ICES PGNAPES REPORT 2007

ICES RESOURCE MANAGEMENT COMMITTEE
ICES CM 2007/RMC:07
Ref. LRC, ACFM, ACE

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

14-17 AUGUST 2007

IJMUIDEN, THE NETHERLANDS

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

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

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

Recommended format for purposes of citation:

ICES. 2007. Report of the Planning Group on Northeast Atlantic Pelagic Ecosystem Surveys (PGNAPES), 14-17 August 2007, IJmuiden, the Netherlands. ICES CM 2007/RMC:07. 98 pp.

Contents

Executive Summary

This present report was prepared by the Planning Group on Northeast Atlantic Pelagic Ecosystem Surveys (PGNAPES) in Ijmuiden, the Netherlands 14–17 August 2007 and contains the results of the acoustic, hydrographic, plankton and fish sampling from two international ICES coordinated survey in 2007. The **International blue whiting spawning stock survey** on the spawning grounds west of the British Isles in March-April 2007 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 2007 with participation of Denmark (EU coordinated), Faroes, Iceland; Russia 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 "Eros" and a Russian survey with RV "Smolensk" in June 2007. 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 2007. 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. Unfortunately, no hydrographical or plankton expertise participated in the PGNAPES meeting this year. Broad plans for the ICES coordinated surveys for 2008 are also outlined with descriptions of the relevant protocols, preliminary participants and suggested survey designs.

1 Introduction

1.1 Terms of Reference 2007

The **Planning Group on Northeast Atlantic Pelagic Ecosystem Surveys** [PGNAPES] (Chair: A. I. Krysov, Russian Federation) will meet in Ijmuiden, the Netherlands, from 14–17 August 2007 to:

ITEM	ToR 2007	SECTION
a)	Critically evaluate the surveys carried out in 2007 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 2007 survey data and provide the following data for the Northern Pelagic and Blue Whiting Working Group:	3,4
	i) stock indices of blue whiting and Norwegian spring-spawning herring	3.1.2, 3.2.3-4 and 3.3.2.2-4
	ii) zooplankton biomass for making short-term projection of herring growth	3.2.2
	iii) hydrographic and zooplankton conditions for ecological considerations	3.2.1-2
	vi) aerial distribution of such pelagic species as mackerel	
c)	describe the migration pattern of the Norwegian spring-spawning herring and blue whiting stocks in 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 2007 including the following:	5
	i) the international acoustic survey covering the main spawning grounds of blue whiting in March-April 2008	5.1
	ii) the international coordinated survey on Norwegian spring-spawning herring, blue whiting and environmental data in May-June 2008	5.2
	iii) Russian investigations on pelagic fish and the environment in May-July 2008	5.2
	vi) Icelandic investigations on pelagic fish and the environment in June-July 2008	5.2
	v) Norwegian investigation on pelagic fish and the environment in August 2008	5.2

PGNAPES will report by 1 September 2007 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
Morten Vinther	Denmark
Jan Arge Jacobsen,	Faroe Islands
Leon Smith,	Faroe Islands
Guðmundur Oskarsson	Iceland
Ciaran O'Donnell,	Ireland
Sytse Ybema	Netherlands
Are Salthaug,	Norway
Mikko Heino,	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

Norwegian spring spawning herring are 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, participation from Denmark, Germany, Ireland, the Netherlands, Sweden and UK) 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. 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.

In 2007 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 2007 the coverage included the Barents Sea 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 2007. 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 2007:

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 June-August 2007 on a national basis:

(Norway and Russia, 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.

1.4 Recommendation

1.4.1 Practical achievements

Manual

The first version of a combined PGHERS and PGNAPES survey manual has been finalised during the meeting. This manual is still to be reviewed by the PGHERS group members. The manual includes new practical items such as a description on data upload and extraction from the web based databases, species specific sample level protocols, a detailed vessel/gear specification list of contributing countries and photo footage on scale extraction and deep-sea species identification. Both the hydrography and plankton chapters need to be updated since no expertise was present at the meeting.

Species

Follow up from 2006: In 2006 species names from Species lists used in Ireland, the Faroes, the Netherlands, Norway, Germany and Denmark were being compared in order to get a complete species list with their taxonomical numbers (TSN) to be used in the international PGNAPES database. The international combined species list in the PGNAPES database has now been updated with regularly encountered species from this list.

Meeting

The first day of the meeting was used for finalising the Ecosystem Survey report. A subgroup reviewed and updated the combined manual.

Suggestions:

It is hoped that the exchange of expertise during the Faeroes blue whiting survey be continued into 2008.

Survey planning requirements for 2008:

The temporal progression of the blue whiting survey in 2007 met the pre-agreed survey design requirements in part. The area along the shelf edge stretching from south Porcupine bank to the Faeroes was covered with well matching overlaps. It is planned that the 2008 survey program be carried out over a three week period beginning on the 25 March 2008 (+/- 3 days).

The group stressed the need to adhere to pre-agreed area coverage and survey design at all times during the survey program.

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, this has been adapted for survey data exchange formats within the group.

During the PGNAPES meeting EU effort allocation is to be planned for the coming year's survey program. To date no scientific personnel to the EU International blue whiting survey has been received. In order to allocate effort more efficiently, request emails for participation of Spain, France and UK will be sent directly after the PGNAPES meeting. The situation in 2007 saw Germany providing expertise.

Acoustic log interval distance in the exported data is set to 1 nautical mile as recommended by the group in 2007; this remains an issue and will be addressed again in 2008.

The next post-meeting of the International Blue whiting spawning stock survey will determined in early 2008.

All countries agreed on performing hydrographic CTD downcasts down to a maximum depth of 1000m, this remains an issue and will be addressed at the meeting in 2008.

It was agreed by the group that hydrographic and plankton survey data submissions be adhered to on the same submission time lines as all other components of the coordinated report. The group find the large amount of effort and shiptime required to secure both hydrographic and plankton data is not being used to its full potential for ecological analysis. The group encouraged members to address this issue back at their respective national laboratories.

It was agreed by the group that the "Manual for the Northeast Atlantic and North Sea Acoustic Survey Programs" Version1, will be forwarded to the chairman PGHERS for final assessment at the next meeting in early 2008.

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 the survey report given as annexes to this report.

International Blue whiting spawning stock survey. Five vessels participated, the Dutch RV "Tridens", the Irish RV "Celtic Explorer", the Russian RV "Atlantida", the Faroese RV "Magnus Heinason" and the Norwegian F/V "Eros" Annex 2 Table 1. The surveyed area (cruise tracks) in March-April 2007 is shown in Annex 2 Figure 1. More details are given in the combined cruise report (Annex 2).

International North East Atlantic Ecosystem Survey. Six vessels participated, the Danish RV "Dana", the Norwegian RVs "G.O. Sars" and "Håkon Mosby", the Icelandic RV "Árni Fridriksson", the Faroese RV "Magnus Heinason" and the Russian RV "Smolensk" (. Technical details are given in the combined technical survey report (Annex 3). The surveyed area (cruise tracks) in May-June 2007 is shown in Annex 3 Figure 2. Map showing area I to III used in the acoustic estimate of herring and blue whiting is shown in Annex 3 Figure 1.

Other relevant surveys

In addition to the two surveys that are dealt with by PGNAPES a number of national surveys on Norwegian spring spawning herring and blue whiting are also carried out. Information from some of these surveys has been reported to the group.

The surveys are:

Russian conducted survey by RV "Smolensk" in the period 12/6–21/6 2007. This was an acoustic survey in the distribution of herring in the Norwegian Sea. Details given in Section 3.4

A Norwegian conducted 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 2007 by two chartered Norwegian commercial vessels M/V "Libas" and M/V "Eros" Details given in Section 3.4

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 2007 are given in the combined survey report Annex s1 and 2

2.2 Plankton

Details of the sampling intensity of plankton made by the participating vessels are shown in Annex 2 Table 1. During the International ecosystem survey in the North East Atlantic in 2007 a total of 269 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. All data obtained by WP2 are presented as g dry weigh m^2.

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 500 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 (LSSS/BI500-system) [Dana, G.O.Sars], Echoview version 4.2 [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 (ρ_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 2007. Five vessels participated in the survey: RV "Atlantniro", RV "Celtic Explorer", FV "Eros", RV "Magnus Heinason" and RV "Tridens". This is the fourth 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.*, 2007) reproduced as Annex 2 in this report, as well as in national reports from individual vessels (Celtic Explorer: O'Donnell *et al*., 2007; Eros: Godø *et al*., 2007; Magnus Heinason: Jacobsen *et al*., 2007, Tridens: Ybema *et al*., 2007).

3.1.1 Hydrography

CTD stations are shown in Figure 2 of Annex 2 for all vessels. Unfortunately there was no sufficient interest to analyse the data.

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 southwest 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 Annex 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 11.1 million tonnes and 102 x 10^9 individuals, a marginal and statistically insignificant change compared to 10.3 million tonnes and 105 x 10^9 individuals in 2006 but clearly more than in 2005.

The age-disaggregated total stock estimate is presented in Table 3 of Annex 2, showing that the stock is now dominated by blue whiting of 4–5 years in age (2002–2003 year classes). These age classes made up 55% of spawning stock biomass. The numbers of the 2003 year class remain unchanged, whereas the numbers of age class 2002 are reduced by 36 %. The highest numbers of "young" blue whiting (age 1–3 years) were observed in the northern areas.

Mean age (4.6 years), length (27.7 cm) and weight (108 g) are the highest on record in the international survey time series (2004–2007). Numbers of "old" blue whiting, ages 6 to 8 years, are the highest on record. On the other hand, numbers of young blue whiting, ages 1 to 3 years, are record low. Recruitment to the spawning stock appears to be rather low.

Time series from the survey is presented in Table 3.1.1. Indicative confidence limits are only known for total biomass estimates (see Figure 3 of Annex 3 in Annex 2 of this report), suggesting that changes in total stock from 2006 to 2007 are not significant.

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. With the limited coverage by the Norwegian vessel in 2007, no update of this time series can be provided.

3.1.3 Deal fish

Dealfish (*Trachipterus arcticus*) continued to be present in most of the trawl catches. Also catch numbers were often high, and dealfish was often among the species that made up bulk of

the sample biomass. Furthermore, some commercial vessels reported very high proportions of dealfish in their catch.

3.2 International ecosystem survey in the Nordic Seas

An international ecosystem survey was carried out in the Nordic Seas from late April to early June 2007 aimed at observing the pelagic ecosystem in the area, with particular focus on Norwegian spring spawning herring, blue whiting, zooplankton and hydrography. The survey area was split into three Subareas (Figure 1 of Annex 3): Area I (Barents Sea), Area II (northern and central Norwegian Sea), and Area III (south-western area, i.e. Faroese and Icelandic zones and south-western part of the Norwegian Sea). As last year six vessels participated in the survey: RV "Dana", Denmark (EU coordinated with participation from Denmark, Germany, Ireland, The Netherlands, Sweden and UK), RV "Magnus Heinason", Faroe Islands, RV "Árni Friðriksson", Island, RV "G.O. Sars" and RV "Håkon Mosby", Norway and RV "Smolensk", Russia. The high vessels effort in this survey with such a broad international participation (Table 1 of Annex 3) allowed for broad spatial coverage as well as a relatively dense net of trawl and hydrographic stations (Figures 2 and 3 of Annex 3). The results from the international ecosystem survey have been described in detail in the joint cruise report attached (Annex 3), as well as in national reports from individual vessels (Dana: DFH 2007, Magnus Heinason: Jacobsen *et al.*, 2007, Arni Friðriksson: MRI 2007, G.O. Sars and Håkon Mosby, Smolensk).

In general the weather conditions were excellent during the survey with the exception of some short periods of bad weather in the eastern area.

3.2.1 Hydrography

CTD stations are shown in Figure 2 of Annex 3 for all vessels. The temperature distribution in the ocean distributions at sea surface, 20, 50, 100, 200, 400 m depth in May/June 2007 is shown in Figures 4–9 of Annex 3. The distribution of the waters carried from northwest into the Norwegian Sea by the relatively cold East Icelandic Current, from south relatively warm Atlantic in the eastern Norwegian Sea were very similar to the last year at all depths (compare Figures 3.2.1.3–3.2.1.8 from the 2006 report). In the central Norwegian Sea (~68-70^{o}N) temperature was somewhat higher in 2007 than in 2006, while the 5^{o}C isotherms at surface-50 m in 2007 were closer to Jan-Mayen than in 2006.

The basic feature of the oceanographic situation in the Barents Sea in the end of May beginning of June 2007 is preservation of the increased thermal condition of waters of the basic warm currents. Thus, practically most of the southern part of the Barents Sea occupied waters with positive temperature anomalies, due to both intensive advection of warm Atlantic waters, and increased rates of spring warming. The thermal level of the Atlantic corresponds to warm years.

In the western Barents Sea the distributions of the temperatures were in 2007 similar as in 2006. On the section «Kola meridian », temperature waters in layers 0-200, 50-200 and 150-200 m of central branch of the North Cape currents were considerably above long term average from 1951.

3.2.2 Zooplankton

Zooplankton stations and zooplankton biomass are shown Fig 10 of Annex 3. The zooplankton abundance was low in 2007 with the highest concentrations in the cold water of the East Icelandic current and along the Arctic front of the western Norwegian Sea, and in the Northern Norwegian Sea, which is consistent with previous survey results. A time series of recorded average zooplankton abundance is given in Table 3.2.1 showing that the biomass in 2007 was the lowest on record since 1997. The recorded zooplankton biomass was separated

into an western and an eastern area divided by the 2°W meridian, and the average biomass equalled the mean for the time series in the western region, and was low for the eastern region, as was the case in 2006 (Table 3.2.1).

3.2.3 Norwegian spring spawning herring

Survey coverage was considered adequate in 2007 and it was a huge benefit that the Barents Sea was again included in the coverage, as this allows complete spatial coverage of the whole distribution area of the Norwegian spring spawning herring. Herring were recorded throughout most of the surveyed area as shown in Figure 11. Distribution was similar to that observed in 2006.

The recorded concentrations of herring in the central Norwegian Sea (Area II) were limited compared to the recordings in the Barents Sea and especially in the southwestern part (Area III) of the surveyed area. The highest values were recorded at the eastern edge of the cold waters of the East Icelandic Current (Figure 11 in Annex 3). This southern displacement is further reflected in a more southern centre of gravity of the acoustic recordings in 2007 as compared to 2006 and 2005 (Figure 12 in Annex 3). It was mainly older herring that appeared in the Icelandic waters (the 1998 and 1999 year classes now at age 9 and 8), while in Faroese waters also the 2002 year class appeared in addition to the 1999 and 1998 year classes contributed equally to the biomass. Older herring from the 1991, 1992, and 1993 year classes were also observed in the southwestern area. In the Barents Sea four year classes, the 2003, 2004, 2005 and the 2006 appeared with the 2004 year class dominating (62 %), indicating that the 2004 year class might be strong. As in previous years the smallest fish are found in the northeastern area, size and age were found to increase to the west and south (Figure 14 in Annex 3).

The age-disaggregated total stock estimate for 2007 is presented in Table 2 of Annex 3. The herring stock is now dominated by 5 year old herring (2002 year class) representing 20% in weight and the 8-9 year old herring (1999 and 1998 year classes) by 25% each of the total stock.

The time series of abundance (in numbers) since 1996 is shown in Table 3.2.2. The high numbers (biomass) of the 2002 year class recorded this year reconfirm that this year class is very strong and has now completed its annual migration west and south to join the adult herring in their annual migration.

The total number of herring recorded was 20.2 billion individuals in Area I (Barents Sea), 29.3 billion in Area II (North-east) and 19.7 billion in Area III (South-west). This corresponds to a total acoustic herring estimate for the whole area in May 2007 of 12.4 million tonnes, which was higher than the 2006 estimated biomass of 10.2 million tonnes (Table 3.2.2). The high numbers (biomass) of the 2002-year class recorded during this year survey reconfirm that this year class is very strong and has now completed its annual migration west and south to join the adult herring in their annual migration.

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 were found to increase to the west and south.

3.2.4 Blue whiting

The total biomass of blue whiting registered during the May 2007 survey was very low, only 2.4 million tonnes (Table 3 in Annex 3), as compared to the 2006 estimate, which was in the order of 50% greater, for a similar area (ICES 2006/RMC:08). Blue whiting were distributed mainly along the shelf edges whereas open waters yielded little biomass (Figure 15 in Annex 3).

In the report an estimate was made from a subset of the data. A "standard survey area" between 8°W-20°E and north of 63°N (Figure 15 in Annex 3) have been used as an indicator of the abundance of blue whiting in the Norwegian Sea because the spatial coverage in this are provides a coherent time series with adequate spatial coverage – this estimate is used as an abundance index in the NPBWWG (Figure 16 in Annex 3). The age-disaggregated total stock estimate in the "standard area" is presented in Table 4 of Annex 3, showing that the part of the stock in this index area is dominated by blue whiting of 3–5 years in age (2002–2004 year classes). Time series from the "standard survey area" is presented in Table 3.2.3.

The mean length of blue whiting is shown in Figure 17 of Annex 3. In the southern area, one year old fish dominated with up to one third in the Icelandic area, in addition to 3-6 year old fish. While in the northern area only 3-6 year olds were observed (Table 5 of Annex 3). The number 2 year olds (2005 year class) observed were low in the surveyed area, especially in the southern area. There were indications that the 2005 and 2006 year classes are weak, as the latter was only observed in the southwestern area.

It should be noted that the spatial survey design was not intended to cover the whole blue whiting stock during this period.

3.3 National surveys

The results of these surveys are preliminary as the surveys ended short time before the compilation of this report.

3.3.1 Russian survey in June in the Norwegian Sea

During the Russian acoustic survey in the Norwegian Sea, herring was found in the central and western part of the Norwegian Sea. The largest density of herring concentration were distributed between 71° N and 69° N. Herring were recorded in the uppermost 40 m water layer as separate small and average schools with a vertical extension 5–15 m. As well as in May the herring of 1998, 1999 and 2002 year classes dominated over the west of the Sea, 2002 and 2003 — in the east.

3.3.2 Norwegian survey in July–August in the Norwegian Sea

Institute of Marine Research in Bergen conducted a Norwegian Sea pelagic ecosystem survey with two chartered fishing vessels, "F/V Eros" and "F/V Libas", in July–August 2007. This survey initially started as a mackerel survey with only epipelagic trawling. In recent years, more emphasis has been placed also on other fish. The survey has been included in this report since 2006. The survey in 2007 was the first one where blue whiting was also targeted with deeper trawl hauls (150-400 m). Abundance of target species (blue whiting, mackerel, herring) in trawl samples is shown in Figure 3.3.1.

Cruise tracks with CTD stations are shown in Figure 3.3.2.

3.3.2.1 Hydrography

Temperatures in the upper water column were from 14ºC along the Norwegian coast down to 0.2ºC in Arctic waters along the ice-edge in the Greenland Sea. Atlantic water masses penetrated far into the northern and western part of the Norwegian Sea, contributing to the extended distribution of both herring and mackerel into these waters compared to previous years. Higher surface temperatures should affect the migration and distribution pattern of mackerel in the Norwegian Sea through a direct physiological influence on the mackerel itself and an indirect influence on their main prey species.

Sub-surface temperatures recorded at 6 m water depth every hour are shown in Figure 4. Surface temperatures ranged from 15–16ºC along the coast of Norway to cold Arctic water

masses in the northwest with surface temperatures of 2-4ºC around Jan Mayen and –0.2–2.0ºC in the Greenland Sea close to the ice edge. The temperature in the central Atlantic water masses ranged from about 10-14ºC (Figure 3.3.3). Salinity varied from 28.5–35.0 within the Norwegian Sea (Figure 3.3.4). Atlantic water masses spread deep into the western and northern part of the Norwegian Sea.

