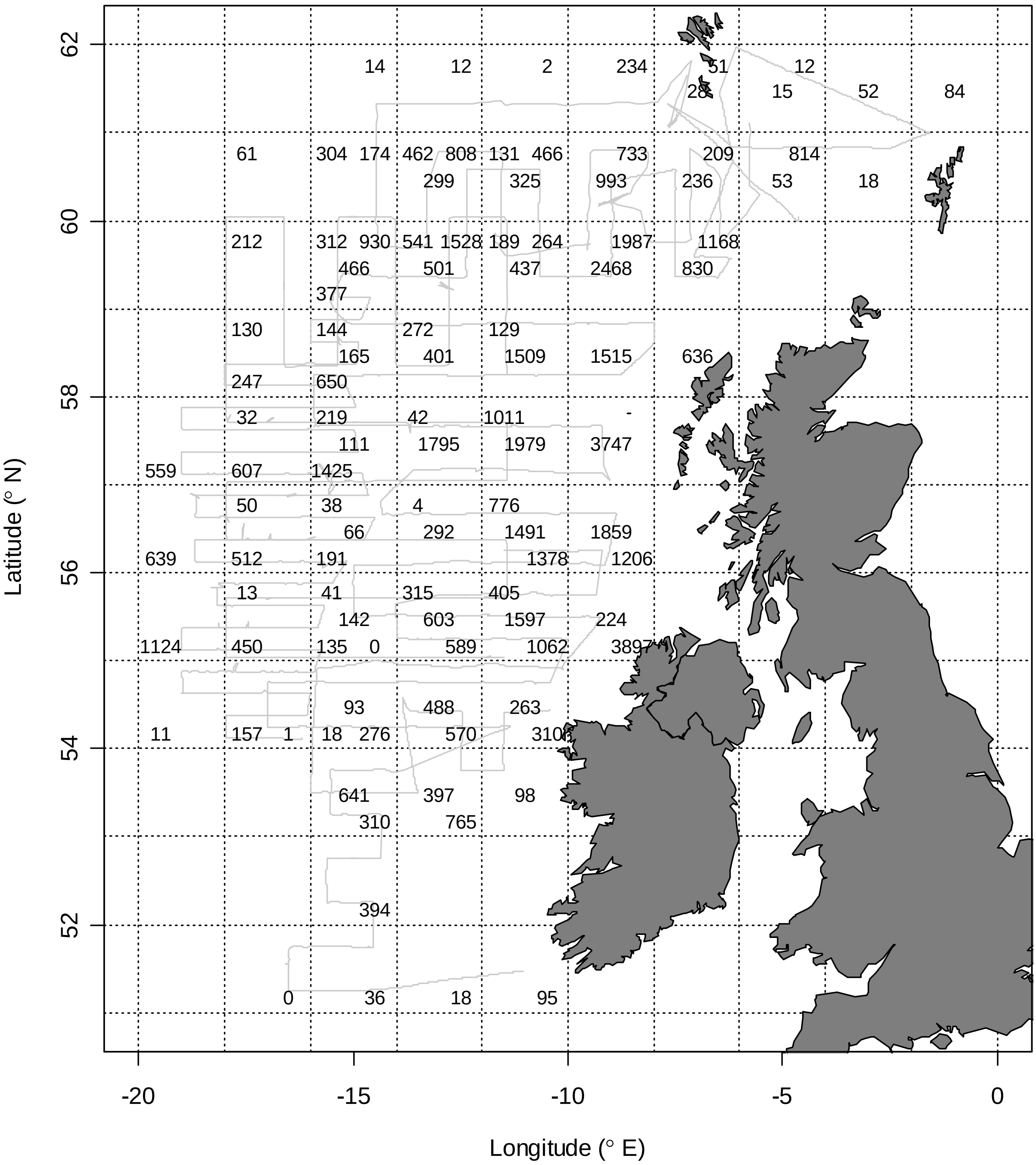

Figure 5. Mean blue whiting acoustic density (s_A, m^2/nm^2) for each vessel. top left: Celtic Explorer; top right: Magnus Heinason; bottom right: Tridens; bottom left: Atlantniro; centre: G.O. Sars.

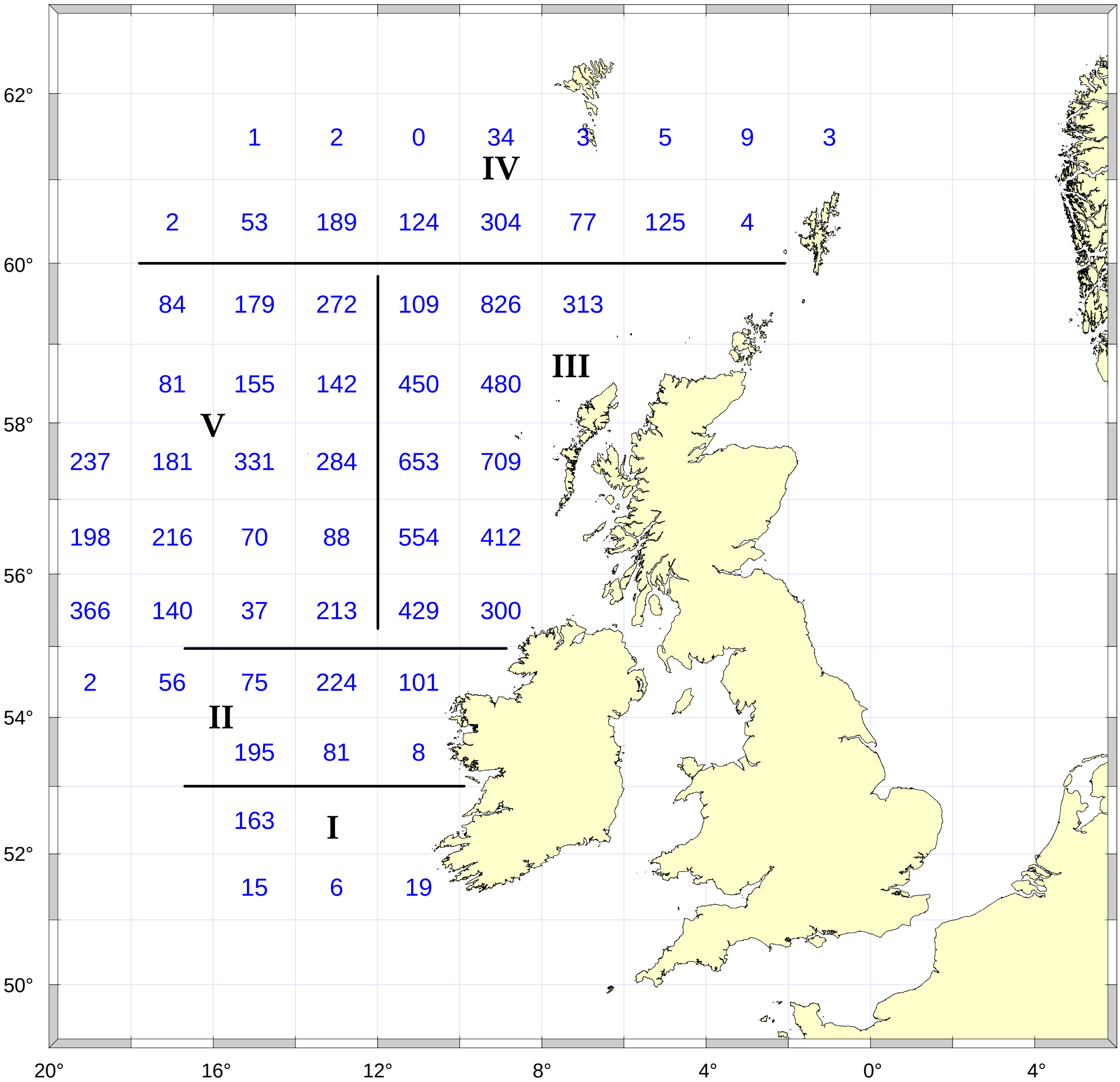

Figure 6. Blue whiting biomass in 1000 tonnes, spring 2006. Marking of sub-areas I-V used in the assessment.

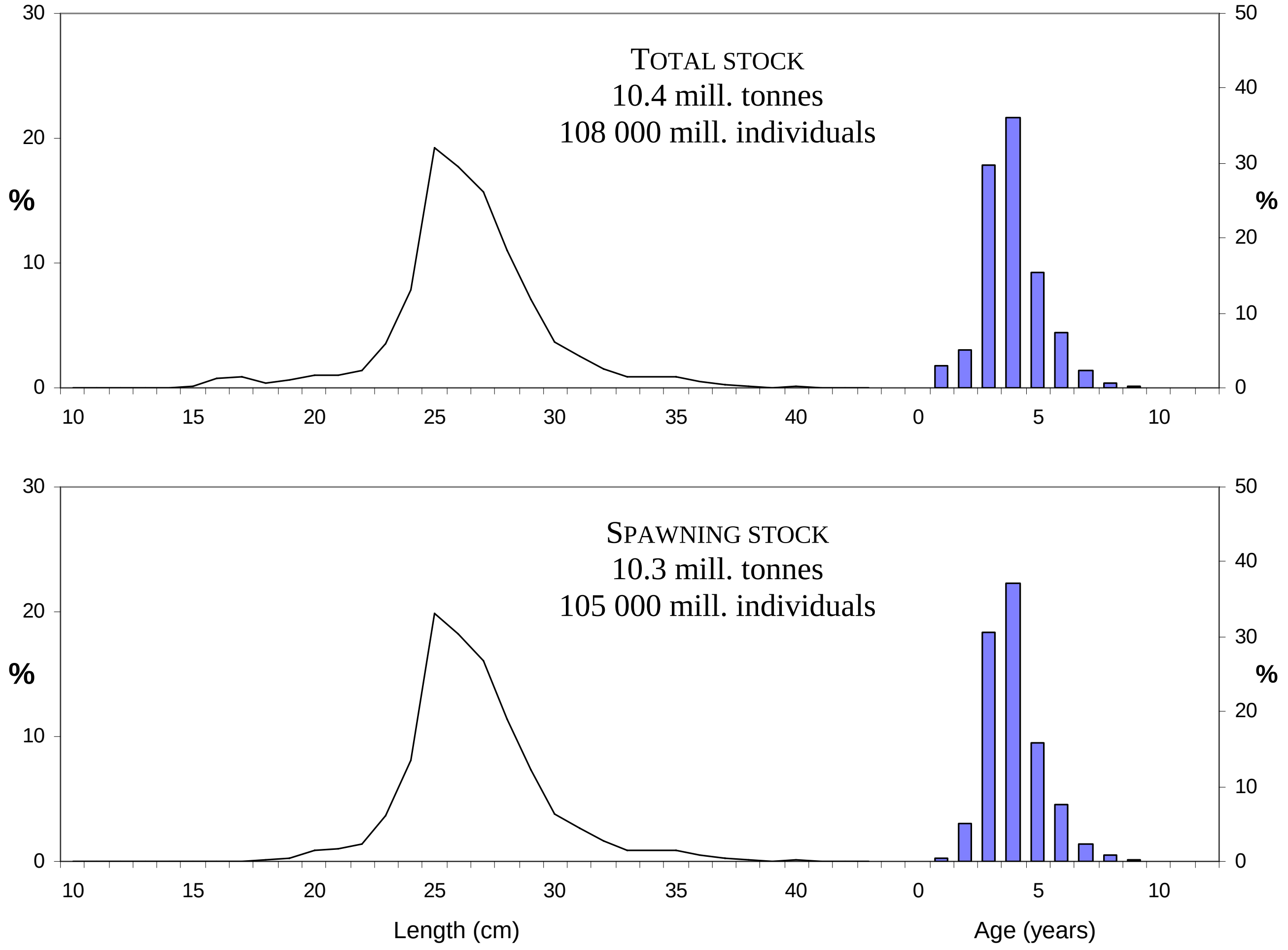

Figure 7. Length and age distribution in the total and spawning stock of blue whiting in the area to the west of the British Isles, spring 2006.

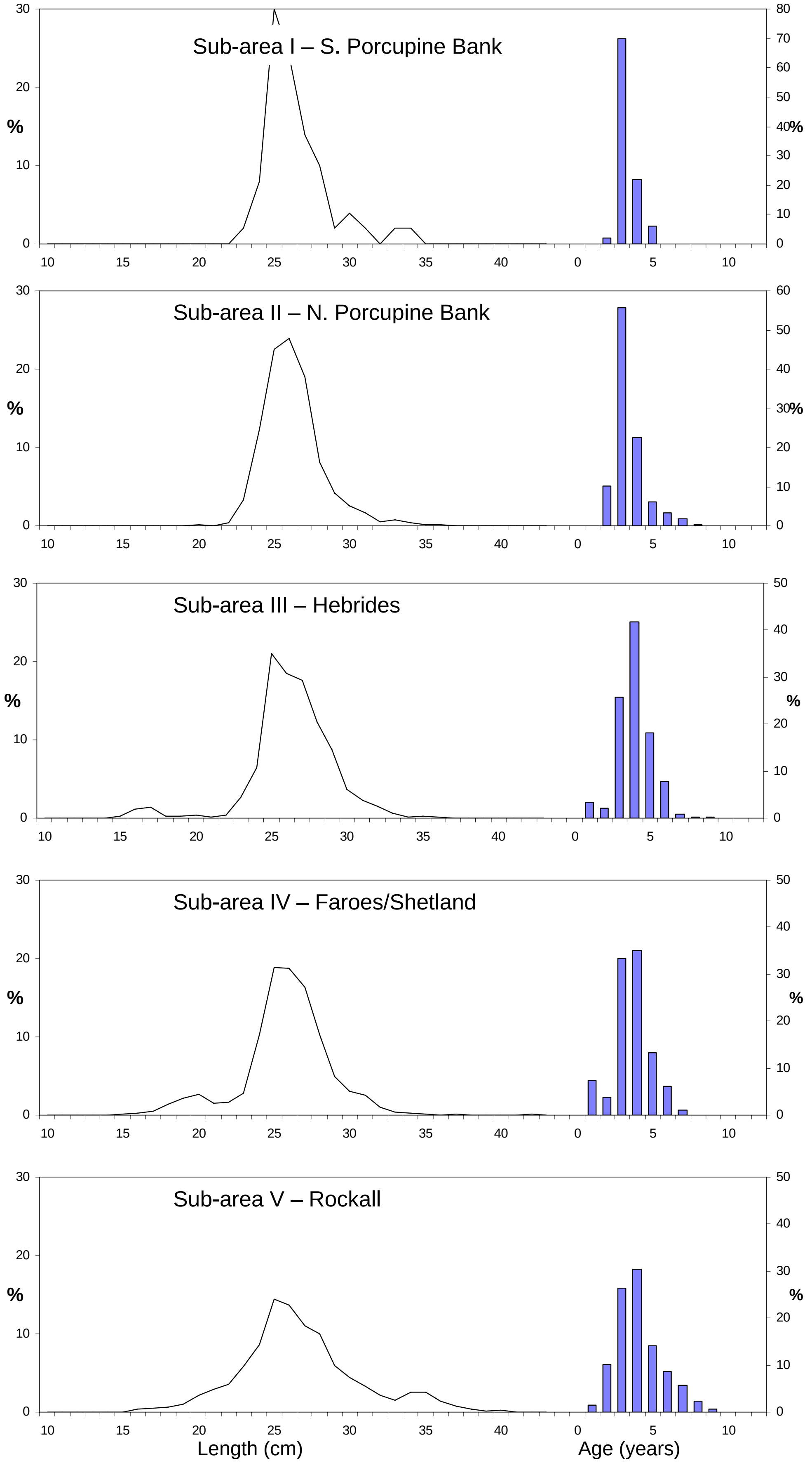

Figure 8. Length and age distribution of blue whiting by sub-areas (I–V), spring 2006.