3.3.2.2 Zooplankton

The largest zooplankton concentrations, based on the preliminary qualitative measurements, were found in the western and northwestern part of the Norwegian Sea, probably linked to the Arctic front between warmer Atlantic water masses and colder Arctic water masses from the Northeast Icelandic current. Low plankton biomasses were generally found in coastal and central areas of the Norwegian Sea, coinciding with moderate mackerel and herring catches.

3.3.2.3 Blue whiting

Some blue whiting were recorded throughout the survey area, with the highest densities in southern and southeastern parts of the Norwegian Sea (Figure 3.3.5). The estimated biomass of blue whiting is 3.4 million tons representing $28 \cdot 10^9$ individuals (Table 3.3.1). Age and length distribution is given in Figure 3.3.6, showing that blue whiting of ages 3–4 years were dominant. Young blue whiting (ages 1–2 years) were present only in low numbers.

About two thirds of stock biomass (2.3 million tons) was recorded in Subarea II with rest in Subarea III (1.0 million tons). Blue whiting in Subarea III were on average larger (29.0 cm) and older (4.3 years) than blue whiting in the Subarea II (27.5 cm and 3.7 years).

3.3.2.4 Herring

Herring were found to be distributed over immense area including Coastal, Atlantic, Arctic and frontal regions from 62°30-74.00° N and 22°00 E-12°00 W (Figure 3.3.7). The largest concentrations of herring were acoustically detected and caught by pelagic trawling along the periphery in the southwestern, western and northern part of the Norwegian Sea. The densest registrations were in the northeast.

The estimated biomass of herring is 13.0 million tons representing $48 \cdot 10^9$ individuals (Table 3.3.2). Age and length distribution is given in Figure 3.3.8, showing that herring of ages 3-9 years were dominant, of which year class 2002 (age 5 years) made almost one half.

Most of stock biomass (10.5 million tons) was recorded in Subarea II with rest in Subarea III (2.4 million tons). Herring in Subarea III were on average larger (33.2 cm) and older (7.1 years) than herring in the Subarea II (30.5 cm and 5.1 years).

3.3.2.5 Mackerel

Mackerel was distributed over substantial areas in coastal, Atlantic and Arctic water masses as well as frontal coastal and Arctic regions within shallow waters less than 50 meters depth. The dominant catches were taken in the southern and eastern part of the Norwegian Sea. The largest and oldest mackerel were typically caught in the western and northern part of the Norwegian Sea in the Jan Mayen area (Figure 3.3.9). 5 years old individuals dominated the catches (21%), together with 2 years old (20%). Mackerel were caught as far north as 73°30 N.

4 Discussion

4.1 Hydrography

The influence of the EIC was similar in May 2007 compared to May 2006. Eastern and central Norwegian Sea and western Barents Sea has been warmer then last two years.

More detailed analysis of hydrography conditions was not possible in connection with absence of experts.

4.2 Plankton

The recorded zooplankton biomass in 2007 was the lowest on record since 1997.
A more detailed analysis of zooplankton conditions was not possible in connection with absence of experts.

4.3 Norwegian spring spawning herring

It was decided not to draw up a suggested herring migration pattern for 2007 in connection by lack of data. However, the general migration pattern is believed to resemble that of 2003 with the exception that the herring had a somewhat more southerly distribution in 2004.

The Norwegian spring spawning herring is at present characterised by a state of large dynamics with regard to migration pattern. This applies to the wintering, spawning and feeding area. The following discussion will in particular concentrate on the situation in the feeding areas.

In 2006 and 2007 of the strong 2002 and average 2003 year classes feeding in the Norwegian Sea were dominating the stock in number. The 2002 year class completed to recruit to the spawning stock in 2008. The 2003 year class began to recruit to the spawning stock in 2008. The Barents Sea component now consists of abundant 2004 year class and weak 2005 and 2006 year classes.

During the period from 1996 to 2001 the migration pattern showed a northeasterly trend with the centre of gravity in May moving further to the NE year by year (Figure 12 in Annex 3). The NE trend stopped in 2002 and the stock started moving in southwesterly direction again and has continued this displacement since. There is obviously no simple explanation to this behaviour and many factors could be proposed as covariates. It is well known that the size of the feeding area is stock size dependent, so are the ocean climate and current systems as obvious candidates with more northerly migrations in warming periods. Other factors could be the entrance of large year classes of young herring from the Barents Sea into the Norwegian Sea and asymmetrical plankton concentrations throughout the potential feeding area.

The recent southwestern extension of the herring feeding area started in 2003. The Norwegian commercial charter survey carried out on herring in the Norwegian Sea in July/August supports the migration tendency of herring within this area. The concentration of herring in the southwestern area increased somewhat in 2004 but showed a more significant increase after 2005. The increased concentrations are reflected both in the surveys and through a significant fishery in the southwestern area during the 2006. As seen from the fishery pattern from 2005 there is a split in a southwestern and northern fishing area, which can be explained by the division of the larger fish in the southwestern and northern area as observed during the May survey. Most of the oldest herring fed in the southwestern area during 2007. About one fourth of the abundant 2002 year class was found in this area.

As in last year the plankton concentration during May survey in southwestern part of the ocean is consistently higher than further north and east. The herring feeding in this region have to been shown to have a higher condition factor than the rest of the stock. There is not enough data to conclude on this.

Some underestimation of herring due to vessel avoidance during the acoustic survey is likely to have occurred, mainly due to the distribution of herring in the upper surface layer above the depth of the hull mounted transducer. This was confirmed by surface trawling and sonar registrations at the surface layer. However it was not possible to quantify the significance of these observations.

4.4 Blue whiting

For the first time, uncertainties in stock estimates have been assessed. At present, only one source of uncertainty is considered, spatio-temporal variability in acoustic recordings. These analyses indicate that uncertainty was stable in 2004–2006 with 50% confidence limits for mean acoustic density being in the range 3–6% relative to mean. In 2007, the width of confidence limits was almost doubled because of a few very high acoustic records. Uncertainty in the estimates from the International ecosystem survey in the Nordic Seas has only been assessed for 2007. Blue whiting estimates in this survey are more precise, with 50% confidence limits for mean acoustic density being in the range 2-3% relative to mean.

Given the uncertainty in the estimate, no change in blue whiting stock abundance in the spawning area could be detected. Point estimates suggest a slight increase in stock biomass and stable stock numbers. In contrast, the estimates in 2006–2007 are significantly higher than the estimate in 2005. Mean age has increased from the estimate in 2006 and is now the highest on record (notice that the international survey was started only in 2004). Recruitment to spawning stock seems weak with numbers at ages 1–3 years the lowest in the time series. On the other hand, numbers of "old" blue whiting (ages 6–8 years) are relatively high. However, age distributions seem noisy. In part, this seems to be caused by variability in recruitment, with some cohorts recruiting earlier than others. However, between-vessel comparisons of mean age at length also suggest that there could be problems in age reading.

In conclusion, the international blue whiting spawning stock survey appears to give moderately precise biomass estimates, although single extreme observations may erode its precision. Evaluation of the precision in estimating age structure is at present difficult as there is relatively little contrast in the data (no very strong or weak year class has yet passed through the survey).

International ecosystem survey in the Nordic Seas shows a strong decline in stock numbers and biomass. This decline is far larger than could be explained by acoustic uncertainty (assuming that the precision of 2007 survey is typical for this survey). The situation resembles somewhat that in 2000 when what now appear to be too low values were estimated. The reason this is unclear, but could relate to migrations or scrutinizing low density acoustic recordings. A well known problem is migration of post-spawning blue whiting from the spawning area to the southern part of the survey area, but this should not affect juvenile blue whiting (for this reason, only indices for ages 1–2 years are used in tuning the assessment). Somewhat higher stock estimate was obtained for similar area in July-August, but even this estimate is considerably (-30%) lower than the estimate in 2006.

The decline is particularly dramatic in terms of numbers (-71%), reflecting increasing average size and age of blue whiting in this survey. Mean age of blue whiting fluctuated between 1.3 and 2.1 years in 2000-2005, increased to 2.8 years in 2006, and was estimated to be 3.7 years in 2007 survey. This change reflects strengths of 2005 and 2006 year classes, which are low if not extremely low. Similar signal has been recorded in the Barents Sea February-March, and again in the Norwegian Sea in July-August. There are all reasons to believe that the low numbers of recruits suggested by this survey are real.

5 Planning

5.1 Planned acoustic survey of the NE Atlantic blue whiting spawning grounds in 2008

It is planned that five parties; Faroe Islands, Ireland (EU-coordinated), the Netherlands (EU-coordinated), Norway and Russia, will contribute to the survey of blue whiting stock survey in March-April 2008.

Survey timing and coverage were discussed in some detail. It was decided to maintain the traditional timing, from mid-March to mid-April. At this time, little blue whiting is expected to be found in the southern parts of the Porcupine Bank, and this area will not be covered in 2008 survey. However, it was emphasized that duration of the survey should be compressed in time, such that maximally synoptic coverage is obtained. This would also make inter-calibrations easier.

The preliminary sea programme with the target areas for each vessel is (the target areas are shown in Figure 5.1.1):

SHIP	NATION	VESSEL TIME (DAYS)	ACTIVE SURVEY TIME (DAYS)	PRELIMINARY SURVEY DATES	PRIMARY TARGET AREA [SECONDARY]
Celtic Explorer	EU (Ireland)	21	18	24/3–13/4	1
Chartered fishing vessel	Norway	14	12	25/3–7/4	1 [2a,b]
Magnus Heinason	The Faroes	14	11	26/3–9/4	2c [1]
Tridens	EU (Netherlands)	21	14	5/3–23/3	2a [1,3a]
Atlantniro	Russia	?	?	?	2a,b

'?' denotes no information at present

At present it is unclear whether AtlantNIRO will contribute to the survey. If this turns out to be the case, Norwegian chartered fishing vessel will cover shelf edge from the Porcupine Bank to the Hebrides with densely spaced cruise tracks. Preliminary cruise tracks for this scenario are presented in Figure 5.1.2. If, however, AtlantNIRO will be unable to contribute to the survey, Norwegian chartered fishing vessel will cover international waters west of Rockall (Figure 5.1.3).

As coordinator of the survey for 2008 Ciaran O'Donnell (Ireland) 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.

The survey 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 2007).

5.2 Planned acoustic survey of pelagic fish and the environment in the Norwegian Sea and in the Barents Sea, spring/summer 2008

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 2008. The participation and area coverage for the different parties are given in Figures 5.2.1.

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-40°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 also start at the beginning of May (the date(s) and name(s) of vessel(s) will be decided by mid November 2007) and start by conducting the Svinøy hydrographic section. After this it will start surveying the area north of 66°N. The Faroes will start at the same time as the other vessels and survey the area north of 62°N (mainly the Faroese area). The Icelandic vessel has planned to conduct their survey at the same time 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 and 2007 survey. Therefore, effort should be put into this task at the 2008 survey. Fishing would also be carried out during this intercalibration exercise and the trawl selectivity compared.

The Russian vessel will start the survey in the middle of May in Barents Sea and cover the area between E 38° and E 20° 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).

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 2008.

Iceland will apply for vessel time for three weeks in June-July 2008 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 2008 to investigate the distribution, biomass, and the environment.

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	20	21	02/5 – 23/5
Johan Hjort	Norway	?		
RV	Russia	15	15	15/5 – 30/5
Dana	Denmark (EU)	30	23	2/5 – 24/5
Magnus Heinason	Faroes	14	12	2/5 – 16/5
Arni Fridriksson	Iceland	26	23	28/4 – 24/5
RV	Russia	30	27	June
Bjarni Sæmundsson	Iceland	?		

Final dates will be decided by the end of the year 2007.

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.

6 Survey protocol and standardisation

At the PGNAPES meeting in 2007 a combined survey manual was produced from both PGHERS and PGNAPES existing acoustic manuals**,** "Manual for the Northeast Atlantic and North Sea acoustic survey programs". Version 1.0, August 2007, was presented and adopted by the group.

Some outstanding issues remain and these are to be addressed at the PGHERS meeting in 2008.

- Adherence to pre-defined cruise track designs as described in the manual.
- Survey progression and timing issues were discussed and it is hoped that the problem with timing will be alleviated during the 2008 survey.
- The standardisation of echogram scrutinization routines within the group should be addressed at a dedicated workshop.
- A standardised approach is recommended for hydrographical data collection by means of vertical CTD casts.

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 rule 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. No plankton specialist attended the 2007 meeting; as a result this issue remains outstanding for the 2008 meeting.

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. Therefore, it is recommended that at future cruises the displacement volume of all partitionings should be determined. 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. See the 2006 PGNAPES report for a more detailed description (Figure 6.2.1).

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 a sufficient vertical net-opening in order to get a representative catch (i.e. sample) of herring schools. (See text table Section 1).

For a detailed overview of the survey gears employed during the coordinated survey program please refer to table 2.1 in the survey manual.

6.4 PGNAPES exchange format

On the recommendation from last year the ITIS (Integrated Taxonomic Information System, www.itis.usda.gov) system has been implemented in the data exchange format and adopted by all members. The status of the international time series data is currently being reviewed and participants will be contacted to update datasets where necessary. The overall status of the database will be presented to the group in 2008.

7 PGNAPES database

Internet database

A PGNAPES Internet database (Oracle 10g Express platform) was established at the Faroese Fisheries Lab. before the post-cruise meeting in Ijmuiden, The Netherlands from 17–20 April 2007.

Data from the April cruise 2006 where used to test the database, and migration of queries developed in MS Access was performed.

Data from April survey

During the April post cruise meeting, data from **all** participating countries, very satisfactory, where uploaded via the Internet to the database in Faroe Islands. Queries from the working group where executed on the database, and the performance of the database was excellent.

Data from the May survey

The data from the May survey has only been partially uploaded, due to change of data platforms on national levels.

An effort was made at the PGNAPES meeting at IJmuiden 14–17 August 2007 to facilitate conversion from LSSS-exports of acoustic data to the PGNAPES format, getting the Norwegian acoustic data uploaded to the database. Datasets are not complete, especially the plankton data from all countries except FO and IS were missing. Aggregated data sets were submitted to the coordinators, but data from RU and DK has not been submitted to the PGNAPES database.

Species code table

The species code table was scrutinized, and got two extra columns containing Norwegian and Faroese names in addition to the columns containing Latin and English names. Countries are encouraged to deliver names in their own language.

The 3-letter code is still a key value in the database, making it easier to allocate species to acoustic values during the scrutinizing operations. Though, the species list includes the TSNs (Taxonomical Serial Number) and NODC-codes. Results with these codes can be obtained from the database.

The species list will evolve over time, as countries will submit "new" species as they are introduced in the survey area. (E.g. the Snake Pipefish and the Dealfish)

PGNAPES PGHERS/FishFrame cooperation

PGHERS is using the FishFrame database to organize their data. In 2006 PGHERS invited PGNAPES to attend their meeting to consider the opportunity of cooperation. Already then it was obvious that data easily can be interchanged between the two databases.

The FishFrame version 5.0 will be finished in the spring 2008, making upload of PGNAPES data very easy. This is very encouraging, as the FishFrame developers are aiming to develop an acoustic assessment application on top of their database.

This means that the PGNAPES group can perform calculations on the Internet application in the future in a more transparent way, as several scientists can perform assessment calculations on the same dataset in their own way, before the working group sessions.

Future Effort

Effort has to be made to streamline the national data systems to be able to produce data tables in the PGNAPES exchange format immediately after the national cruises. This will facilitate the upload of data into the database.

The working group concentrates its effort getting the most recent data worked up to PGNAPES format, but are also committed to work up their old data sets into PGNAPES format, and submit them to the PGNAPES internet database.

8 Recommendations

Listed below is a range of recommendations compiled by the group.

- Scrutinization workshop to be carried out possibly in Hirtshals after future consultation with the local institution. Exact times and dates to be confirmed.
- Staging of the second part of blue whiting aging workshop (1st part concentrated on <3yrs individuals) was discussed to concentrate on older individuals (3+ yrs). The Faeroes were unable to participate in the last workshop.

- Acoustic manual to be forwarded to PGHERS Chairman for final review at their next meeting in early 2008.
- The need for a hydrographic and plankton specialist to become full time member of the group was stressed.
- Valid acoustic data only should be submitted to the GPNAPES database for use in abundance estimation.
- A more coordinated approach for hydrographic data collection during the blue whiting survey was highlighted. It was suggested that this be simultaneously planned with the acoustic transects in 2008 to allow for maximisation of sampling effort.
- It was recommended that the PGNAPES 2008 meeting be held in Hirtshals during the same time period as 2007.

9 References

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Table 1.3.1. Organisational frame of the coordinated herring investigations in the Norwegian Sea, 1995–2007.

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 (ICES CM 2007/RMC:08)
2007	Faroe Islands, Iceland Norway, Russia, EU	4	Reykjavik (ICES CM 2007/ RMC:08) + correspondence	Ijmuiden (This report)

Table 3.1.1. Estimated total stock numbers and biomass from the International blue whiting spawning stock survey, 2004–2007.

Total stock numbers (in millions)

YEAR\AGE	1	2	3	4	5	6	7	8	9	10	11	TOTAL
2004	4886	17603	34350	44397	16775	5521	3111	1962	1131	127		129863
2005	3631	4320	18774	25579	26660	8298	2016	728	323	2	4	90335
2006	3162	5540	32201	38942	16608	7972	2459	791	293	7		107975
2007	1723	2654	16343	32851	24794	13952	7282	2509	951	420	235	103714

Total stock biomass (in 1000 tons)

YEAR\AGE	1	2	3	4	5	6	7	8	9	10	11	TOTAL
2004	138	1092	2697	3762	1775	713	427	262	205	34		11105
2005	99	217	1377	2194	2546	1046	320	128	76	0.5	0.7	8004
2006	87	329	2598	3603	1896	1104	495	206	73	3		10394
2007	68	181	1415	3285	2793	1732	1006	393	167	153		11193

Table 3.2.1. Average zooplankton biomass [g dry weight m^{-2}] at the international ecosystem surveys in the Nordic Seas carried out in May for the period 1997-2007. Zooplankton biomass calculated from vertical plankton net (WP2) hauls from 200m to the surface.

YEAR	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	MEAN
Total area	8.2	13.4	10.6	14.2	11.6	13.1	12.4	9.2	9.2	8.9	8.0	10.8
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	10.3	12.3
Region E of 2°W	7.5	14.4	10.2	11.8	8.7	13.6	9	8	8.2	4.8	5.6	9.3

Table 3.2.2. Norwegian spring spawning herring in the Norwegian Sea and Barents Sea estimated at the international ecosystem survey in the Nordic Seas carried out in May given in numbers '000 and total biomass in '000 tonnes for the period 1996-2007.

SURVEY YEAR /AGE	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	24	0	0	0	0	32,073	0	0	3,688	2,058
2	0	0	1404	215	157	1,540	677	8,115	13,735	1293	35,020	4,122
3	4114	1169	367	2,191	1,353	8,312	6,343	6,561	1,543	19679	5,604	15,437
4	22461	3599	1099	322	2,783	1,430	9,619	9,985	5,227	1353	15,894	7,783
5	13244	18867	4410	965	92	1,463	1,418	9,961	12,571	1765	1,035	20,292
6	4916	13546	16378	3,067	384	179	779	1,499	10,710	6205	1,810	1,261
7	2045	2473	10160	11,763	1,302	204	375	732	1,075	5371	6,336	1,992
8	424	1771	2059	6,077	7,194	3,215	847	146	580	651	7,372	6,781
9	14	178	804	853	5,344	5,433	1,941	228	76	388	558	5,581
10	7	77	183	258	1,689	1,220	2,500	1,865	313	139	651	647
11	155	288	0	5	271	94	1,423	2,359	367	262	171	486
12	0	415	0	14	0	178	61	1,769	1,294	526	344	371
13	3134	60	112	0	114	0	78	0	1,120	1003	807	403
14	0	2472	0	158	0	0	28	287	10	364	792	1,047
15+	0	0	415	128	1,135	85	26	45	88	115	324	953
Number in '000	50,514	44,915	37,415	26,016	21,818	23,353	26,115	75,625	48,709	39,114	80,406	69,214
Biomass in '000 t	NA	9,141	8,053	6,392	5,798	4,714	5,027	8,562	8,869	7,045	10,342	12,373

Table 3.2.3. Estimated blue whiting stock numbers and biomass from the International Norwegian Sea ecosystem survey, 2000–2007. The estimates are for the standard area, north of 63°N and between 8°W–20°E.