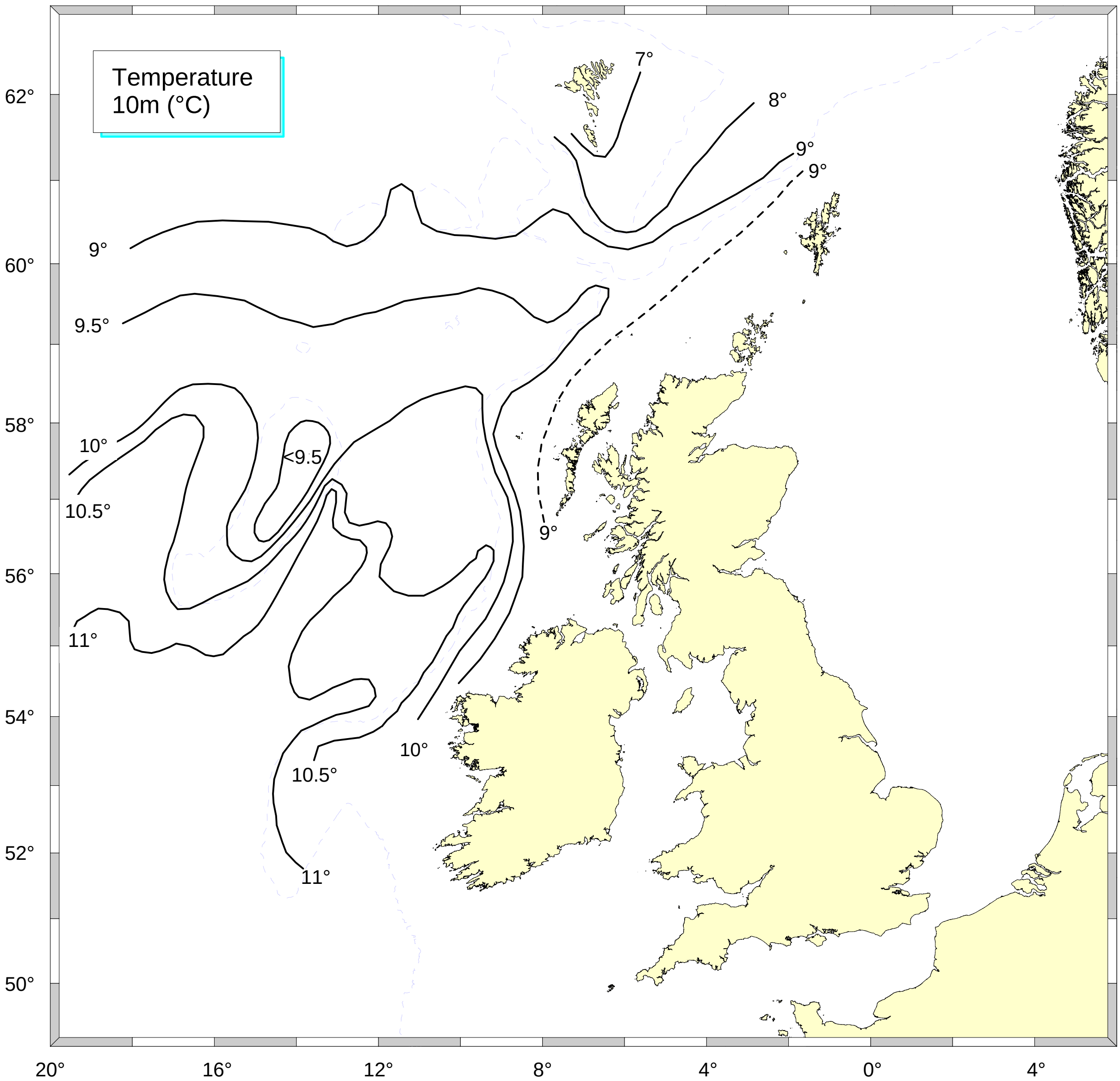

Figure 9. Horizontal temperature distribution, °C, in March-April 2006 at 10m depth.

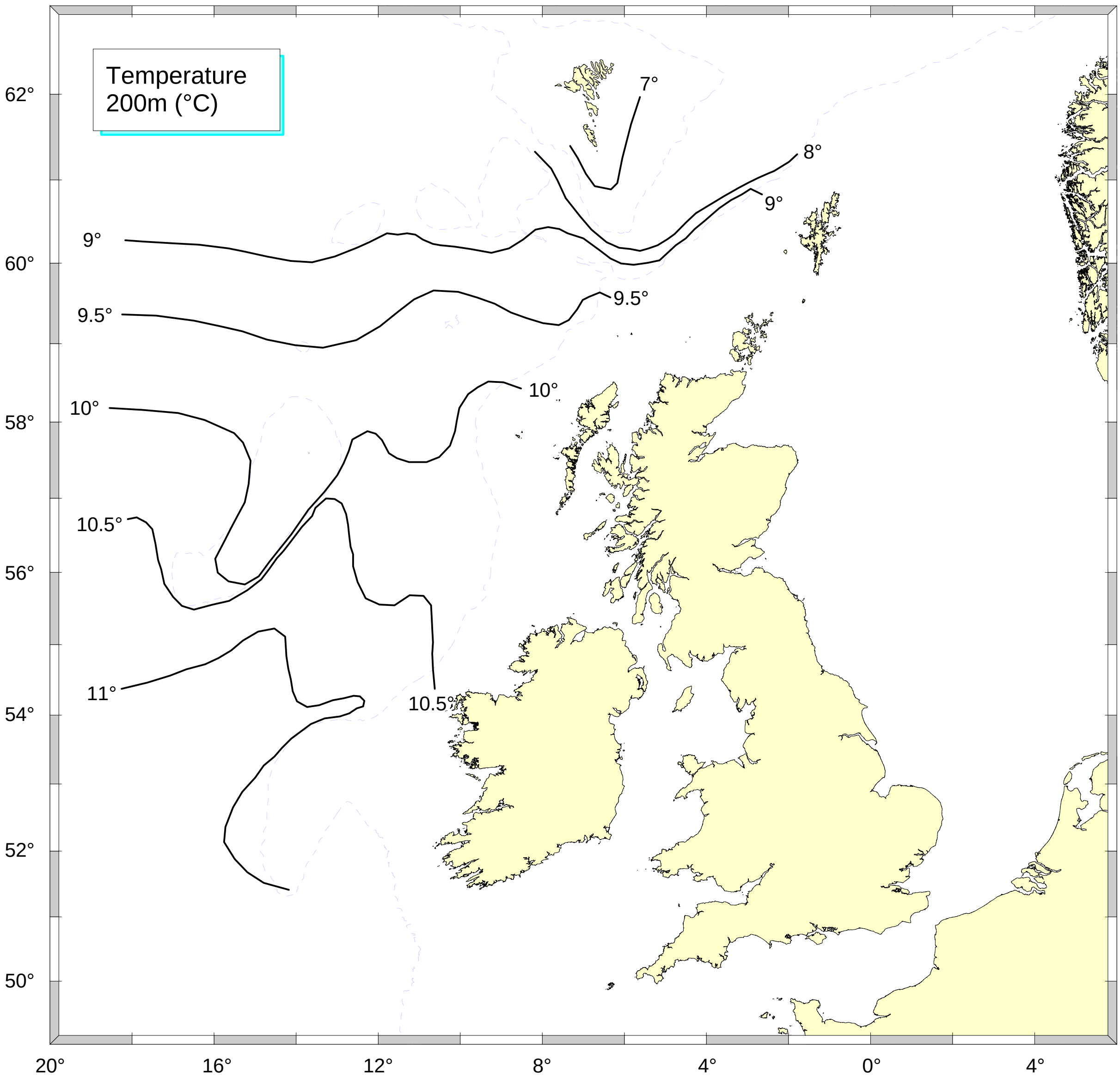

Figure 10. Horizontal temperature distribution, °C, in March-April 2006 at 200m depth.