Total stock numbers (in millions)

YEAR\AGE	1	2	3	4	5	6	7	8	9	10	11	TOTAL
2000	48927	3133	3580	1668	201	5						57514
2001	85772	25110	7533	3020	2066							123501
2002	15251	46656	14672	4357	513	445		15		6		81915
2003	35688	21487	35372	4354	639	201	43	3				97787
2004	49254	22086	13292	8290	1495	533	83	39				95072
2005	54660	19904	13828	4714	1886	326	103	43	8	3	11	95486
2006	570	18300	15324	6550	1566	384	246	80	47	2	8	43077
2007	21	552	5846	3639	1674	531	178	49	19			12509

Total stock biomass (in 1000 tons)

YEAR\AGE	1	2	3	4	5	6	7	8	9	10	11	TOTAL
2000	1795	260	335	193	25	1						2608
2001	2735	1776	763	418	322							6014
2002	651	2640	1289	526	76	64		3		2		5250
2003	1475	1539	2897	497	88	31	11	1				6538
2004	1643	1437	1188	886	193	77	13	6				5442
2005	1558	1204	1124	502	233	49	16	8	2	1	2	4699
2006	23	1099	1330	704	198	51	36	12	8	0	2	3463
2007	0.7	38	526	383	204	71	27	8	3	0	0	1261

Table 3.3.1. Age- and length-stratified abundance estimate of blue whiting in July–August 2007 in the Norwegian Sea. Data from F/V Libas and F/V Eros.

LENGTH (CM)	1	2	3	4	5	6	7	8	9	10	NUMBERS	BIOMASS	WEIGHT
21	40										40	2	49
22	86										86	6	64
23			56	56							112	11	97
24		536	357								893	76	85
25		523	2268	273							3064	289	94
26		163	3036	1437	380	81					5097	527	103
27		134	2970	3253	567	128					7052	807	114
28		47	898	2695	591	47					4278	536	125
29			322	1224	1050	422	27	52			3097	431	139
30			41	472	1349	125	87	64	20		2158	333	155
31				206	285	325	50				866	147	170
32				64	165	173	47	37	11		497	91	183
33				23	70	87	17	133	17		347	68	196
34						48	48	20	34	20	170	37	218
35					9	5			6		20	5	234
36									2		2	0	221
37											0	0	245
Numbers 10^6	126	1403	9948	9703	4466	1441	276	306	90	20	27779		
Biomass 10^3t	7.5	133	1065	1185	628	223	48.5	54.5	17.7	4.3	3366		
Length cm	22.2	25.5	26.8	28.1	29.5	30.4	31.8	32.1	33.3	34.5	27.9		
Weight g	59.3	94.6	107	122	141	155	176	178	197	212	121		

Table 3.3.2. Age- and length-stratified abundance estimate of herring in July–August 2007 in the Norwegian Sea. Data from F/V Libas and F/V Eros.

LENGTH (CM)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	NUMBERS	BIOMASS	WEIGHT
22		47	47													94	9	99
23																0	0	.
24		91	91													182	22	119
25		116	1048													1164	167	143
26		146	2783	0	146											3075	488	159
27			2004	589	472											3065	548	179
28			1149	1609	230											2988	604	202
29			335	2133	2154	84	84				84					4874	1120	230
30				1506	6136	158	58	120	14							7992	2087	261
31				494	7357	938	194	312	102	43						9440	2686	285
32				85	3320	551	396	556	270	41				19		5238	1603	306
33					925	320	858	1405	864	84	65		23			4544	1483	327
34					88	86	480	1419	1046	71	89			17	35	3331	1150	345
35							127	508	593	111	31	62	127	17	80	1656	601	363
36						20	62	103	62	61	21	102	144	42	104	721	279	387
37								27	27		41	27	27	14	82	245	97	399
38					37						1			1	9	48	20	419
Numbers 10^6		400	7457	6416	20865	2157	2259	4450	2978	411	332	191	321	110	310	48657		
Biomass 10^3t		55.6	1274	1479	5707	637	729	1476	1009	141	107	73.6	120	39.5	117	12964		
Length cm		25.2	27.0	29.5	31.1	32.1	33.3	33.8	34.2	34.3	33.6	36.3	36.0	35.5	36.3	30.9		
Weight g		137	171	231	274	295	323	332	339	344	323	385	375	359	378	266		

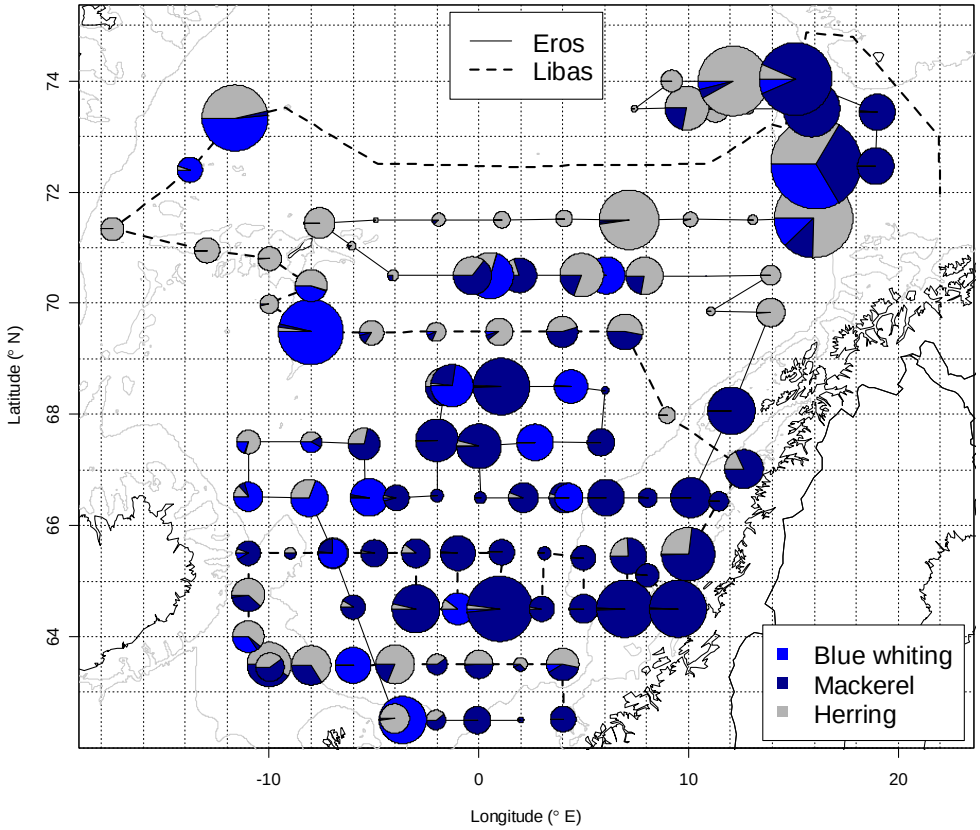

Figure 3.3.1. Blue whiting, mackerel and herring in trawl catches by F/V Libas and F/V Eros, 15 July – 6 August 2007. Sizes of circles indicate total catch (in kg per nautical mile) of these three species, with the distribution between the species shown as pie charts. To make small catches visible it was necessary to downscaled large catches by making radii proportional to logarithm of catch.

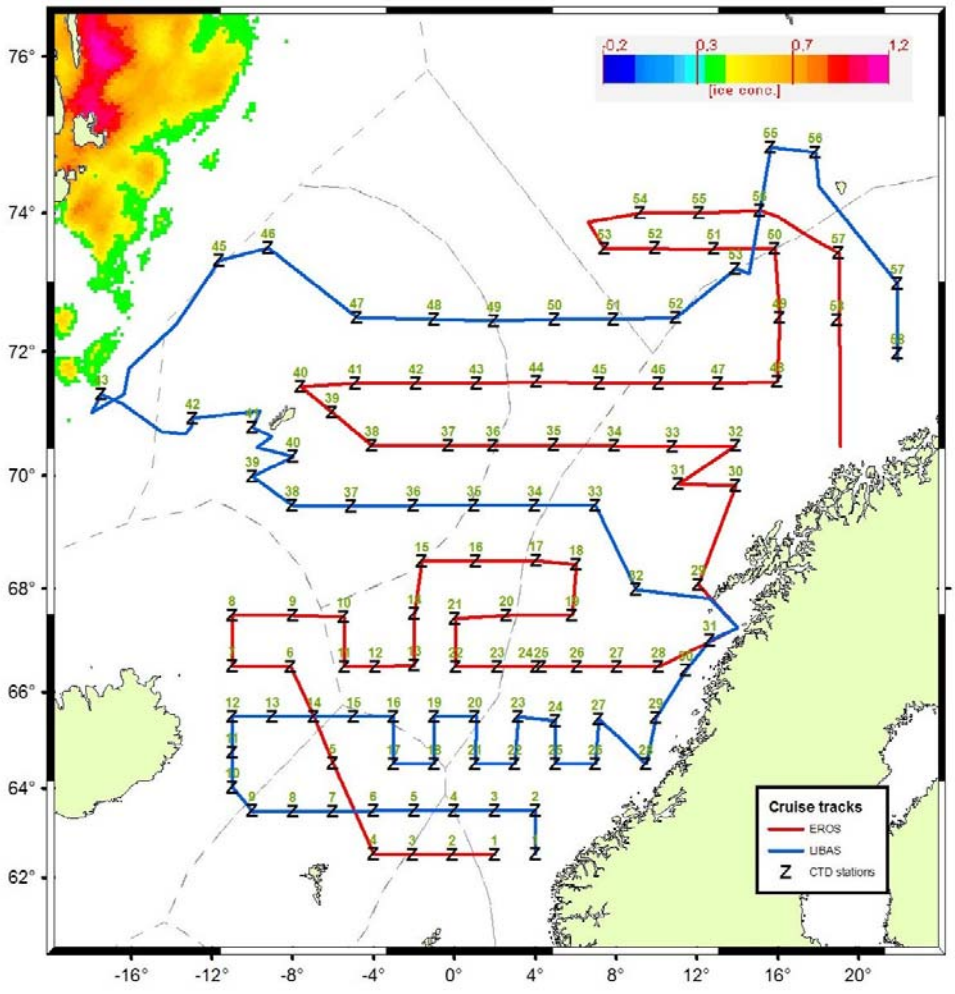

Figure 3.3.2. Survey tracks along the cruise tracks with pre-defined CTD stations (0-500 m) and WP2 samples (0-200 m) for F/V Libas and F/V Eros, 15 July – 6 August 2007. The two vessels took 129 pelagic trawl stations, 116 CTD and WP2 stations and covered about 7400 nm.

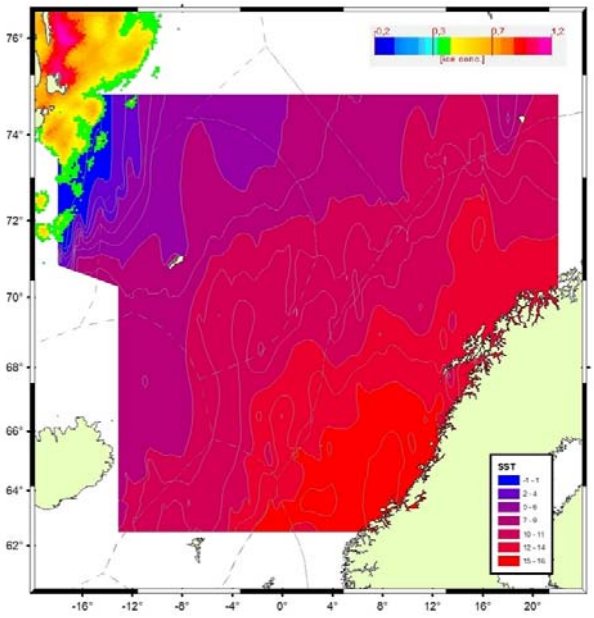

Figure 3.3.3. Sea surface temperature (SST) in the Norwegian Sea, 15 July-5 August 2007.

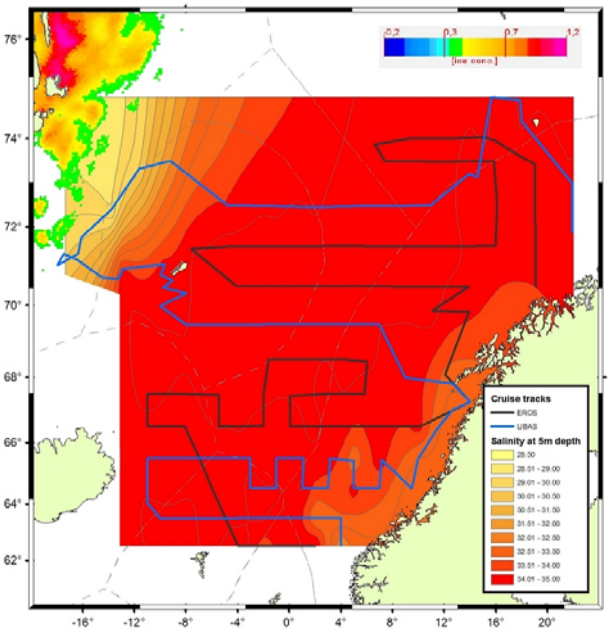

Figure 3.3.4. Salinity distribution at 5 m depth and cruise tracks by F/V Eros and F/V Libas in the Norwegian Sea, 15 July-5 August 2007.

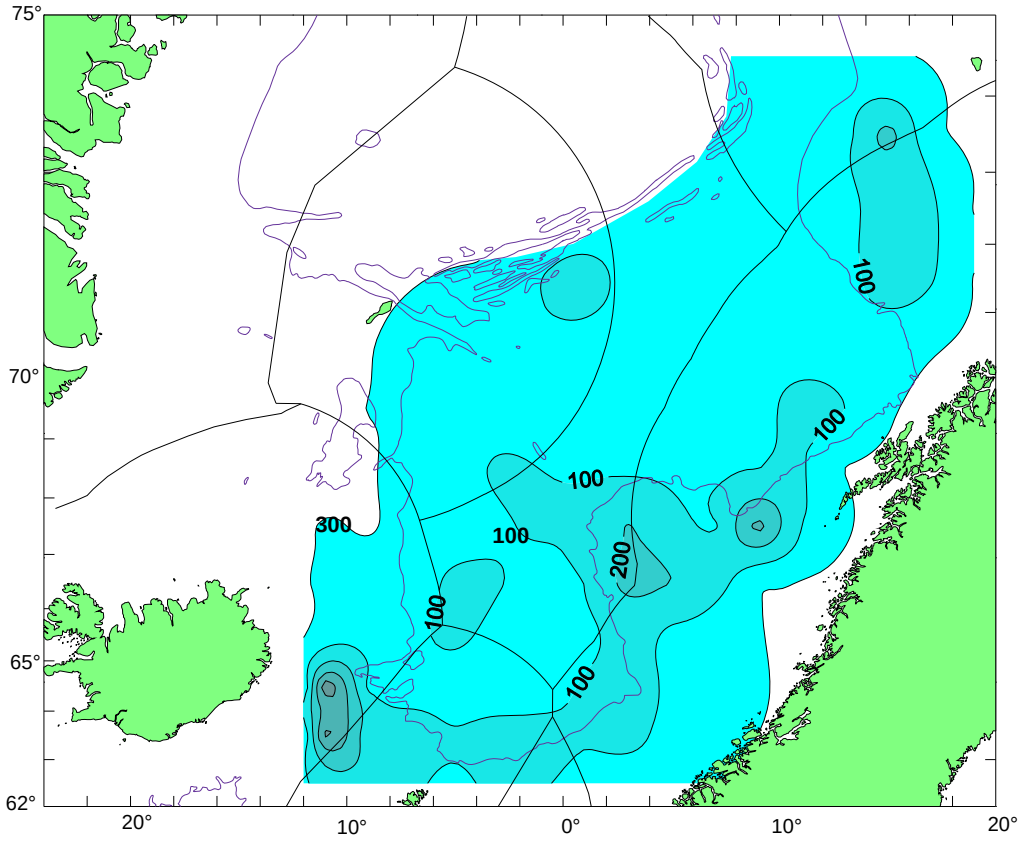

Figure 3.3.5. Acoustic density of blue whiting 15 July-5 August 2007. Density is terms of sA-values (m2/nm2) based on combined 5 nm values by F/V Libas and F/V Eros.

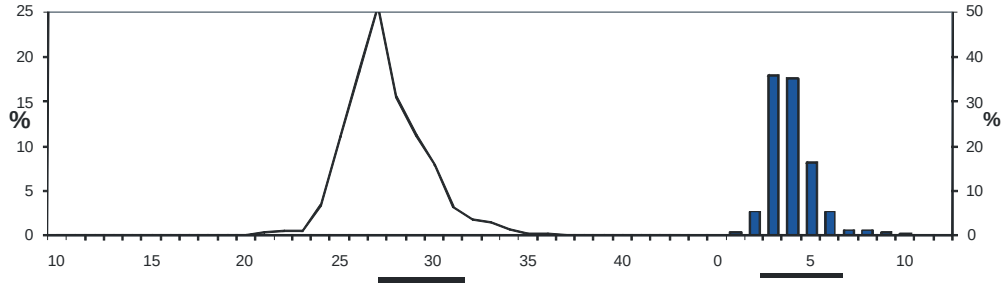

Figure 3.3.6. Estimated age and length distribution of blue whiting in the Norwegian Sea, 15 July-5 August 2007. Data from F/V Libas and F/V Eros.

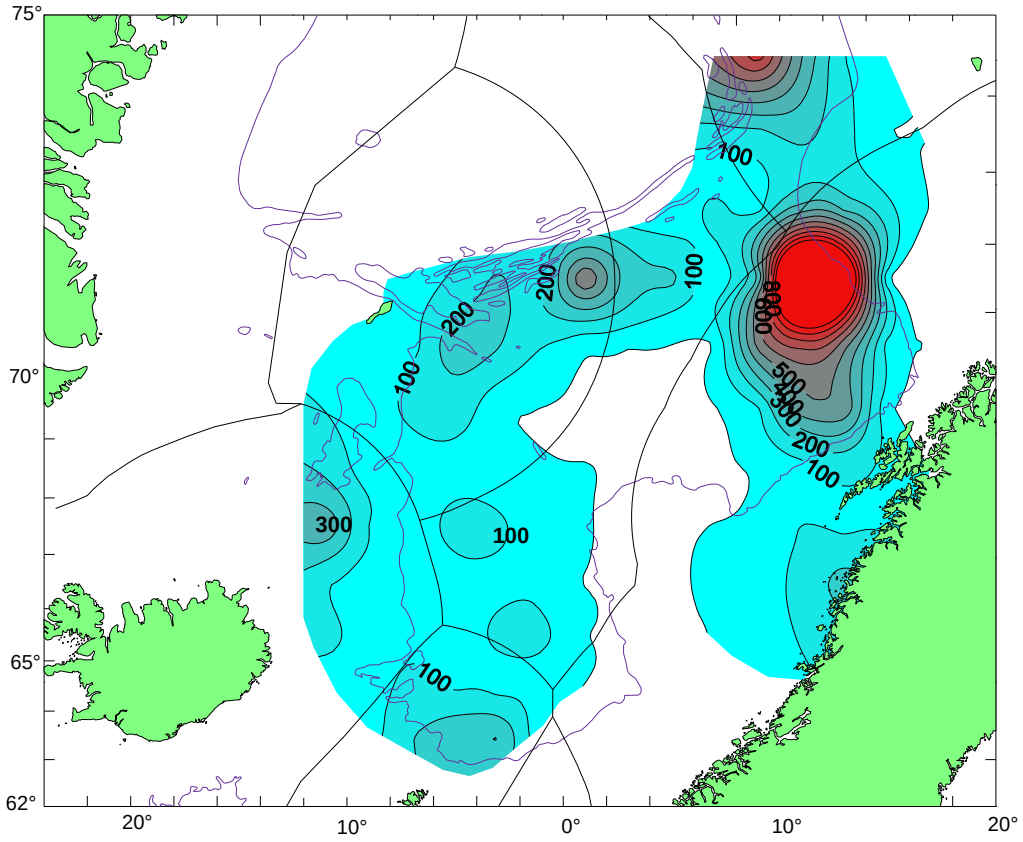

Figure 3.3.7. Acoustic density of herring 15 July-5 August 2007. Density is terms of s_A-values (m^2/nm^2) based on combined 5 nm values by F/V Libas and F/V Eros.

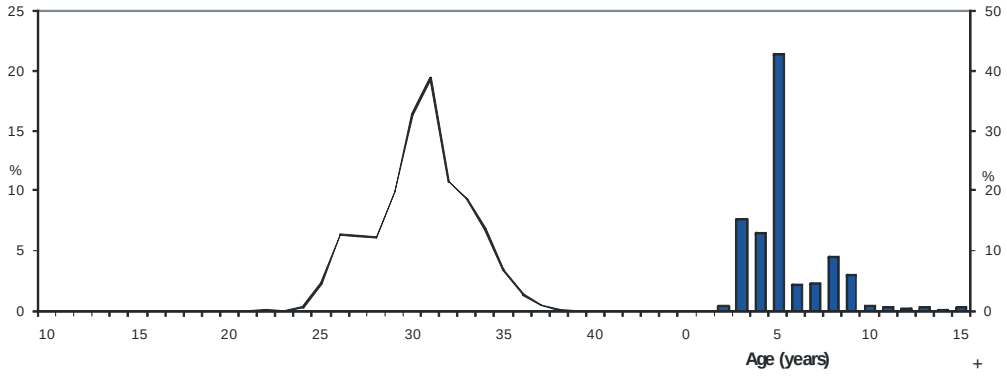

Figure 3.3.8.Estimated age and length distribution of herring in the Norwegian Sea, 15 July-5 August 2007. Data from F/V Libas and F/V Eros.

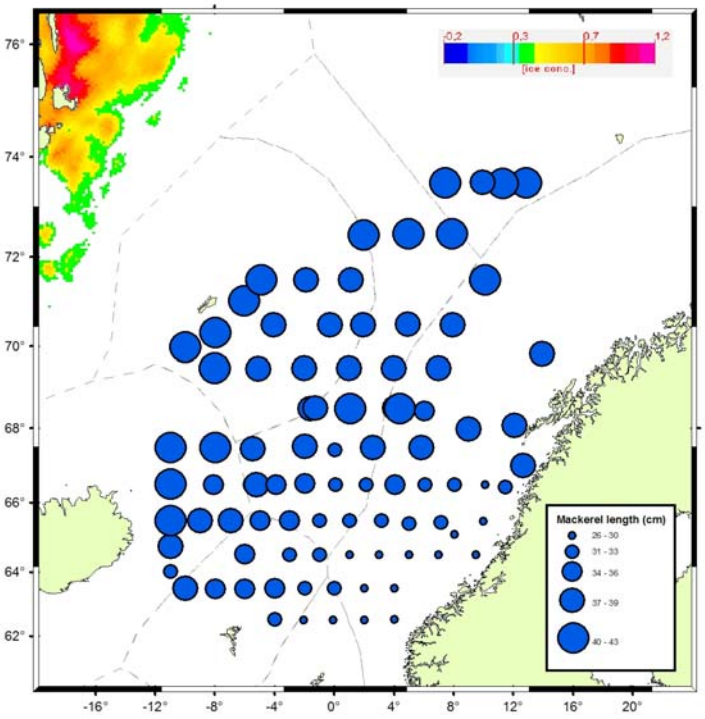

Figure 3.3.9. Mean length of mackerel in trawl samples by F/V Libas and F/V Eros, 15 July-5 August 2007.

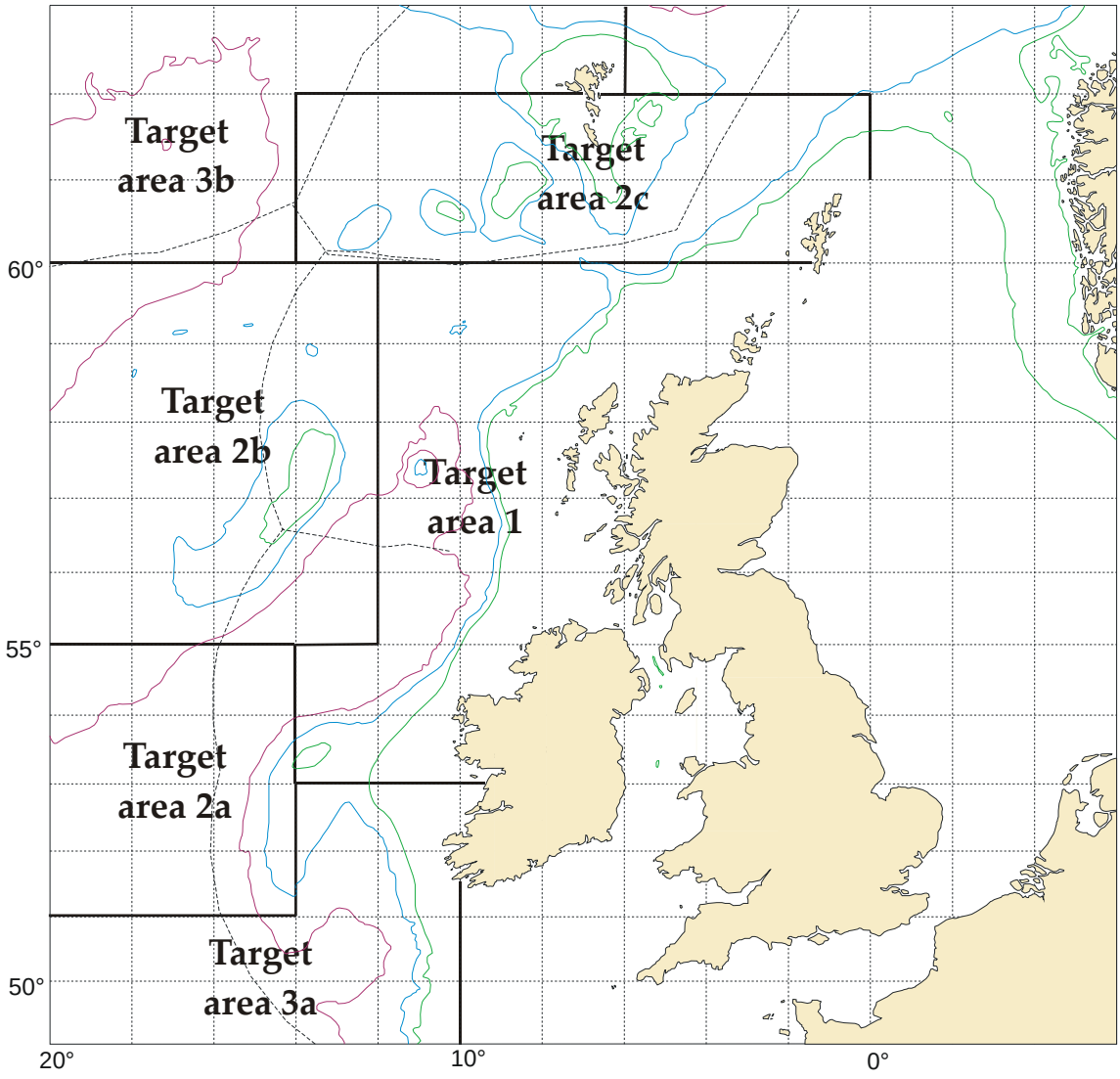

Figure 5.1.1. Target areas for the International blue whiting spawning stock surveys.

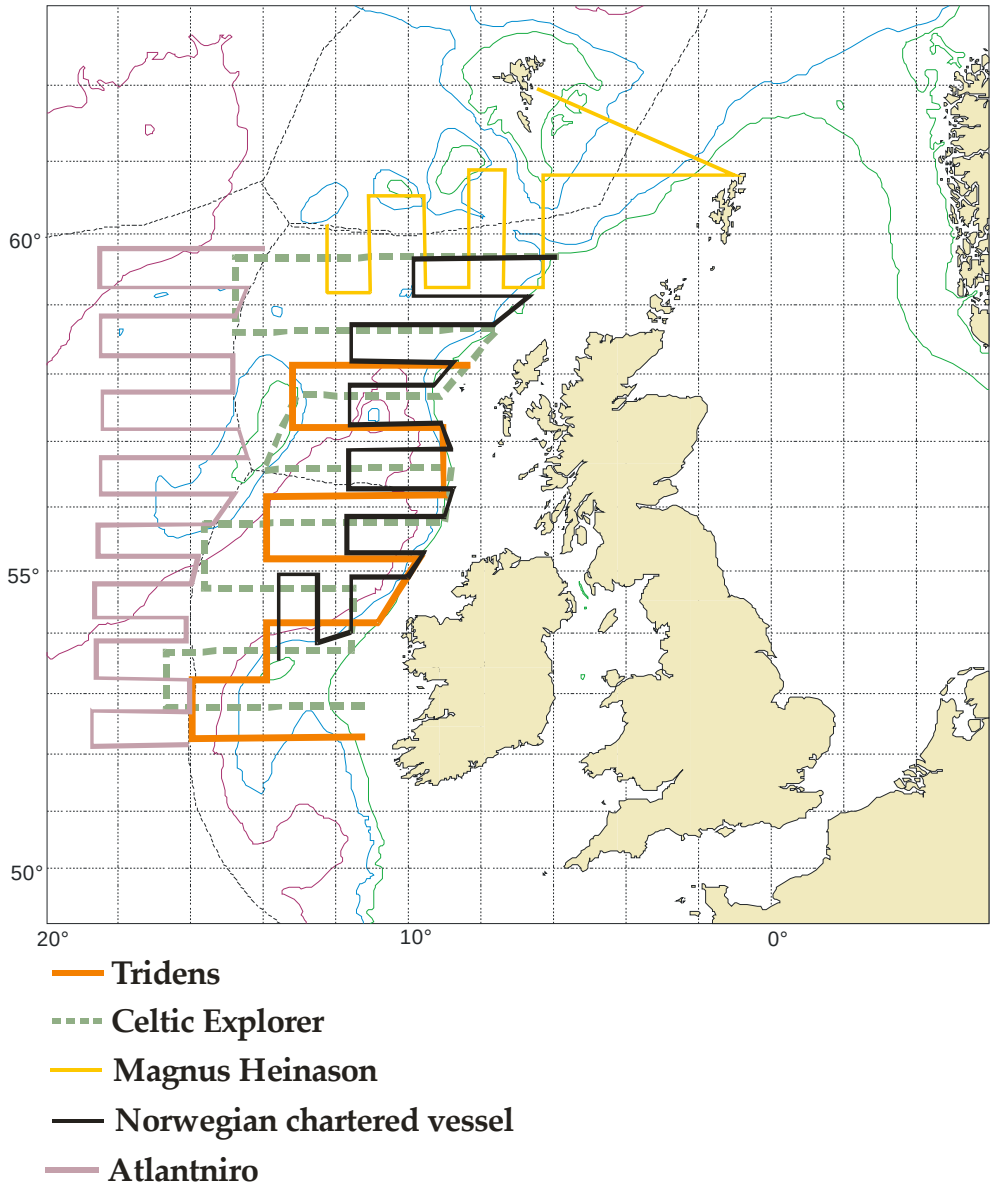

Figure 5.1.2. Preliminary survey tracks for the 2008 International blue whiting spawning stock under the assumption that AtlantNIRO is able to join the survey.

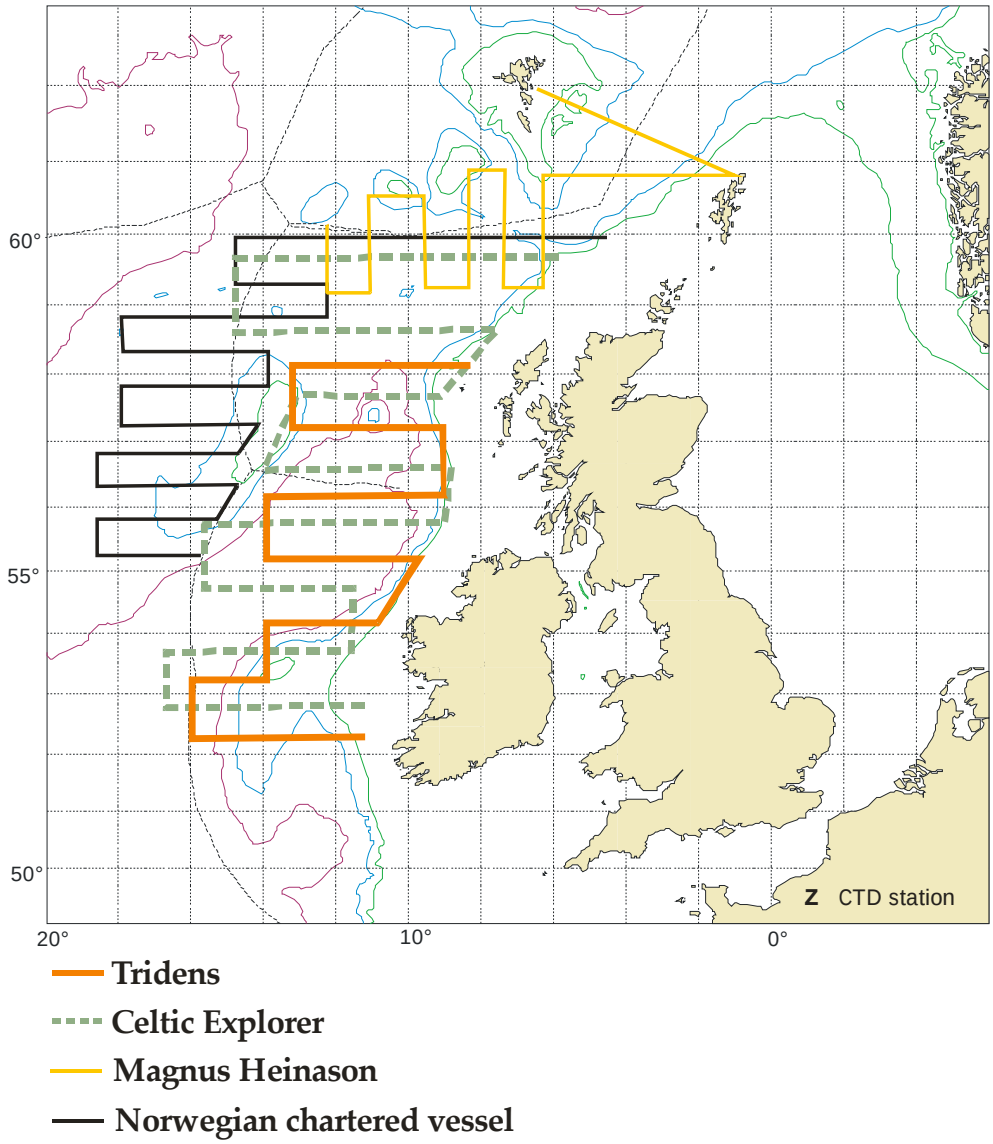

Figure 5.1.3. Preliminary survey tracks for the 2008 International blue whiting spawning stock under the assumption that AtlantNIRO is unable to join the survey.

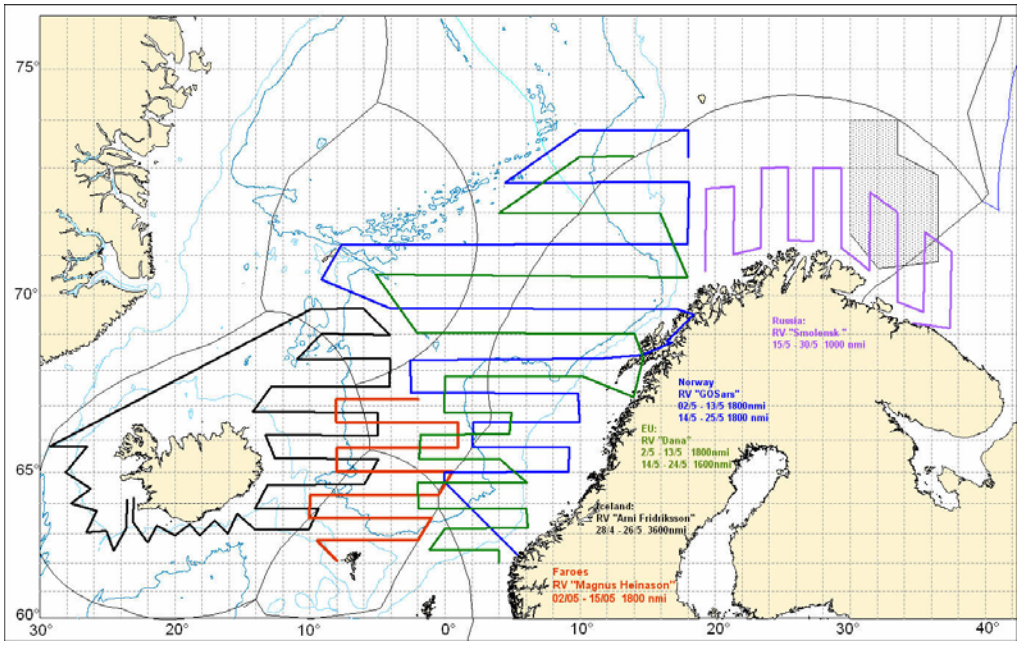

Figure 5.2.1. Preliminary survey tracks for the 2008 International ecosystem survey in the Nordic Seas.

Annex 1: List of participants

NAME	ADDRESS	TELEPHONE	FAX	E-MAIL
Alexander Krysov (Chair)	PINRO 6,Knipovich Street, 183763, Murmansk, Russia	+78152473424	+47 78910518	a_krysov@pinro.ru
Jørgen Dalskov	Danish Institute for Fisheries Research Charlottenlund Slot DK-2920 Charlottenlund Denmark	+4533963380	+4533963333	jd@difres.dk
Morten Vinther	Danish Institute for Fisheries Research Charlottenlund Slot DK-2920 Charlottenlund Denmark	+4533963353	+4533963333	mv@difres.dk
Ciaran O'Donnell	Marine Institute Rinville, Oranmore Co. Galway, Ireland	+353 87 968 1954	+353 9138 7200	ciaran.odonnell@marine.ie
Gudmundur J. Oskarsson	Marine Research Institute Skulagata 4 101 Reykjavik, Iceland	+354 575 2000	+354 575 2001	gjos@hafro.is
Leon Smith	Faroese Fisheries Laboratory Nóatún P.O. Box 3051 FO-110 Tórshavn Faroe Islands	+298 353900	+298 353901	leonsmit@frs.fo
Jan Arge Jacobsen	Faroese Fisheries Laboratory Nóatún P.O. Box 3051 FO-110 Tórshavn Faroe Islands	+298 353900	+298 353901	janarge@frs.fo
Oyvind Tangen	Institute of Marine Research, P.O. Box 1870, N-5817 Bergen, Norway	+47 55238414 +4791803405	+47 55238687	oyvind.tangen@imr.no
Mikko Heino	Institute of Marine Research, P.O. Box 1870, N-5817 Bergen, Norway	+47 55236962 +47 55585444	+47 55238687	mikko@imr.no
Are Salthaug	Institute of Marine Research, P.O. Box 1870, N-5817 Bergen, Norway	+47 55238673	+47 55238687	ares@imr.no

NAME	ADDRESS	TELEPHONE	FAX	E-MAIL
Sytse Ybema	IMARES Haringkade 1 1976 CP Ijmuiden Netherlands	+31 255 564728	+31255564644	sytse.ybema@wur.nl

Annex 2: International blue whiting spawning survey report

International blue whiting spawning survey report.