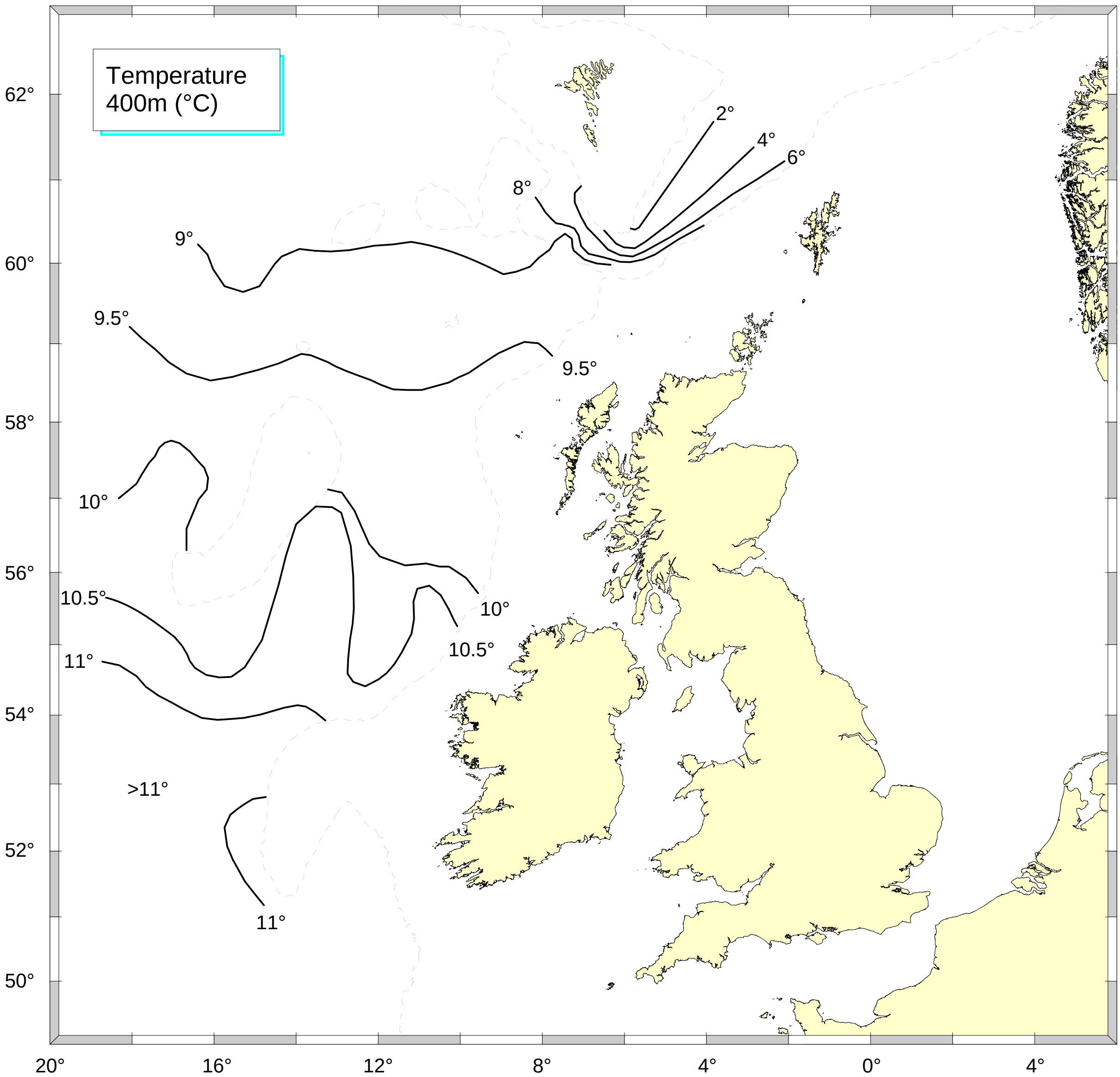

Figure 11. Horizontal temperature distribution, °C, in March-April 2006 at 400m depth.

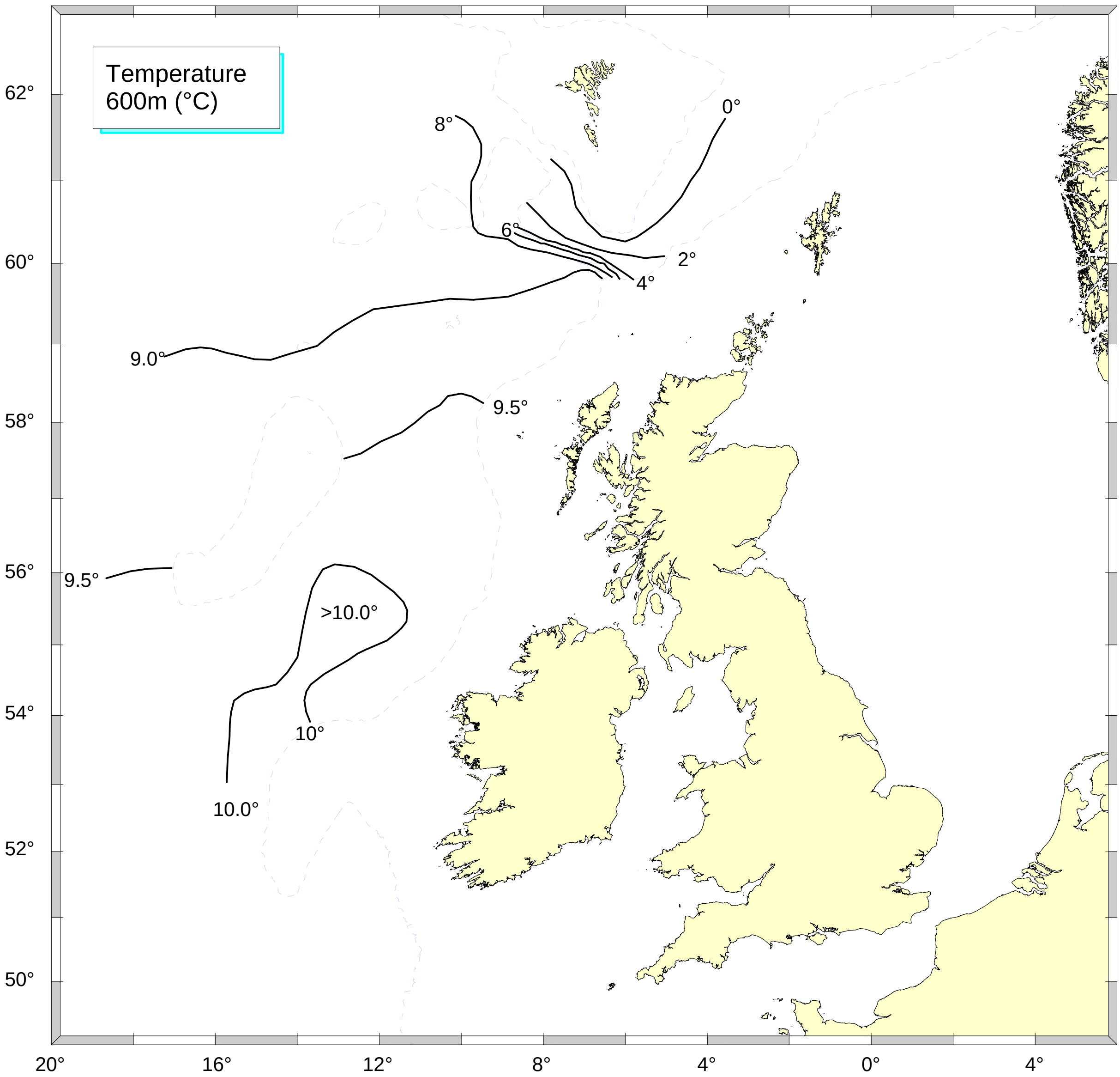

Figure 12. Horizontal temperature distribution, °C, in March-April 2006 at 600m depth.