Annex 2 Toktrapport/Havforskningsinstituttet/ISSN 1503-6294/Nr. X – 2007

Working Document

Planning Group on Northeast Atlantic Pelagic Ecosystem Surveys

IJmuiden, the Netherlands, 14–17 August 2007

The Northern Pelagic and Blue Whiting Fisheries Working Group

Vigo, Spain, 27 August –1 September 2007

INTERNATIONAL BLUE WHITING SPAWNING STOCK SURVEY SPRING 2007

Mikko Heino[1*§]

Ciaran O'Donnel[2*], Graham Johnston[2], Eugene Mullins[2], Jenny Ullgren[3], Susan Bettie[2], Valantine Anthonypillai[1*], Jan Jensen[4],

R/V Celtic Explorer

Sergey Ratushnyy[5], Ivan Oganin[5,] Vladimir Shnar[6]

R/V Atlantida

Olav Rune Godø[1], Øyvind Tangen[1*], Ronald Pedersen[1], Gunnar Lien[1], Jan de Lange[1], Elna Meland[1]

F/V Eros

Jan Arge Jacobsen[7], Leon Smith[7*], Mourits Mohr Joensen[7], Jaime Alvarez[1],

R/V Magnus Heinason

Sytse Ybema[8*], Thomas Pasterkamp[8], Kees Bakker[8], Pablo Tjoe-Awie[8], Eric Armstrong[9], Dominik Gloe[10], Dirk Tijssen[4], Kirsti Eriksen[1]

R/V Tridens

1 Institute of Marine Research, Bergen, Norway
2 Marine Institute, Galway, Ireland
3 National University of Ireland, Galway, Ireland
4 Danish Institute for Fisheries Research, Denmark
5 PINRO, Murmansk, Russia
6 AtlantNIRO, Kaliningrad, Russia
7 Faroese Fisheries Laboratory, Tórshavn, the Faroes
8 Institute for Marine Resources & Ecosystem Studies, IJmuiden, The Netherlands
9 FRS Marine Laboratory, Aberdeen
10 Federal Research Institute for Fisheries, Hamburg
* Participated in the after-survey workshop
§ Survey coordinator, participated the survey on R/V Celtic Explorer

Introduction

In spring 2007, 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 fourth 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 (Celtic Explorer: O'Donnell et al. 2007; Eros: Godø et al. 2007; M. Heinason: Jacobsen et al. 2007; Tridens: Ybema 2007).

This report is based on a workshop held after the international survey in IJmuiden, 18–19/4/2007 where the data were analysed and the report written. Parts of the document were worked out through correspondence during the workshop and during a protracted period 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 2006 (ICES 2006a), 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
Atlantida	AtlantNIRO, Kaliningrad, Russia	17/3–24/3
Celtic Explorer	Marine Institute, Ireland	28/3–12/4
Eros	Institute of Marine Research, Bergen, Norway	20/3–27/3
Magnus Heinason	Faroese Fisheries Laboratory, Faroe Islands	30/3–10/4
Tridens	Institute for Marine Resources & Ecosystem Studies, the Netherlands	9/3–20/3

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). Contacts were maintained between the vessels during the course of the survey, primarily through electronic mail.

Bad weather hampered the survey effort for much of March, causing either a reduction in vessel speed, or periods where surveying had to be suspended. Engine problem forced Atlantida to prematurely abandon the survey.

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 the survey (Celtic Explorer, M. Heinason, Tridens, Eros). Salient acoustic settings are summarized below.

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

	Atlantida	Celtic Explorer	Eros	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**, 120	**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	9	3	7
Upper integration limit (m)	10	15	15	7	12
Absorption coeff. (dB/km)		9.9	9.785	10	9.7
Pulse length (ms)	Medium	1.024	1.024	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)	-21.1	-20.6	-20.8	-20.9	-20.6
Sv Transducer gain (dB)	27.57			27.22	25.11
Ts Transducer gain (dB)	27.73	25.55	25.55	27.35	
s_A correction (dB)		-0.65	-0.65		-0.67
3 dB beam width (dg)					
alongship:	6.81	6.39	7.05	7.02	6.99
athw. ship:	6.67	6.67	7.06	6.86	6.96
Maximum range (m)	750	1000	900	750	750
Post processing software	Sonardata Echoview	Sonardata Echoview	LSSS	Sonardata Echoview	Sonardata Echoview

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

On Celtic Explorer, acoustic data were backed up every 24 hrs and scrutinised using Sonar data's Echoview (V 3.4) 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 (very seldom). In addition, as an experiment, parts of the data were also scrutinised using the Norwegian LSSS system by a different scientist.

On Eros, the acoustic recordings were scrutinized using the Large Scale Survey System (LSSS) 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.

On Magnus Heinason, acoustic data were scrutinised every 24 hrs on board using Sonar data's Echoview (V 4.10) 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 4.10) post processing software. Data were partitioned into only blue whiting using a new developed detection algorithm. Plankton will be partitioned in a later stage. All echograms had been scrutinized by two experienced scientists. To monitor transceiver output, a monitoring algorithm was created in Echoview. Both algorithms will contribute to a general Echoview template used in this survey.

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:

	Atlantida	Celtic Explorer	Eros	Magnus Heinason	Tridens
Circumference (m)	716	768	586	640	1120
Vertical opening (m)	50	50	30-40	42-48	30-70
Mesh size in codend (mm)	16	20	22	40	±20

Typical towing speed (kn)	4.0	3.5-4.0	3.5	3.0-4.0	3.5-4.0

On Eros, some additional samples were taken after the main survey with a commercial blue whiting trawl with 2400 m circumference.

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 30 (Eros), 50 (Celtic Explorer, Tridens) or 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 70 (Eros), 100 (M. Heinason, Celtic Explorer), 200 (Tridens, only length) was measured for length and weight. On Atlantida 30 or more fish were aged, weight and sex and an additional 42 or more 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)[1]. 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

[1] The above-cited TS relationship actually implies $\langle\sigma\rangle = 6.59 \cdot 10^{-7} L^{2.18}$. It is not known where this difference originates from.

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). Atlantida, Celtic Explorer, and Tridens are equipped with SBE911 CTDs. Magnus Heinason was equipped with SBE911 only for the last days of survey, covering the Nolsø–Flugga section. Eros is equipped with SAIV CTD. All vessels were able to take CTD stations to the depth of 2000 meter or more, except Tridens who only took CTD stations to 650 meters.

Results

Inter-calibration results

Results from the inter-calibration between R/V Celtic Explorer and R/V Magnus Heinason are summarized in Appendix 1. Acoustic inter-calibrations showed that the performance of Magnus Heinason appeared to be somewhat different from Celtic Explorer (which was used as the reference vessel). Closer scrutiny of results suggests that some of the difference arose from spatial heterogeneity in blue whiting density. However, the possibility of different behavioural responses of schools should not be overlooked.

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 Celtic Explorer and Magnus Heinason nevertheless suggested rather small differences in size selectivity in mean length relative to Celtic Explorer; the mean length from M. Heinason was 0.8 cm lower. This is a similar difference to that observed between G.O. Sars and M. Heinason in 2006.

Other inter-calibrations were not practical because of large distances in time and/or space.

The age readings from the different vessels showed differences in mean age at a given length (Appendix 2). While these differences may well reflect variability between individuals in different areas, inconsistencies in age readings should also be considered.

Distribution of blue whiting

Blue whiting were recorded in most of the survey area that covered about 135 thousand square nautical miles (Figures 4–6). The highest concentrations were recorded in the area between the Hebrides, Rockall and Faroes Banks. For example, a record dense school was recorded in the northern flanks of the Porcupine Bank (Figure 7).

In comparison to 2006, the biomass was comparatively distributed, although a moderate decrease in biomass was recorded in the Rockall sub area. In the transboundary region between North and South Porcupine and Rockall sub-areas a notable increase of biomass was recorded in 2007. With the exception of the southern and western extremes of the survey confines remaining 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 2007 international survey was 11.2 million tonnes, representing an abundance of 104×10^9 individuals (Table 2). The spawning stock was estimated at 11.1 million tonnes and 102×10^9 individuals. The geographical distribution of total stock biomass by stratum is shown in Figure 8.

In comparison to the results in 2006, there is a modest increase in stock biomass and a modest decrease in stock numbers:

		2004	2005	2006	2007	Change from 2006 (%)
Biomass (mill. t)	Total	11.4	8.0	10.4	11.2	+8
	Mature	10.9	7.6	10.3	11.1	+8
Numbers (10^9)	Total	137	90	108	104	–4
	Mature	128	83	105	102	–3
Survey area (nm^2)		149 000	172 000	170 000	135 000	–20

Survey area is significantly reduced from 2006. This reduction occurred mostly in the peripheral areas which have had low densities in earlier years. Also two rectangles south of Rockall were excluded this year.

There was substantial heterogeneity in the temporal trend between the sub-areas. There was very large relative increase in the southern (Porcupine Bank) sub-areas, whereas biomass was unchanged in the Hebrides, slightly increased in the Faroes/Shetland sub-area and decreased the Rockall sub-area:

Sub-area		Biomass (million tonnes) 2006		2007		Change (%)
			% of total		% of total	
I	S. Porcupine Bank	0.20	2	0.75	7	275
II	N. Porcupine Bank	0.74	7	1.8	16	141
III	Hebrides	5.2	50	5.3	47	1
IV	Faroes/Shetland	0.94	9	1.1	10	17
V	Rockall	3.3	32	2.3	20	–31

Stock composition

Stock in the survey area is dominated by age classes 4 and 5 years (year classes 2003 and 2002), which make together about 55% of spawning stock biomass (Table 3, Figure 8). These are the same year classes that dominated the stock in 2006, although their ranking is now swapped. The numbers of the 2003 year class remain unchanged (suggesting that it was not yet fully recruited to the spawning stock in 2006), whereas the numbers of age class 2002 are reduced by 36 %.

Half of the spawning stock biomass was recorded in the Hebrides sub-area, as was the case also in 2006. The age structure of stock in this area resembled that of the total survey area (Figure 9). In the northern areas, younger blue whiting were relatively more abundant, while in the Rockall, there were particularly few young blue whiting. This is similar spatial structuring as observed earlier.

Virtually 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 virtually all fish were mature in the Hebrides sub-area and all fish were mature in the other areas. In particular, in the Porcupine Bank no juveniles were encountered, despite two hauls on the slopes of the bank where juvenile often occur.

Concluding remarks

Main results

- The fourth international blue whiting spawning stock survey shows a modest increase in stock biomass (~8%) and a modest decrease in stock numbers (~3–4%) in comparison to

the survey in 2006. The biomass estimates are almost as high as in 2004 when the largest stock was measured, whereas stock numbers are markedly lower than in 2004.

- The survey area was reduced by about 20 % from 2006. Most of the reduction came from areas with low density in 2006. Nevertheless, the estimates would have been expected to be higher if the same coverage were achieved.
- Most of the increase in the stock estimate comes from the southern sub-areas (the Porcupine Bank). This area was covered earlier in season this year than in 2006. With later coverage, the biomass would probably have moved to the Hebrides sub-area. In the Hebrides and the Faroes sub-areas biomass was essentially unchanged, whereas biomass decreased in the Rockall sub-area where coverage was also significantly reduced.
- The stock in the survey area is dominated by age classes 4 and 5 years (year classes 2003 and 2002), which make together about 55% of spawning stock biomass. These are the same year classes that dominated the stock in 2006, although their ranking is now swapped.
- Mean age (4.6 years), length (27.7 cm) and weight (108 g) are the highest on record in the international survey time series (2004–2007). Numbers of "old" blue whiting, ages 6 to 8 years, are the highest on record. On the other hand, numbers of young blue whiting, ages 1 to 3 years, are record low. Recruitment to the spawning stock appears to be rather low.
- The spawning stock biomass appears to be maintained to a large degree by growth of individuals in the spawning stock while recruitment makes a moderate contribution.
- Dealfish (*Trachipterus arcticus*) continued to be present at most of the trawl catches. Also catch numbers were often high, and dealfish was often among the species that made up bulk of the sample biomass. 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.
- Distribution of blue whiting in the spawning area is highly dynamic. The survey currently stretches over a five to six week period. Longer survey time periods are considered to increase the likelihood of double counting of migrating schools. It is therefore proposed that a more concerted effort will be made during the 2008 survey to conduct the survey over a four week window.
- Rough assessment of uncertainty in the acoustic data suggests that 95% confidence intervals for total stock biomass estimate are 20%...+22%, and 50% confidence limits are –7.7%...+7.2% (Appendix 3). This high uncertainty is caused by very high proportion of total acoustic backscattering having been observed over very short parts of survey track. In 2004–2006, the uncertainty was lower, roughly ±10…13%. Because of high uncertainty in 2007 in particular, the change in stock biomass is within what could be caused by chance factors, and we cannot reject the null hypothesis that stock biomass is unchanged.

Recommendations

- Coordinated survey timing- the issue of coordinated timing was raised. At present all members agree that the temporal progression of the survey is too long, taking up to 6

weeks to complete the entire survey program. Peak spawning time is between the last 2 weeks of March and the first 2 weeks in April (± 1–2 weeks). The group recommends a more concerted effort to survey the entire area between these times over a 3–4 week time frame.

- Review southern extension of survey coverage with the aim of refocusing survey effort to the area north of 52°N
- Dealfish: Data review underway. The group recommends biological data should be collected from individuals encountered during the 2008 survey.
- Pre-agreed preliminary survey tracks to be formulated at the PGNAPES 2007 meeting for surveys carried out in 2008.
- Dedicated sub group should be maintained within PGNAPES meeting to address issues arising from the survey program in 2007
- Data backlog in PGNAPES database from start of coordinated survey time series (2004 onwards): Leon to update the group at PGNAPES August meeting in 2007.
- Update on PGHERS acoustic manual to be provided at the August meeting.
- Data exchange- the group discussed the issue of at sea data exchange. It was suggested that once a vessel has completed an E–W band of ICES rectangles then all transect data (biological, logbook, hydrographic and acoustic) should be made available to the group. This will be restricted to vessels with broadband systems.
- Continue established at sea communications with data summaries, fleet activity and survey findings.
- Location of 2008 post cruise meeting will be arranged in Kaliningrad.
- Maintain survey methodologies as agreed in the PGNAPES acoustic manual for all survey operations (including CTD depth coverage, parallel transect design and spacing and log sheet entries).
- Group recommends the formation of a single species ID guide for the future surveys combining existing knowledge and onboard guides currently in use.
- Echoview Template. Leon Smith has updated Template (V8) with common species codes. Sytse Ybema has also been working on a template that includes a school detection algorithm and transmission detection window. For the 2008 survey these templates should be combined.
- Intercalibration methods to be reviewed and the manual updated.
- Continuation of knowledge and personnel exchange between participant countries and vessels.
- Discussions are to take place at the PGNAPES meeting on how to use the Oracle database to streamline data extraction into the final survey report format.
- Ways to ensure that hydrographic data are analysed at the same time frame as biological data.

Achievements

- Good coverage of core distribution areas
- Improved coordination of survey effort
- Personnel and skill exchange between vessels
- Improvements in semi-automated school detection in currently used post-processing software packages
- First time use of Online Oracle PGNAPES database for historic data extraction

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Table 1. Survey effort by vessel.

Vessel	Effective survey period	Length of cruise track (nm) *	Trawl stations	CTD stations	Aged fish	Length-measured fish
Atlantida	17/3–24/3	919	3	13	205	377
Celtic Explorer	28/3–12/4	1890	18	27	850	2700
Eros	20/3–27/3	1347	10**	20	171	527
Magnus Heinason	30/3–10/4	1402	13	14	549	1363
Tridens	9/3–20/3	897	8	18	262	400

* Used in the stock estimate. Steaming in, e.g., shallow areas excluded.

** Seven more samples were taken after the main survey for commercial and scientific purposes. These include 203 aged and 1000 length-measured fish.

Table 2. Assessment factors of blue whiting, spring 2007.

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	16095	6.9	6.9	100	0.75	0.75	100	108	28.1	47
II N. Porcupine Bank	16496	17.0	17.0	100	1.8	1.8	100	105	28.0	108
III Hebrides	34936	51.0	51.7	98.6	5.2	5.3	99.4	102	27.5	151
IV Faroes/Shetland	16191	8.7	9.7	89.6	1.1	1.1	96.6	114	26.3	68
V Rockall	51462	18.5	18.5	100	2.3	2.3	100	124	28.4	44
Tot.	135181	102	104	98.3	11.1	11.2	99.4	108	27.7	83

Table 3. Stock estimate of blue whiting, spring 2007.