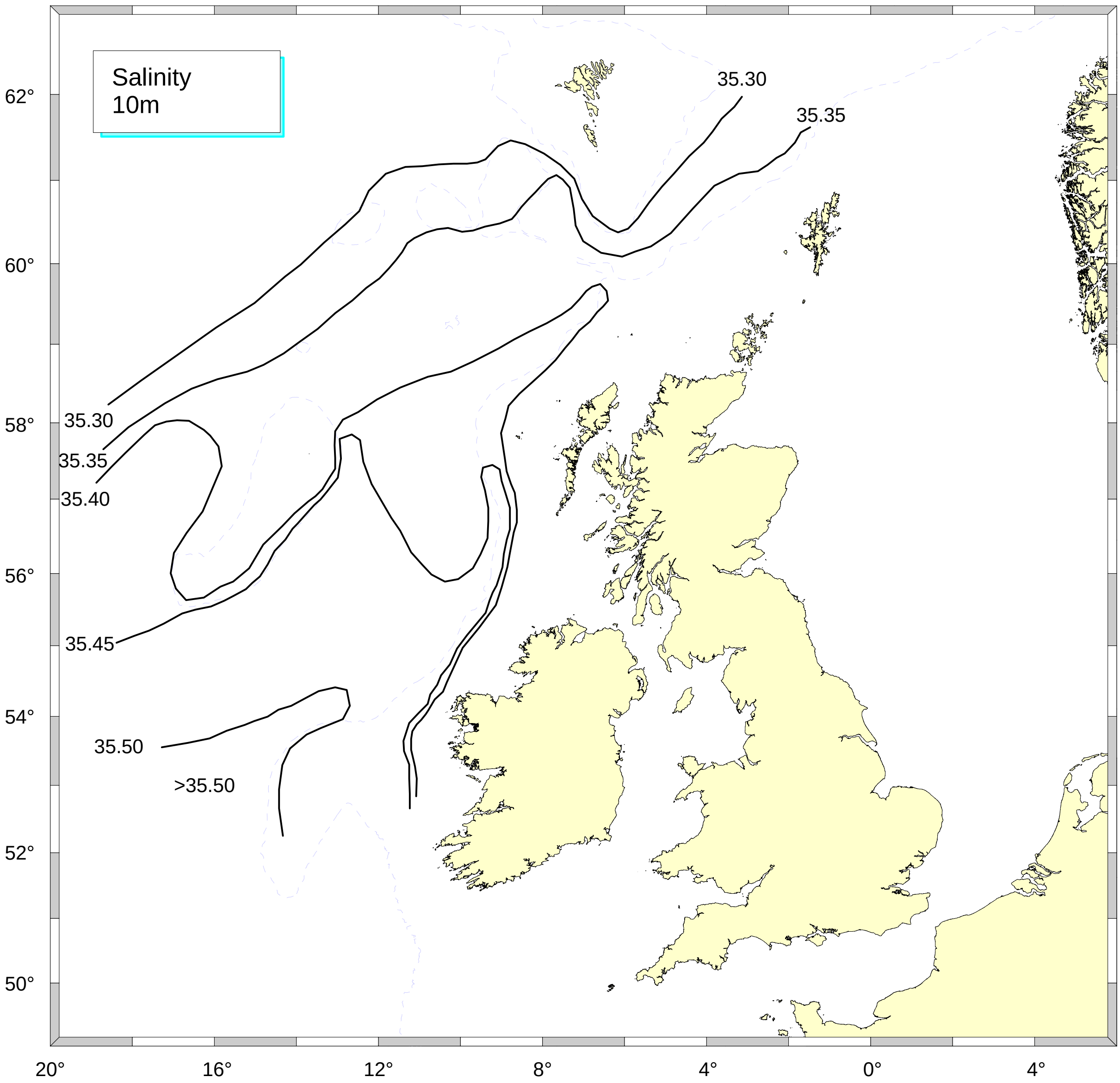

Figure 13. Horizontal salinity distribution, °C, in March-April 2006 at 10m depth.

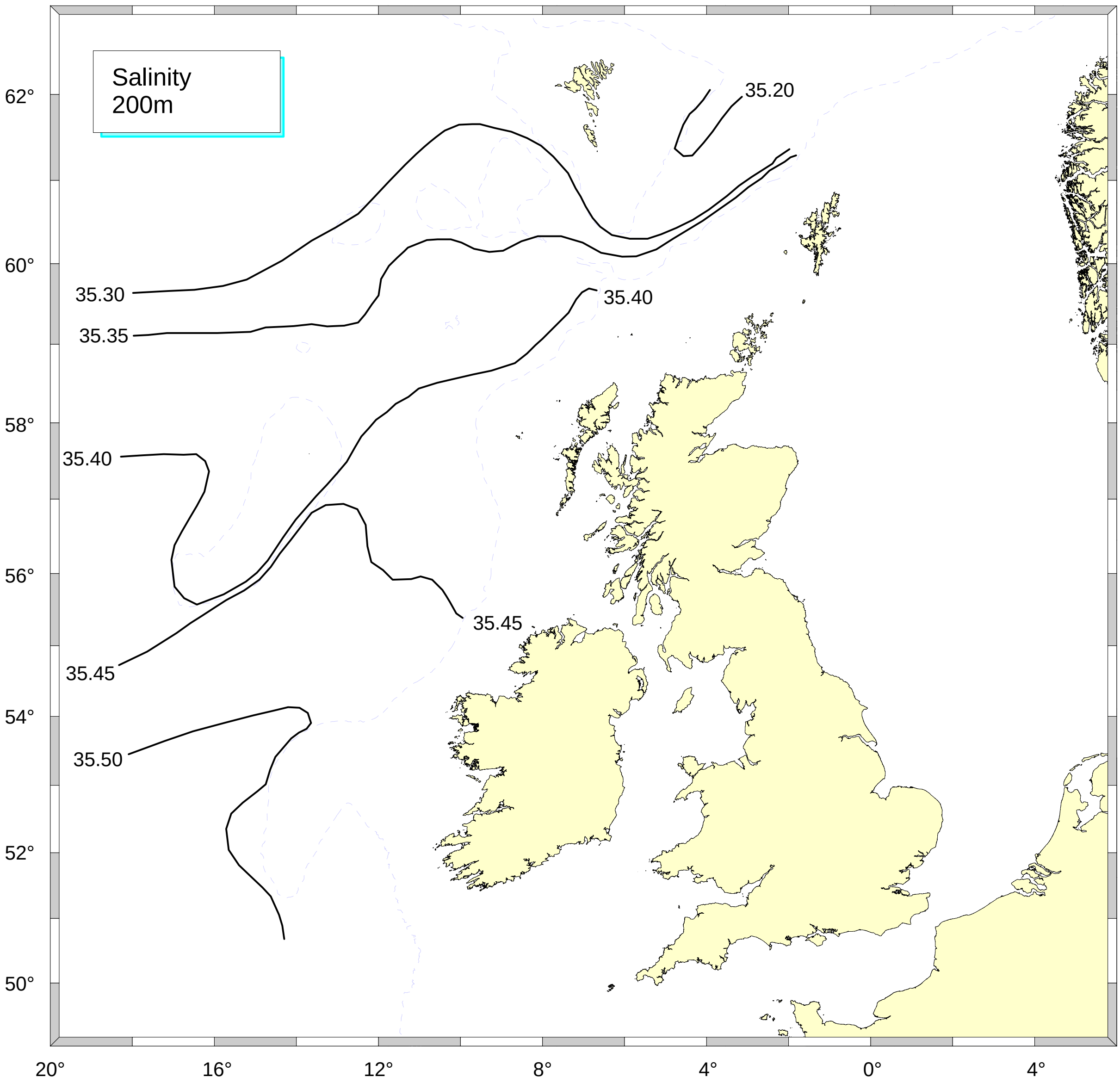

Figure 14. Horizontal salinity distribution, °C, in March-April 2006 at 200m depth.