Length (cm)	Age in years (year class) 1 2006	2 2005	3 2004	4 2003	5 2002	6 2001	7 2000	8 1999	9 1998	10+ 1997	Num-bers (10^6)	Bio-mass (10^6 kg)	Mean weight (g)	Prop. mature* (%)
16.0 – 17.0	57	0	0	0	0	0	0	0	0	0	57	1	25	0
17.0 – 18.0	225	0	0	0	0	0	0	0	0	0	225	7	31	0
18.0 – 19.0	450	9	0	0	0	0	0	0	0	0	459	16	34	2
19.0 – 20.0	465	0	0	0	0	0	0	0	0	0	465	19	41	0
20.0 – 21.0	376	57	0	0	0	0	0	0	0	0	433	20	46	13
21.0 – 22.0	150	387	40	128	0	0	0	0	0	0	705	35	50	79
22.0 – 23.0	0	501	763	88	0	0	0	0	0	0	1352	79	59	100
23.0 – 24.0	0	551	1147	154	16	0	0	0	0	0	1868	126	68	100
24.0 – 25.0	0	753	2631	1080	229	108	0	0	0	0	4801	367	77	100
25.0 – 26.0	0	370	4697	4502	1633	188	22	0	0	0	11413	962	84	100
26.0 – 27.0	0	26	4121	8143	4140	1617	551	0	0	0	18597	1702	92	100
27.0 – 28.0	0	0	2107	9497	5418	2734	1184	0	0	0	20941	2088	100	100
28.0 – 29.0	0	0	713	6125	4645	2740	1415	361	174	0	16173	1771	110	100
29.0 – 30.0	0	0	87	1856	4685	2671	904	510	53	0	10766	1327	123	100
30.0 – 31.0	0	0	36	763	2302	1321	1121	530	154	0	6226	894	144	100
31.0 – 32.0	0	0	0	164	997	767	663	526	118	46	3280	531	162	100
32.0 – 33.0	0	0	0	112	505	810	809	129	114	257	2735	496	181	100
33.0 – 34.0	0	0	0	210	107	484	135	181	211	17	1344	266	198	100
34.0 – 35.0	0	0	0	30	79	179	323	115	12	0	739	172	233	100
35.0 – 36.0	0	0	0	0	31	279	141	93	6	184	735	189	258	100
36.0 – 37.0	0	0	0	0	0	0	15	0	110	86	210	63	299	100
37.0 – 38.0	0	0	0	0	0	35	0	48	0	1	84	23	275	100
38.0 – 39.0	0	0	0	0	8	0	0	17	0	23	47	15	325	100
39.0 – 40.0	0	0	0	0	0	17	0	0	0	42	59	24	405	100
TSN (10^6)	1723	2654	16343	32851	24794	13952	7282	2509	951	655	103714			
TSB (10^6 kg)	67.6	181	1415	3285	2793	1732	1006	393	167	153	11193			
Mean length (cm)	19.3	23.5	25.7	27.3	28.3	29.2	29.8	31.1	31.9	34.5	27.7			
Mean weight (g)	39.3	68.3	86.6	100	113	124	138	157	176	234	108			
Condition (g/dm^3)	5.5	5.3	5.1	4.9	5.0	5.0	5.2	5.2	5.4	5.7	5.1			
% mature*	0	100	100	100	100	100	100	100	100	100	98.3			
% of SSB	0	2	13	30	25	16	9	4	2	1				

* Percentage of mature individuals per age or length class

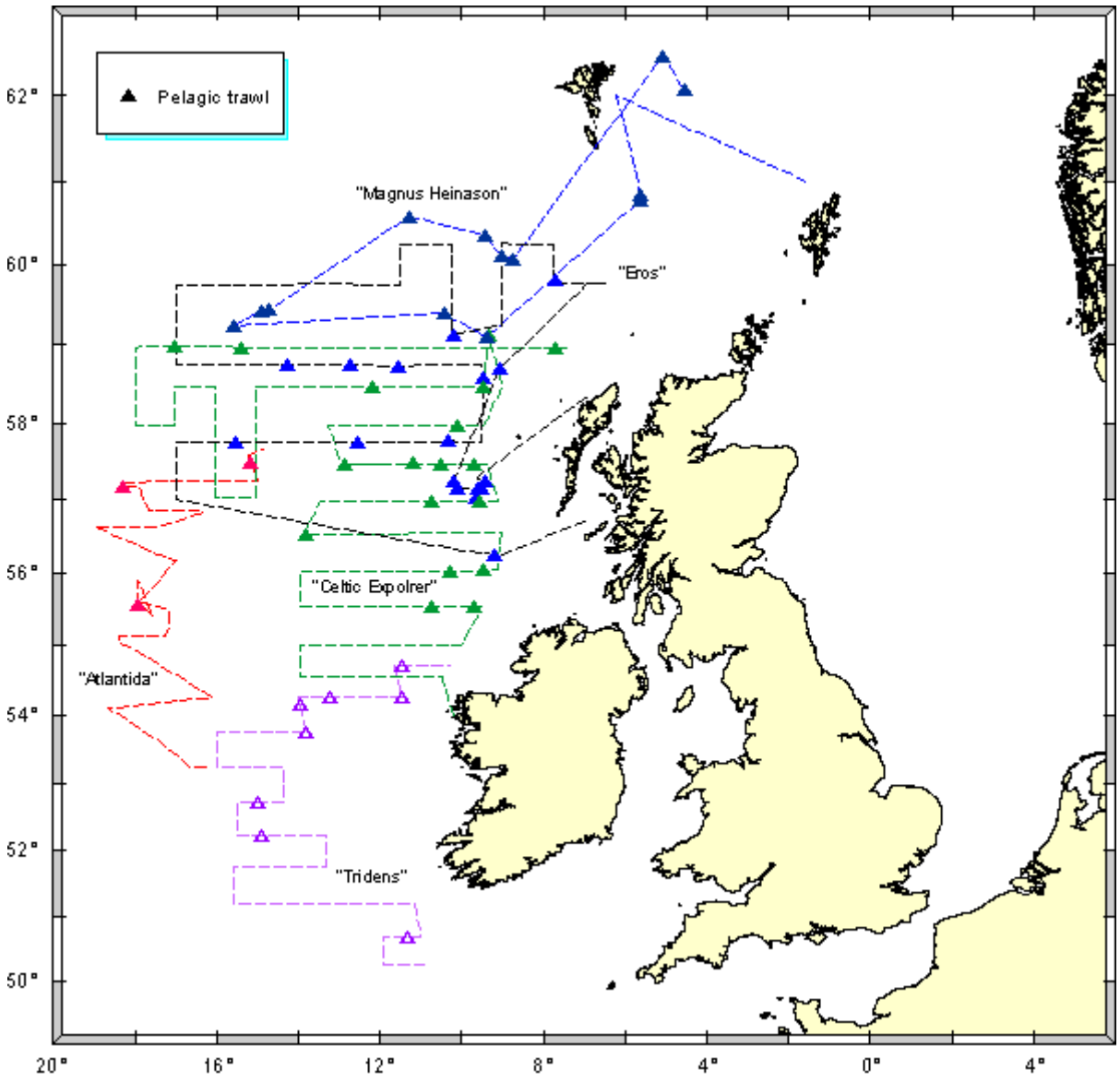


Figure 1. Cruise tracks and trawl stations during the International Blue Whiting Spawning Stock Survey in spring 2007. The figure shows all survey activity; in Figure 4, only the cruise tracks from which acoustic data were used in the stock estimate are shown.

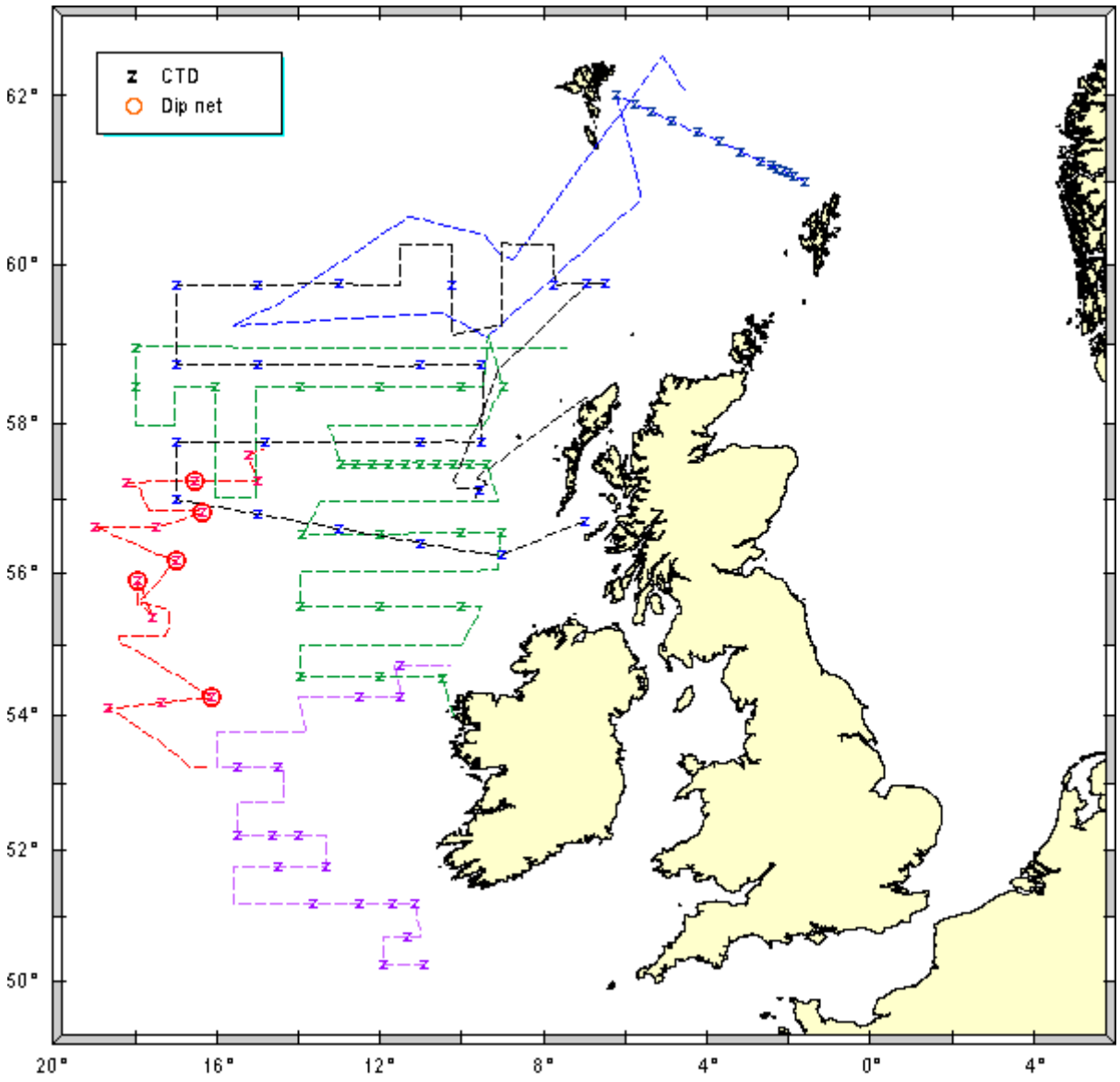


Figure 2. CTD stations for R/V Atlantida, R/V Celtic Explorer, F/V Eros, R/V Magnus Heinason and R/V Tridens in March-April 2007.

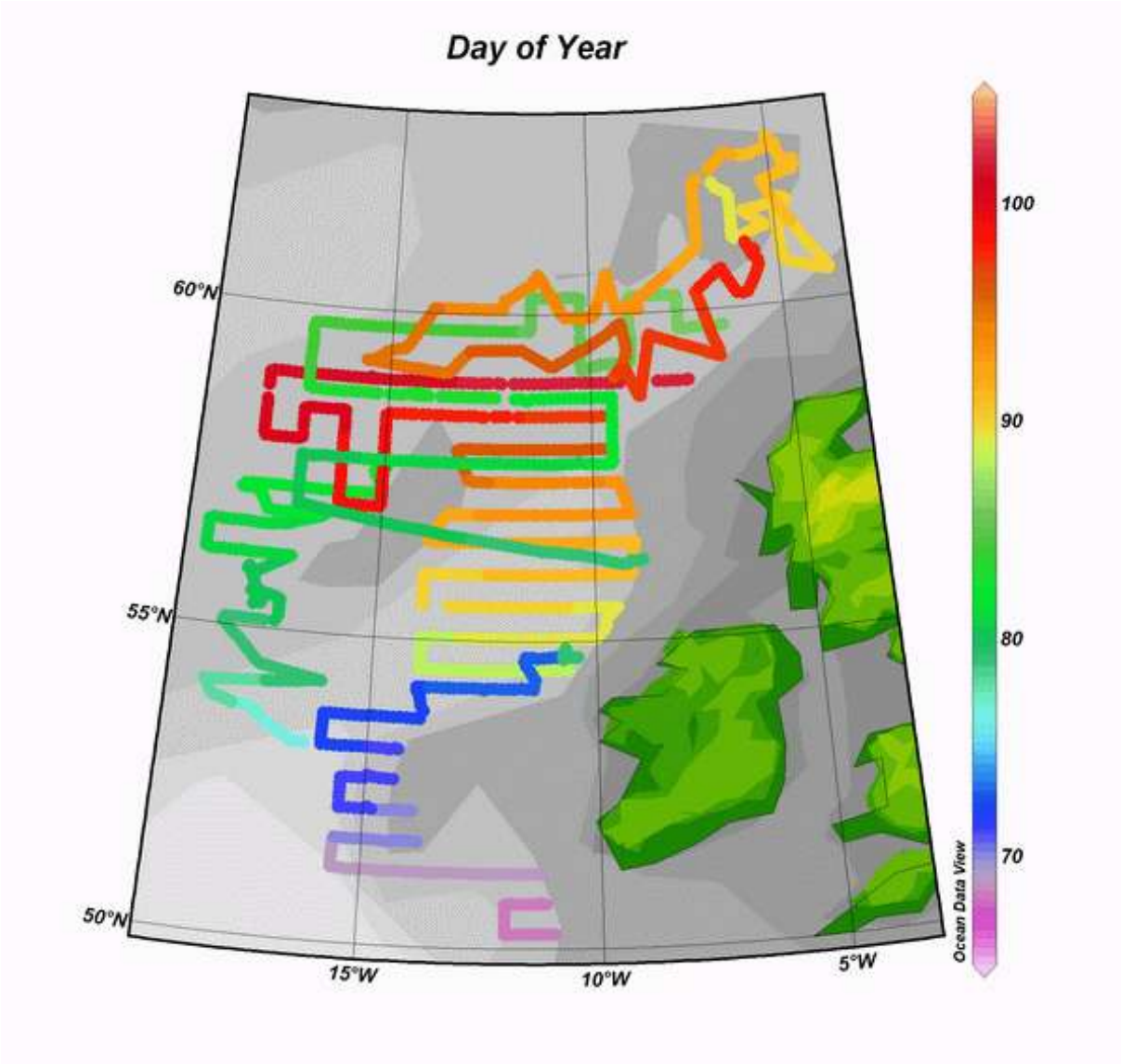


Figure 3. Temporal progression of the survey, 9 March–12 April 2007.

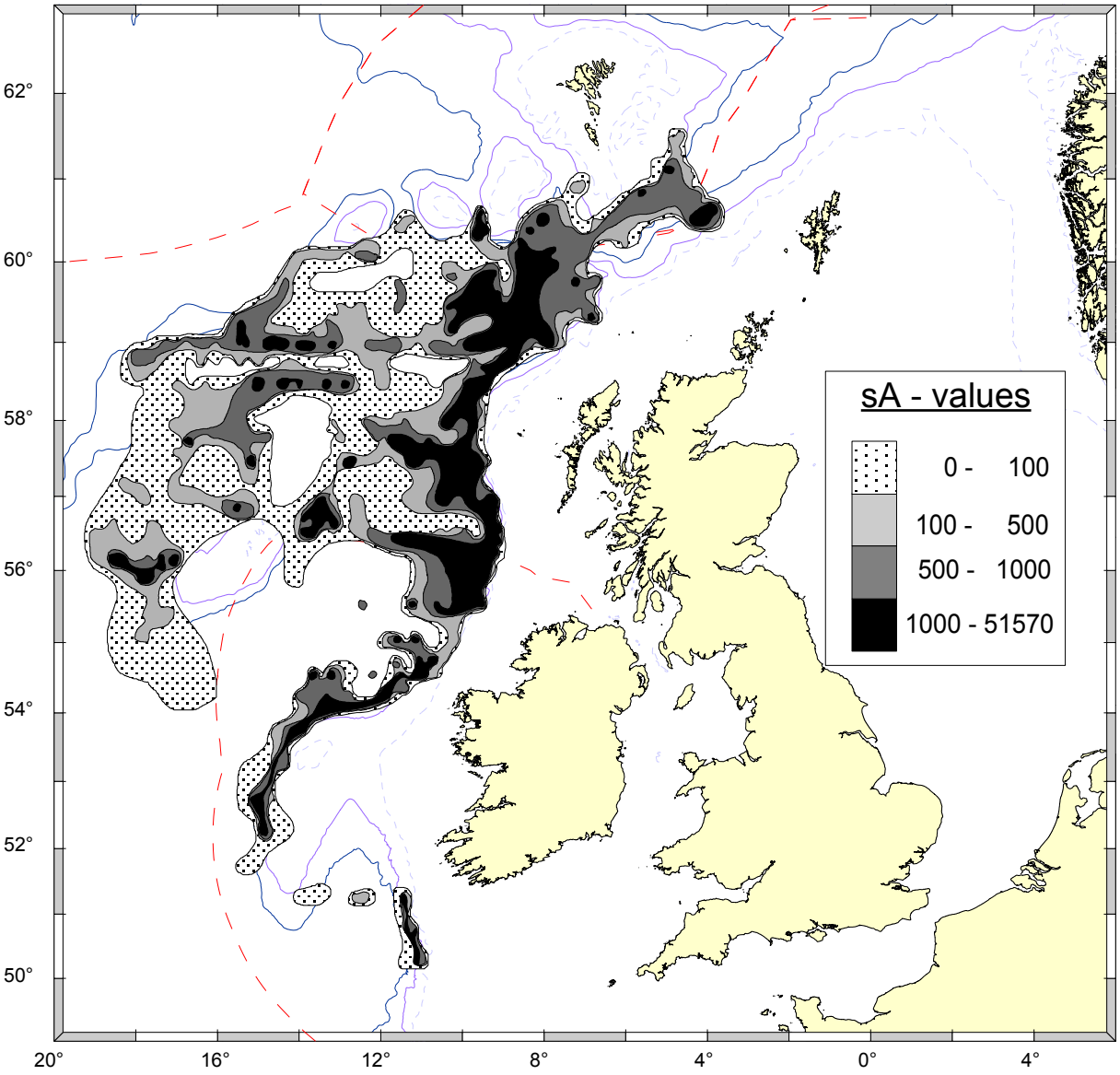


Figure 4. Schematic map of blue whiting acoustic density (s_A, m^2/nm^2) in spring 2007.

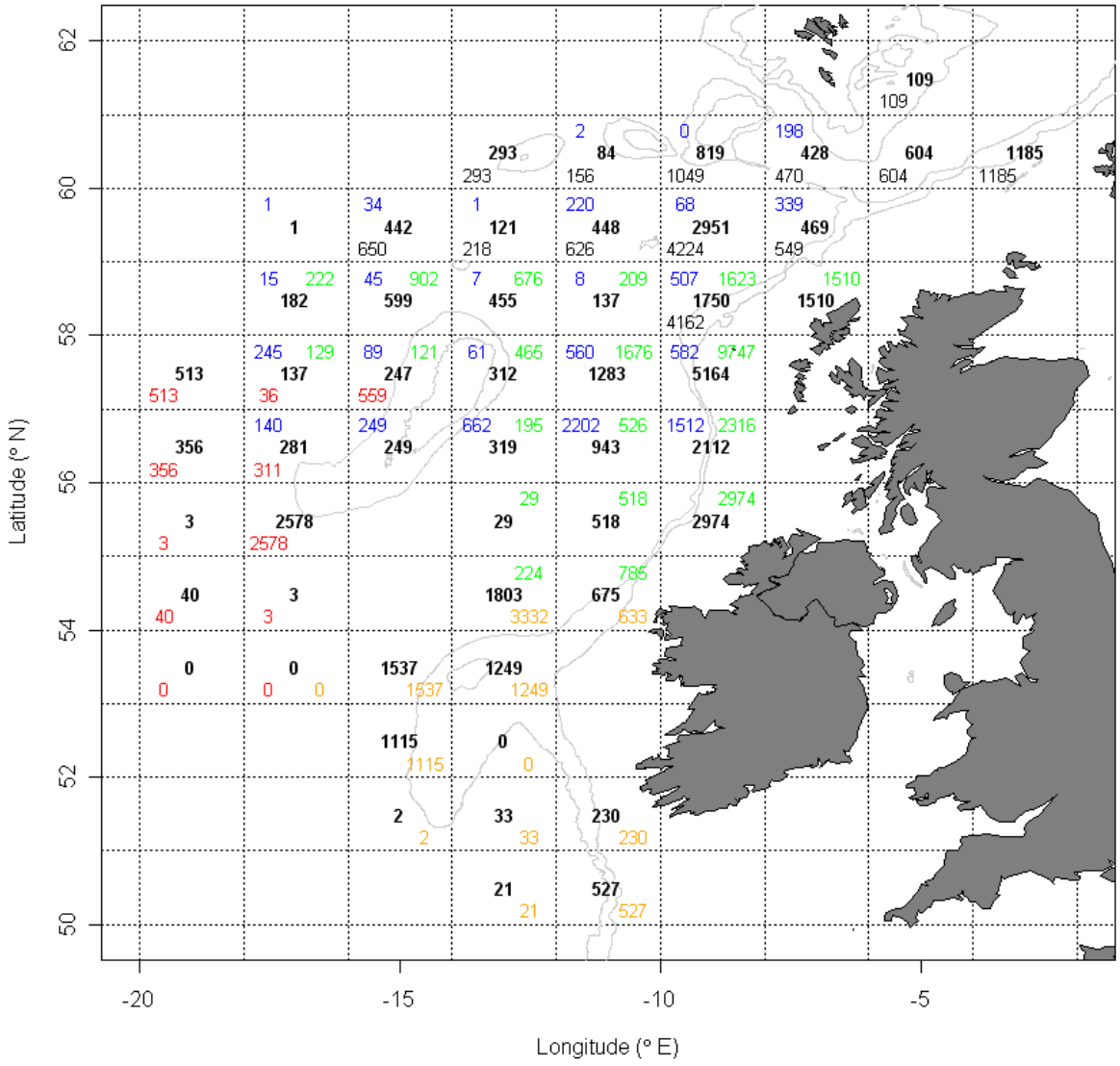


Figure 5. Mean blue whiting acoustic density (s_A, m^2/nm^2) for all vessels combined and for each vessel: Celtic Explorer (top right, green); Magnus Heinason (bottom left, black); Tridens (bottom right, orange); Atlantida (bottom left, red); Eros (top left, blue)

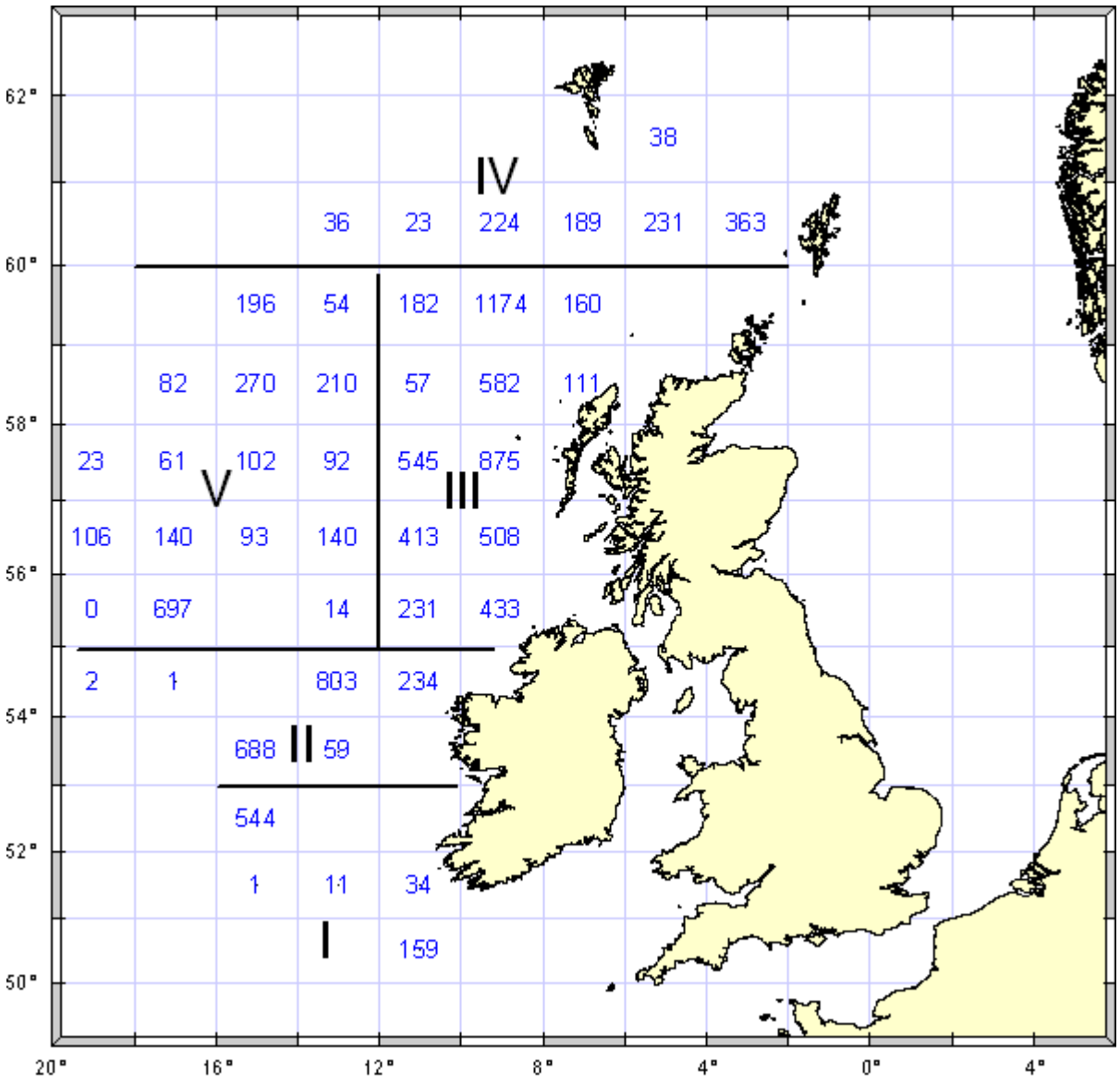


Figure 6. Blue whiting biomass in 1000 tonnes, spring 2007. Marking of sub-areas I-V used in the assessment.

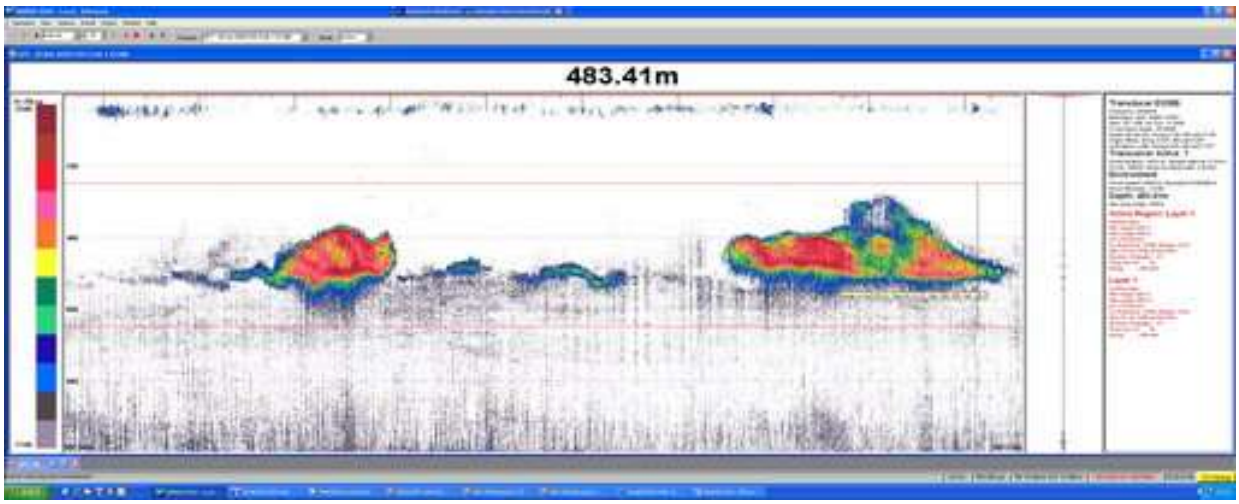


Figure 7. Blue whiting school with acoustic density (s_A) of 279,000 m^2/nm^2 (at 1 nm horizontal resolution) recorded in the northern slopes of the Porcupine Bank. This is the highest acoustic density that has been recorded during the international blue whiting spawning stock surveys.

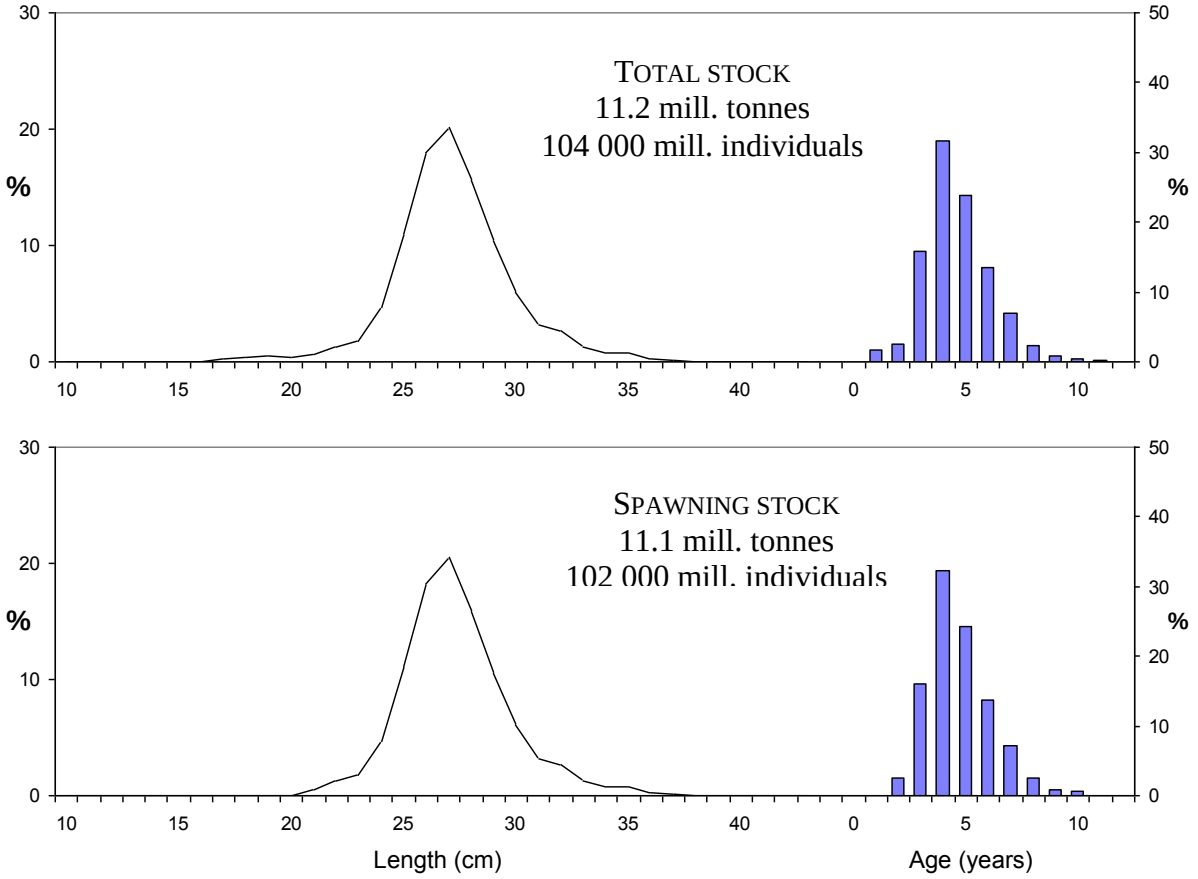


Figure 8. Length and age distribution in the total and spawning stock of blue whiting in the area to the west of the British Isles, spring 2007.

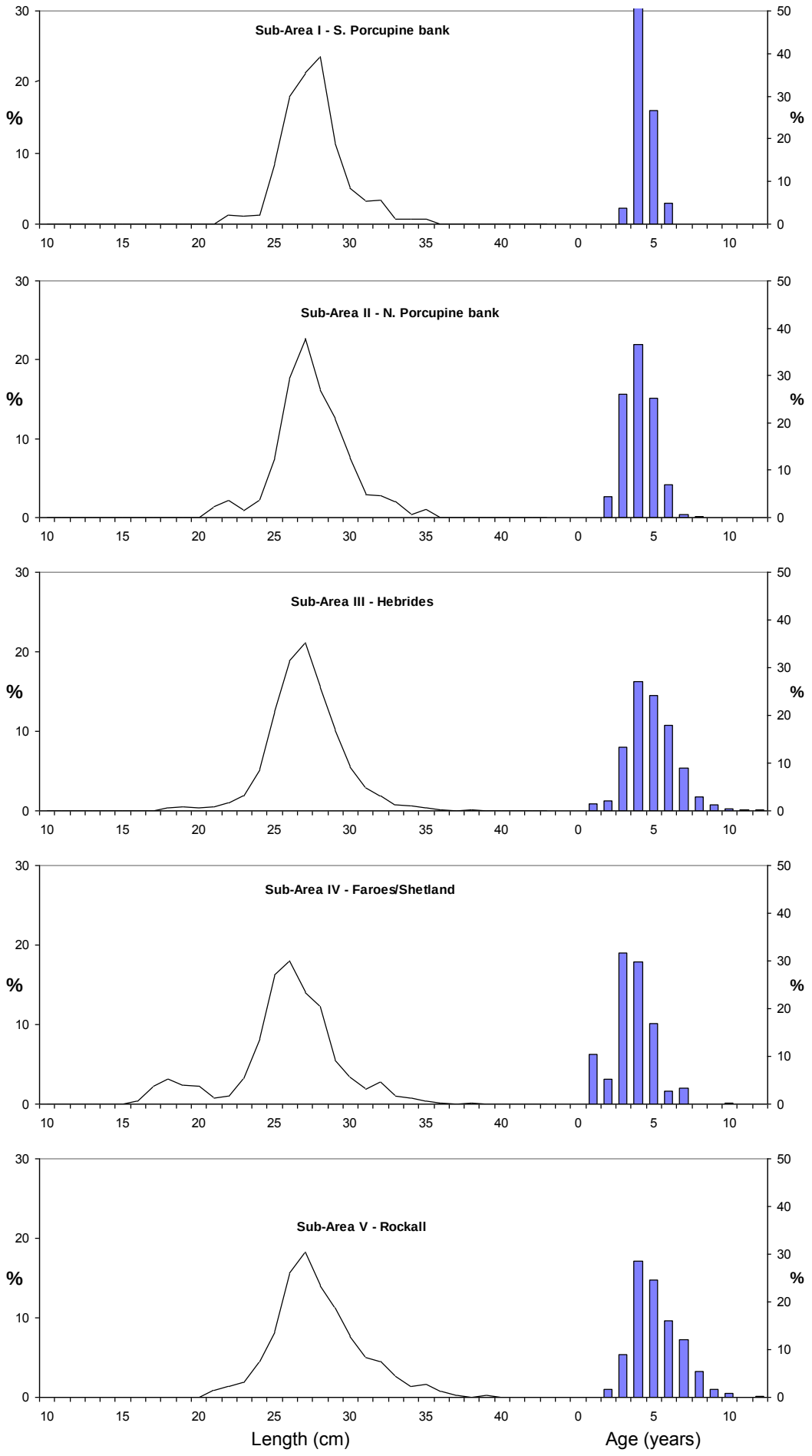


Figure 8. Length and age distribution of blue whiting by sub-areas (I–V), spring 2007.

Appendix 1. Inter-calibration between R/V Magnus Heinason and R/V Celtic Explorer

Acoustic inter-calibration between R/V Celtic Explorer and R/V Magnus Heinason was conducted on April 7 between the Rosemary Bank and the Hebrides shelf break from about N59°05' W09°05' to N58°45' W08°45'. The weather was fairly favourable with moderate wind (18–20kt from WSW) and moderate swell (about 2 metres from W). The main acoustic features in the area were (1) up to 200 metres thick layer of blue whiting in depths between 400 and 600 metres that was strongest towards the end of the transect, (2) a layer of presumed macro-zooplankton from depth 300 metres downward, partly mixed with the blue whiting layer, and (3) plankton and mesopelagic fish, in the uppermost 200 metres.

The inter-calibration was the run over 25 nautical miles between 02:48-05:47 GMT. Vessels were cruising SSE at parallel courses, with the distance between the tracks being 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. The recordings show a fair qualitative agreement. Regression model suggests that intercept is not significantly different from zero. Regression forced through the origin has high coefficient of determination (R^2) and a slope that is significantly larger than one; the model suggests that Magnus Heinason records some 19% higher acoustic densities for blue whiting than Celtic Explorer. This is a rather large difference. Closer scrutiny of the echograms suggests that the difference can be traced to two sources. First, the echograms from Celtic Explorer showed sudden disappearances of blue whiting echoes for a range of about six nautical miles. These lasted for some tens of seconds at time, while other echoes (including the false bottom recording) were unchanged. The likely reason for this phenomenon is behavioural response (diving) to some vessel noise. This was not visible in recordings of Magnus Heinason. Second, echograms suggest that spatial heterogeneity was contributing to the different recordings. As the vessels were sailing 0.5 nm apart, this is entirely reasonable.

Before 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 nm apart. Celtic Explorer towed for 60 minutes at depths of 420–520 metres and caught 222 kg of blue whiting. Magnus Heinason towed in the same depth for the same time and caught 170 kg of blue whiting.

As seen in Fig. 3, blue whiting in the catch of Celtic Explorer were larger in mean length (mean±sd length: 27.4±2.1 cm) compared to the blue whiting in the catch of Magnus Heinason (26.6±2.1cm). The difference in means was statistically significant (p=0.0002). Although spatial heterogeneity may contribute to the difference, the results suggest that Celtic Explorer is somewhat more efficient in capturing large blue whiting. The difference is similar to the difference recorded in inter-calibrations between Magnus Heinason and G. O. Sars in 2005–2006.

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 Celtic Explorer are taken as the independent variable and those from Magnus Heinason as the dependent variable. n=25.

Model	Parameter	Estimate	Std. Error	t value	Pr(>|t|)	R^2 (%)
Intercept estimated	Intercept	-176	189	-1.36	0.361	97.0
	Slope	1.220	0.044	5.01	<0.001	
Intercept=0	Slope	1.193	0.033	5.91	<0.001	98.2

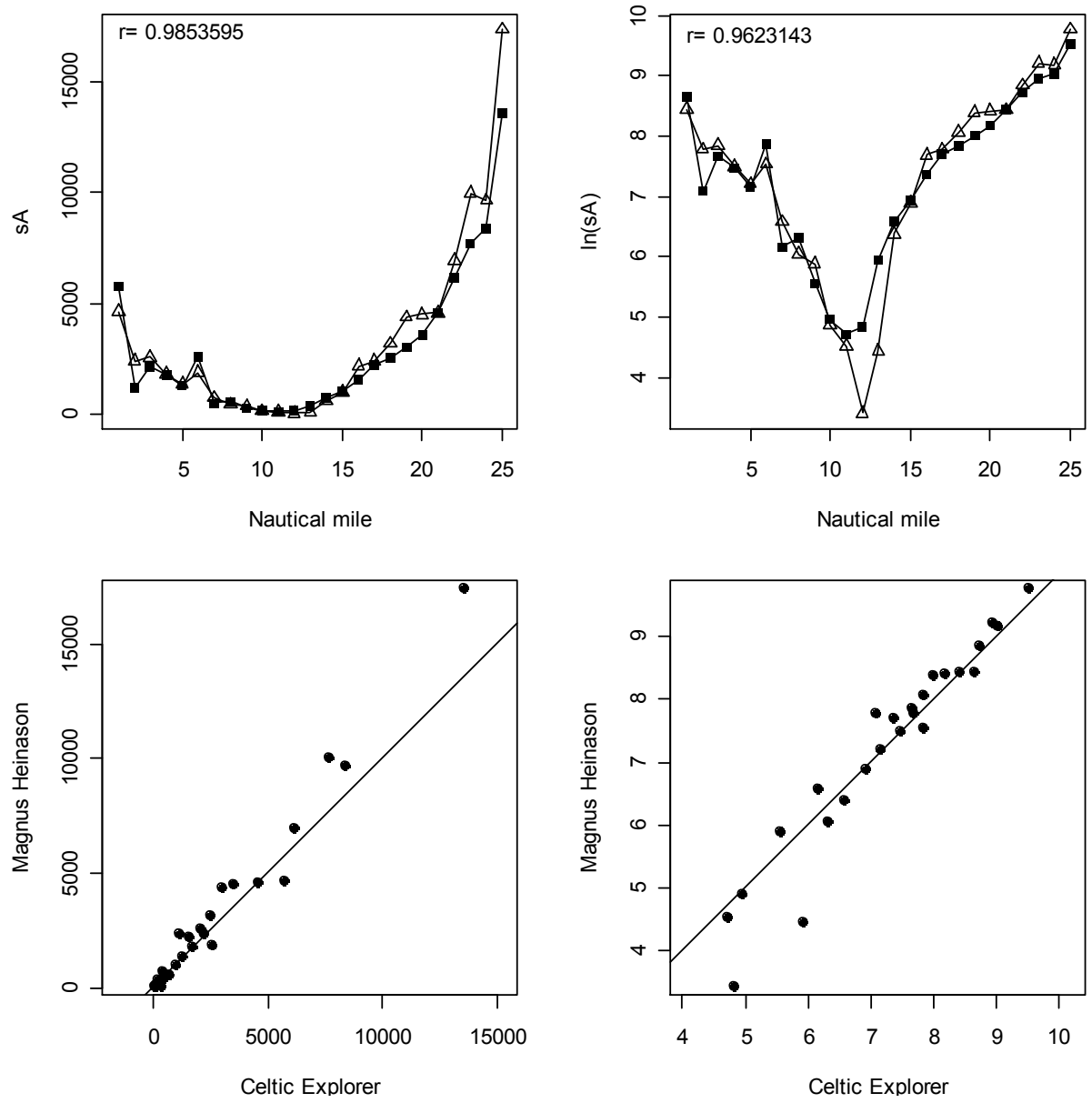


Figure 1. Comparison of blue whiting acoustic densities recorded by Magnus Heinason (open triangles) and Celtic Explorer (squares). The lower panels give same data as scatterplots. The diagonals are drawn as continuous lines.