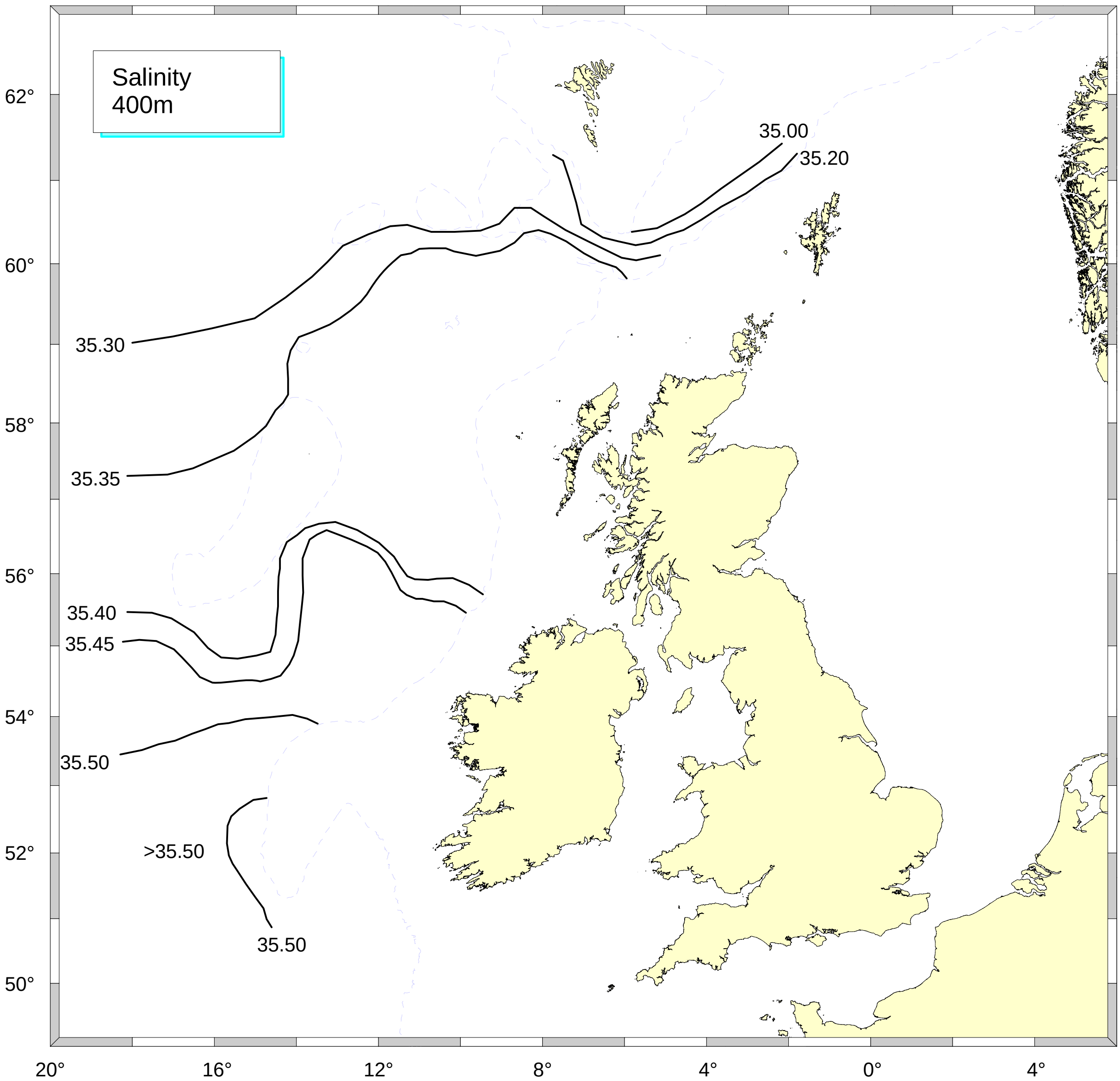

Figure 15. Horizontal salinity distribution, °C, in March-April 2006 at 400m depth.

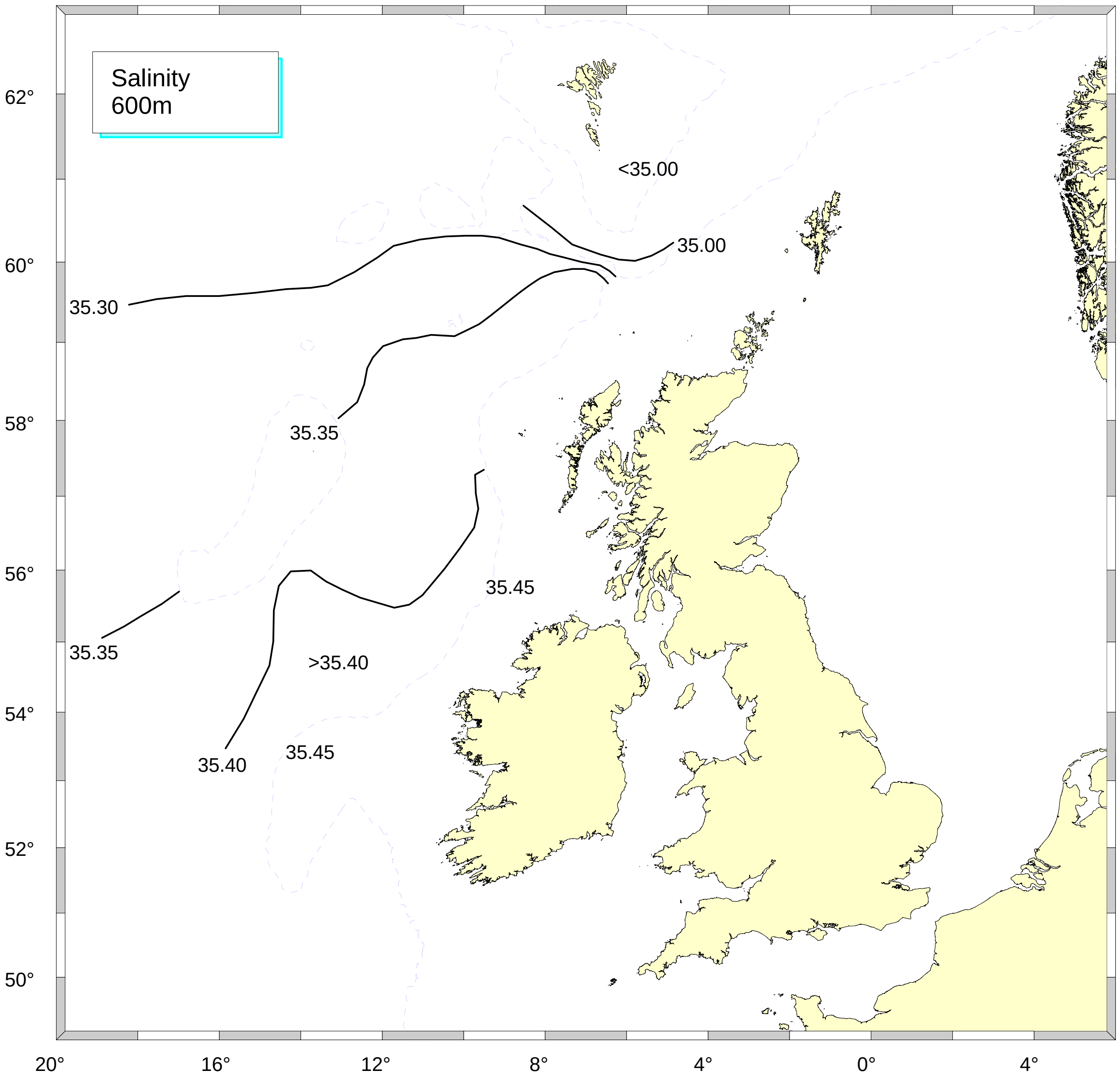

Figure 16. Horizontal salinity distribution, °C, in March-April 2006 at 600m depth.

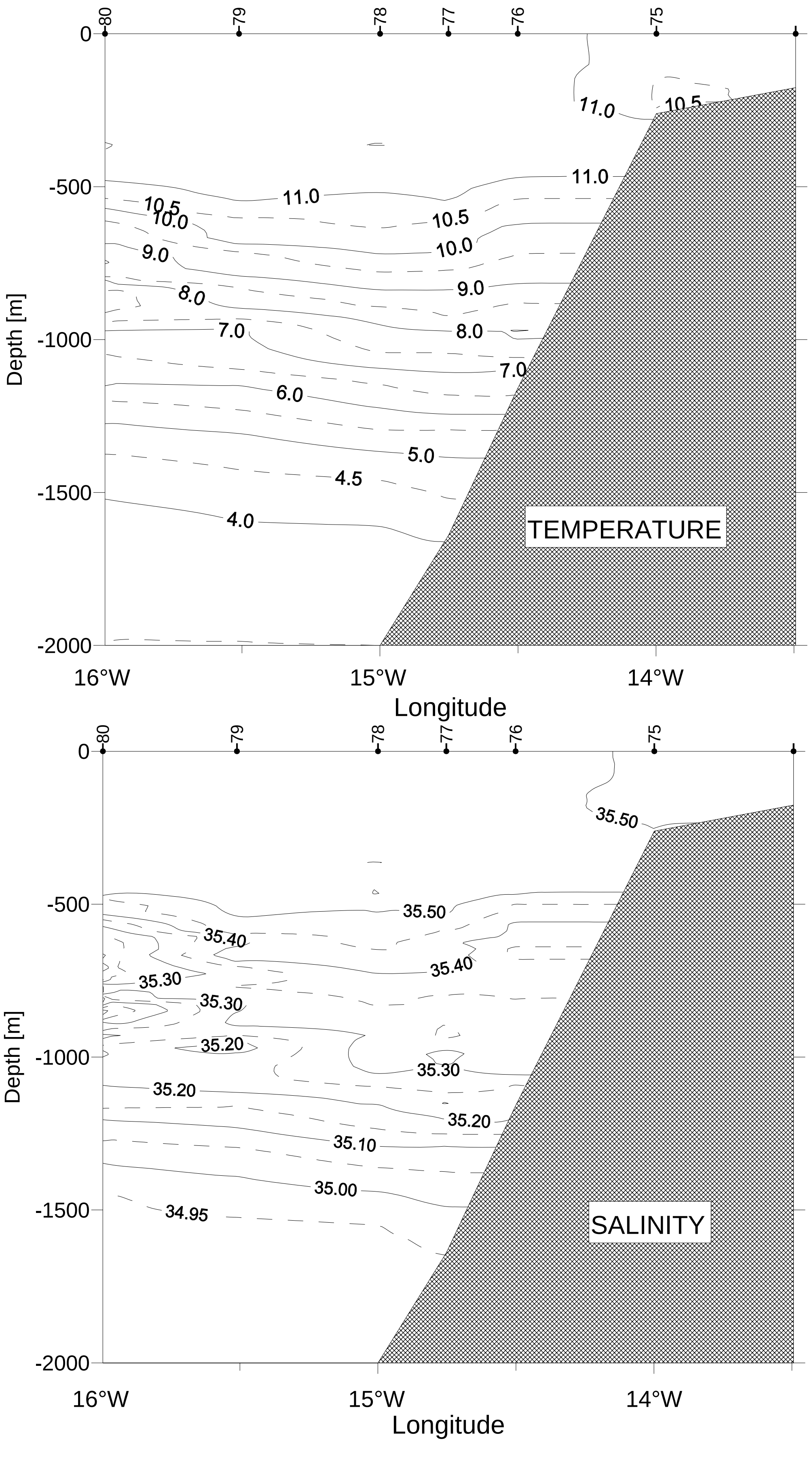

Figure 17. Vertical distribution of temperature (°C) and salinity in a section at the shelf edge at the Porcupine Bank at 53° 30'N. Station numbers at the top of the panels.

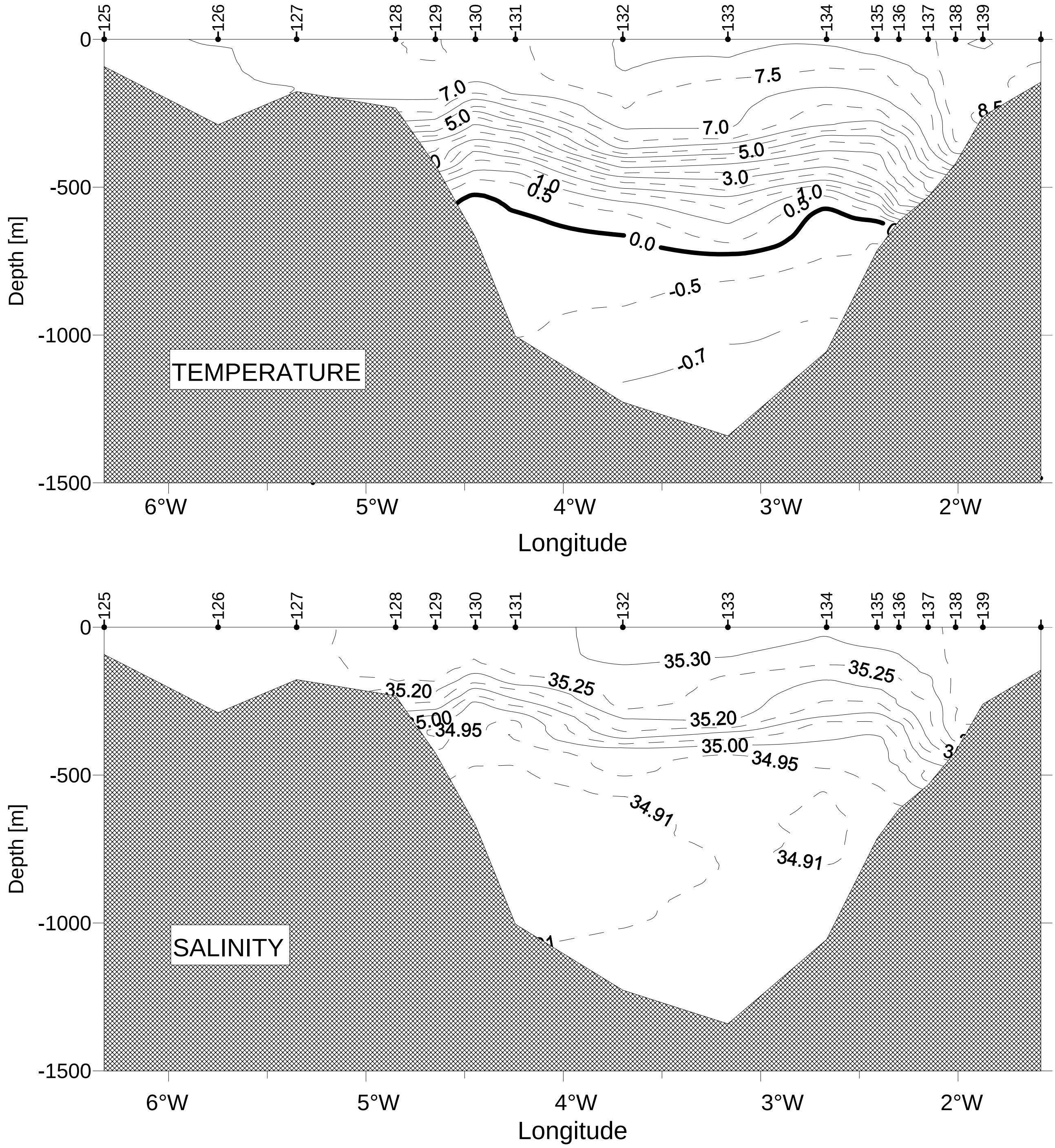

Figure 18. Vertical distribution of temperature (°C) and salinity in a section from the Faroes to Shetland (Nolsø-Flugga). Station numbers at the top of the panels.

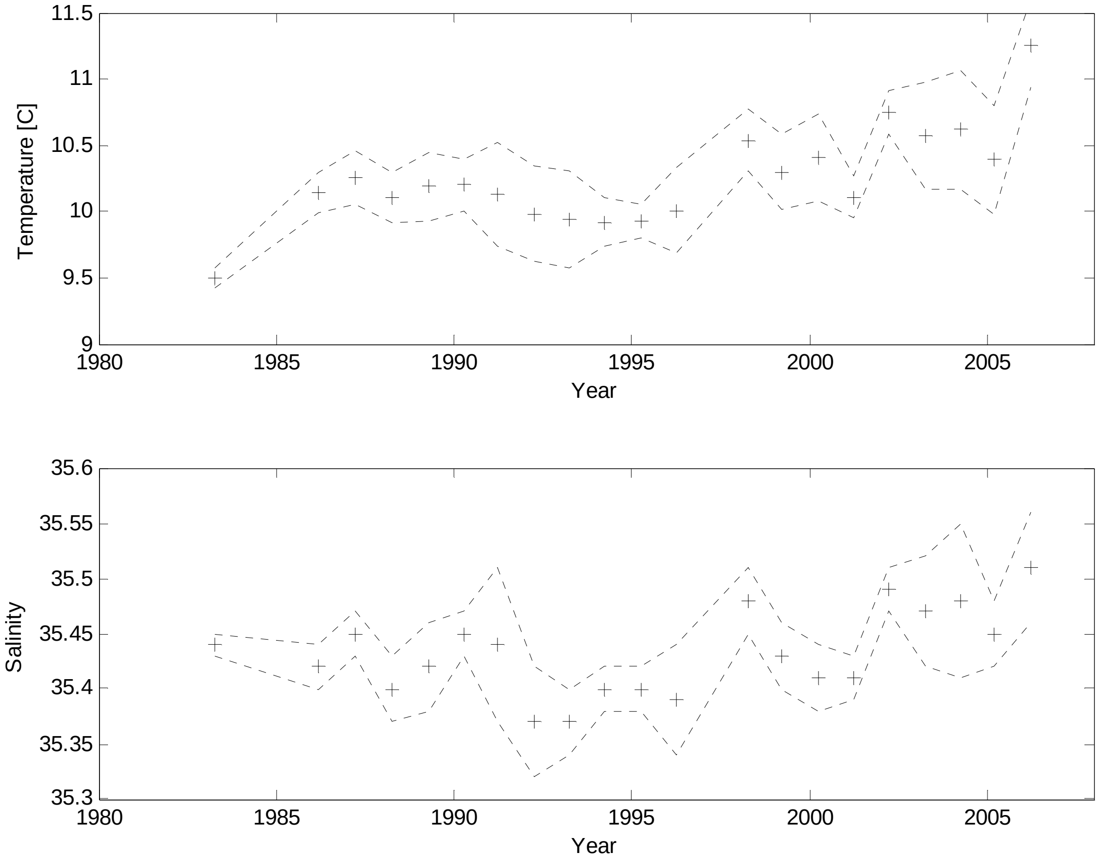

Figure 19. Yearly mean temperature and salinity from 50-600m (crosses) of all stations in a box with bottom depth>600m, west of the Porcupine bank bounded by 52° to 54°N and 16° to 14°W. Dotted lines are drawn at plus-minus one standard deviation of all observations in each box, each year.

Appendix 1. Inter-calibration between R/V 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 April 9 by the Ymir Ridge, south of the Faroes at N 60° 15' and W 9° 00'. The weather was fairly favourable with weak wind (10-15kt from NW) and moderate swell (significant wave height 4 metres) remaining from the strong gale the day before. The main acoustic features in the area were (1) a 100 m thick layer of blue whiting in depths between 450 and 600 metres that was strongest close to the Ymir Ridge, (2) a dense layer of presumed macro-zooplankton immediate below and partly mixed with the blue whiting layer, and (3) mesopelagics, probably mostly pearlside, in depths between 200 and 300 metres.

The inter-calibration was the run over 22 nautical miles between 13:48-16:06 GMT. Vessels were cruising southwest at parallel courses side by side 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. Regression model suggests that intercept is not significantly different from zero. Regression forced through the origin has a slope that is not significantly smaller than one and rather high coefficient of determination (r^2). Given the relatively low overall level of variation in acoustic density of blue whiting along the cruise track (less than one order of magnitude), the results are very encouraging and suggest that combining the acoustic data from these two vessels is unproblematic, at least under decent weather conditions.

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 0.5-1 nm apart. Magnus Heinason towed at depth of 550 m for 60 minutes and caught 23 kg of blue whiting. G. O. Sars towed for 63 minutes at depths of 500-550 metres and caught 29 kg of blue whiting.

As seen in Fig. 2, blue whiting in the pooled catch of G. O. Sars were somewhat larger in mean length (mean±sd length: 27.4±2.2 cm) compared to the blue whiting in the catch of Magnus Heinason (26.5±2.4cm). The difference in means was statistically significant (p=0.0002). In 2005, a similar difference was observed. Although spatial heterogeneity may contribute to the difference, the results suggest that G.O. Sars is slightly more efficient in capturing large blue whiting.

Table 1. Regression models for the full data. 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.

Model	Parameter	Estimate	Std. Error	t value	Pr(>|t|)	R^2 (%)
Intercept estimated	Intercept	237	159	1.49	0.151	82.2
	Slope	0.836	0.084	1.94	0.066	
Intercept=0	Slope	0.946	0.042	1.27	0.219	95.8

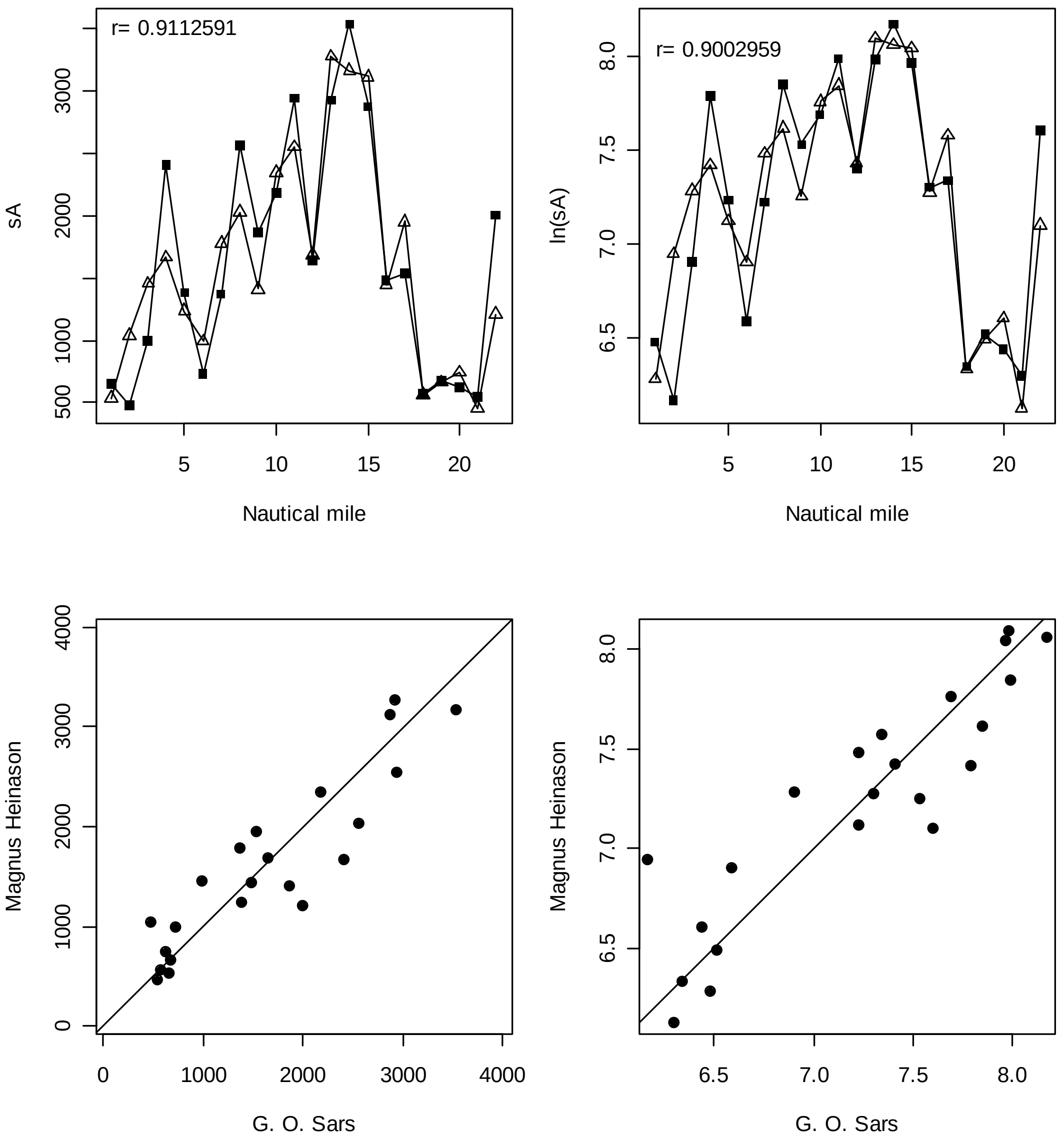

Figure 1. Comparison of blue whiting acoustic densities recorded by Magnus Heinason (triangles) and G. O. Sars (squares). The lower panels give same data as scatterplots. The diagonals are drawn as continuous lines.

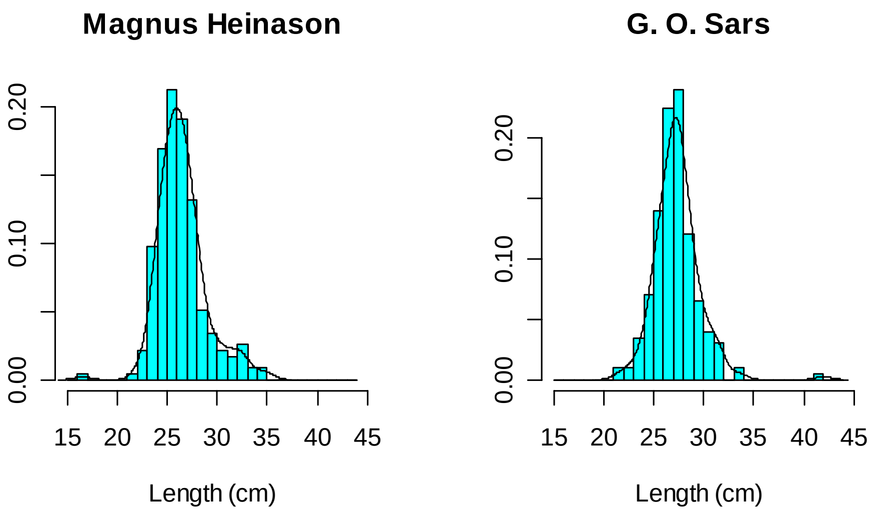

Figure 2. Length distributions from the trawls hauls by Magnus Heinason and G. O. Sars. Smoothing is obtained by normal kernel density estimates. G. O. Sars: n=200; Magnus Heinason: n=235.