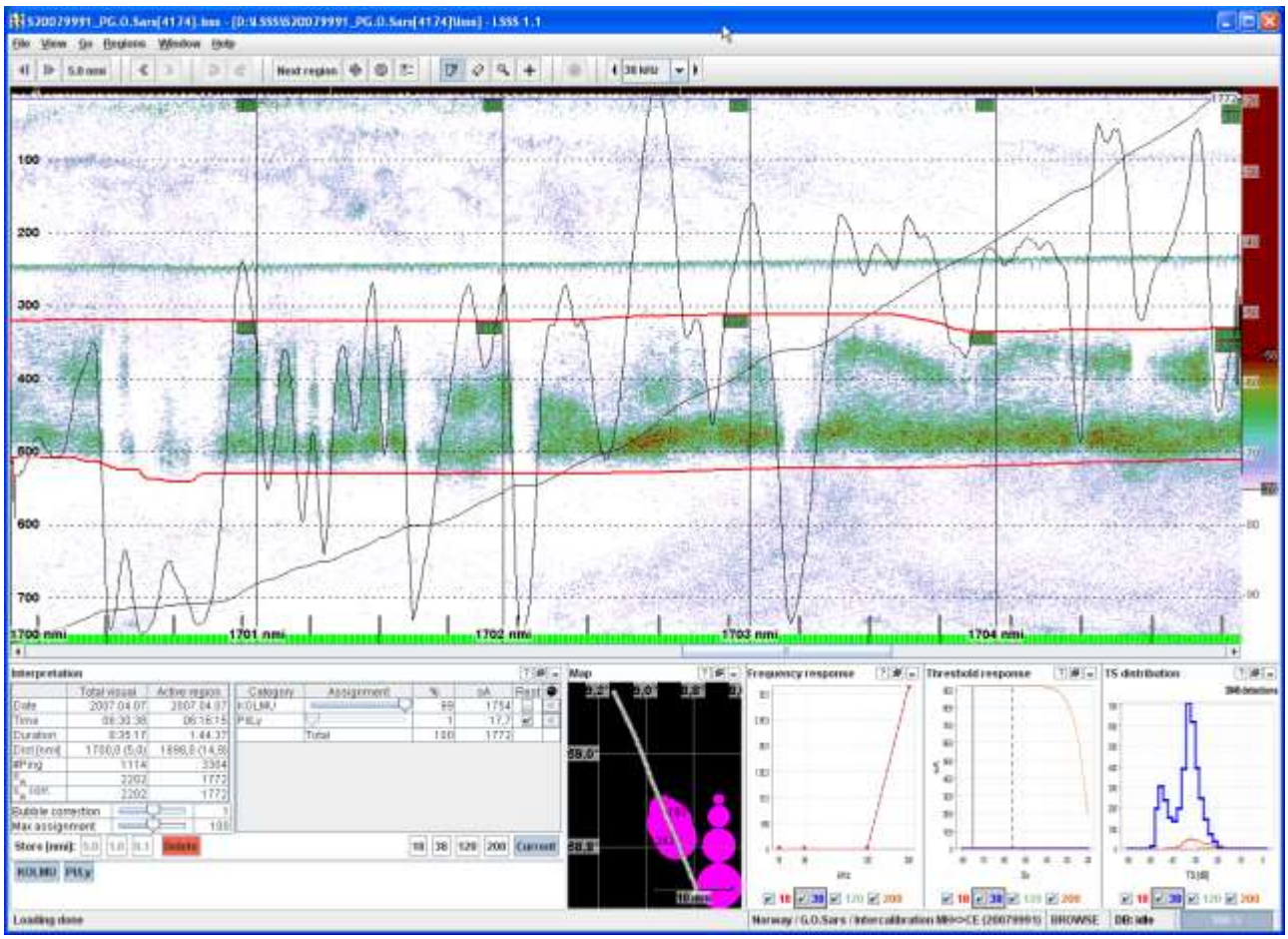


Figure 2. Echogram from Celtic Explorer showing intermittent dissappearance of blue whiting echoes. This phenomenon was virtually absent in the recordings from Magnus Heinason.

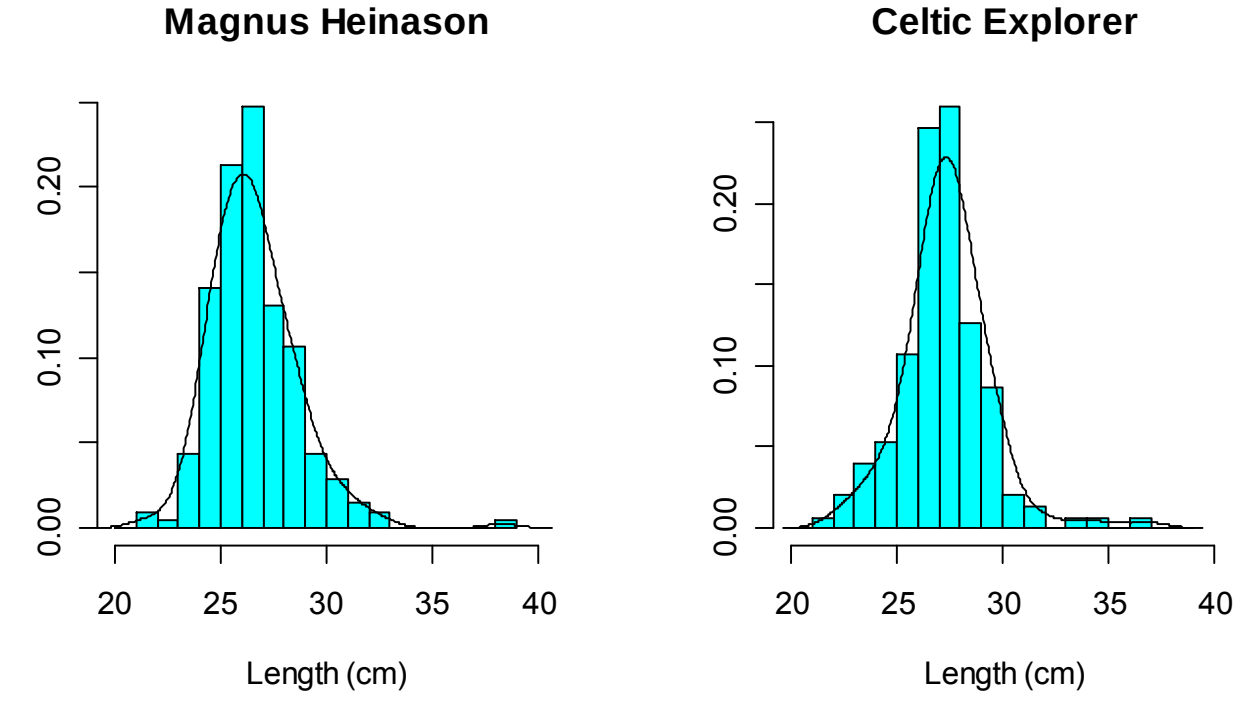
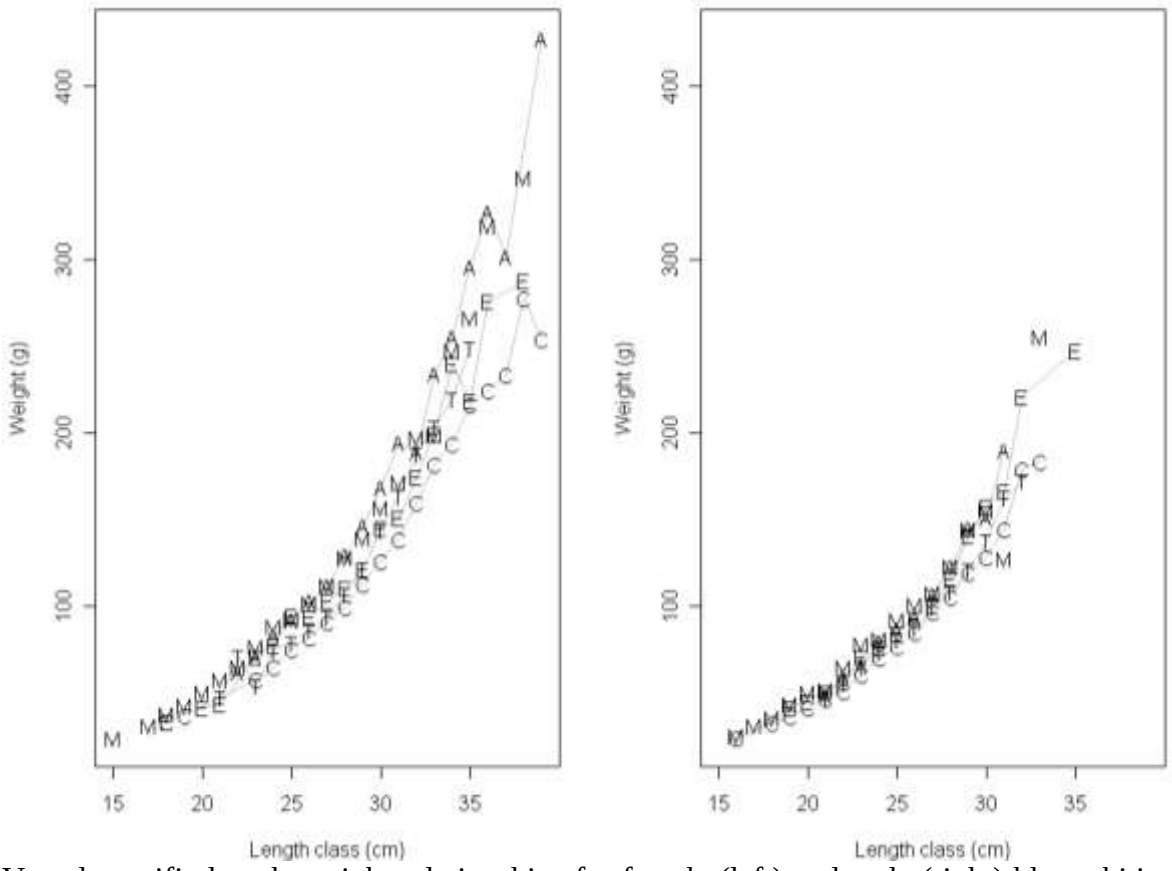
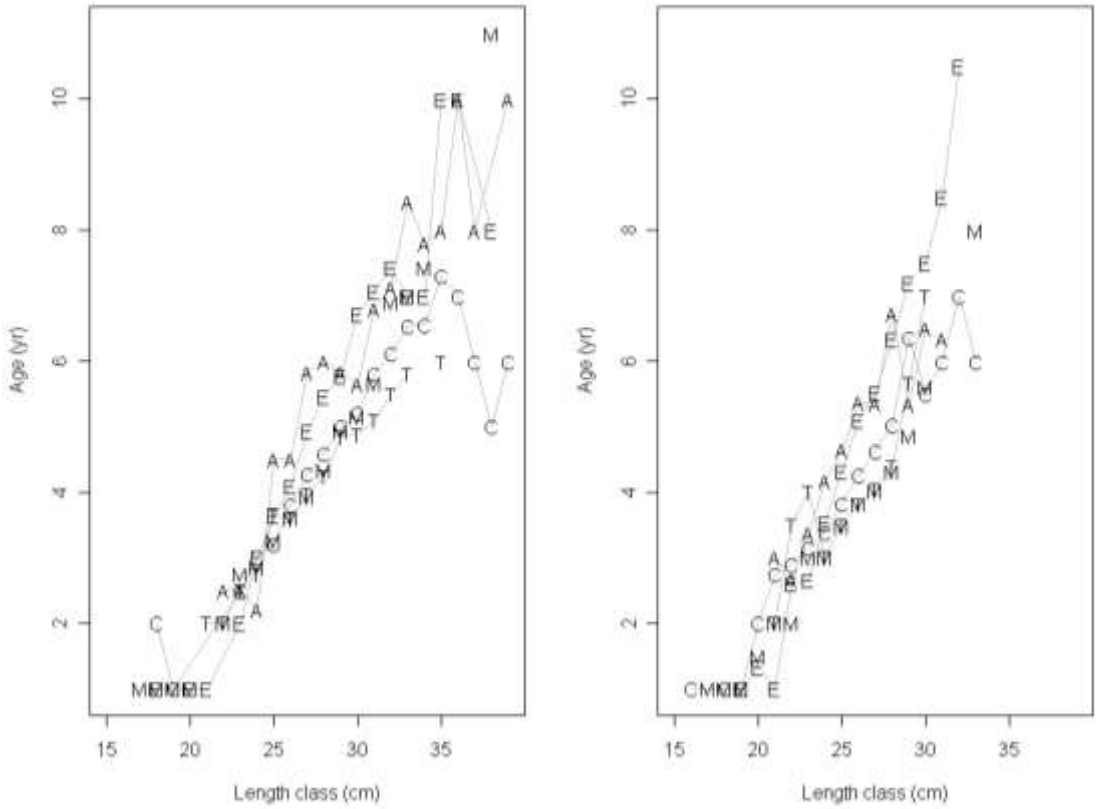


Figure 3. Length distributions from the trawls hauls by Magnus Heinason and Celtic Explorer. Smoothing is obtained by normal kernel density estimates. Celtic Explorer: n=150; Magnus Heinason: n=206.

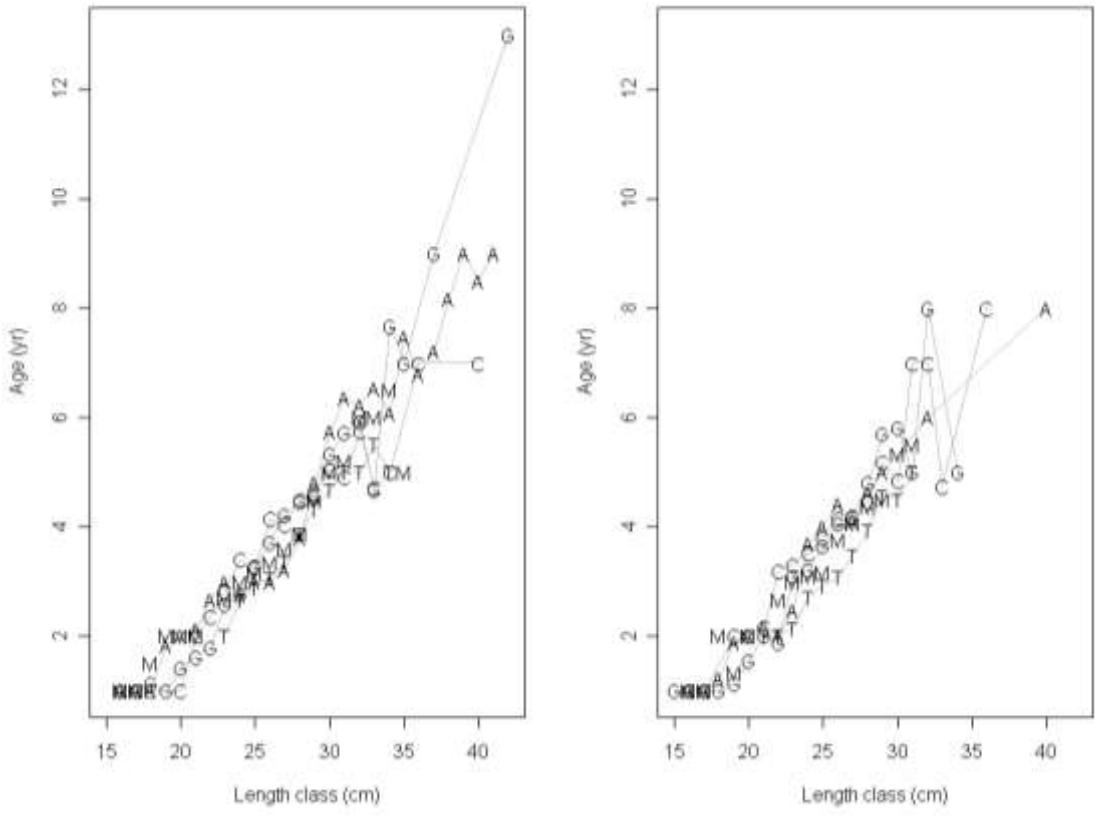
Appendix 2. Comparisons of biological data among the participating vessels



Vessel-specific length–weight relationships for female (left) and male (right) blue whiting in 2007. The letter codes are derived from the vessel names (A=Atlantida, C=Celtic Explorer, E=Eros, M=Magnus Heinason, T=Tridens). There is more variability among the vessels for females than for males, probably because gametes make potentially a larger proportion of body weight in females.



Vessel-specific length–age relationships for female (left) and male (right) blue whiting in 2007. The letter codes are derived from the vessel names (A=Atlantida, C=Celtic Explorer, E=Eros, M=Magnus Heinason, T=Tridens). The differences between smallest and largest mean age for the core length groups are often more than 1 year. Differences this large are unexpected. While it is possible that the vessels have consistently observed blue whiting with different growth rates, it could be that age readings are drifting apart. The differences observed in 2006 were less striking (below).



Appendix 3. Uncertainty in the acoustics observations and its consequences to stock estimates

Stock estimates calculated from trawl-acoustic surveys are subject to many sources of errors, both of observational and structural nature (this issue is discussed from the blue whiting spawning stock survey perspective in Heino 2004). Total uncertainty is practically impossible to characterize, but some sources of uncertainty are quite amenable to quantification. Here the purpose is to estimate observation error originating from observing spatially and temporally heterogeneous blue whiting registrations through acoustic measurements along survey tracks covering a limited part of the survey area.

For the purpose of calculating stocks estimates, acoustic data (acoustics density (s_A) representing blue whiting, in m^2/nm^2) from each vessel are expressed as average values over 5 nm stretches of survey track. Acoustic density for each survey stratum is calculated as an average across all observations within a stratum, weighted by the length of survey track behind each observation (some observations represent more or less than 5 nm). Normally, these values are then converted to stratum-specific biomass estimates based on information on mean length of fish in the stratum and the assumed acoustic target strength; the total biomass estimate is the sum of stratum-specific estimates.

Here we do not attempt to repeat the whole estimation procedure, but instead characterize uncertainty in global mean acoustic density estimate. Since mean size of blue whiting does not vary very much in the survey area, uncertainty in mean acoustic density should give a good, albeit conservative, estimate of uncertainty in total stock biomass.

We use bootstrapping to characterize uncertainty in the mean acoustic density. Bootstrapping is done by stratum, treating observations from all vessels equally and using lengths of survey track behind each observation as weights when calculating mean density. With 1000 such bootstrap replicates for each stratum, we can calculate 1000 bootstrap estimates of mean acoustic density, weighted by the stratum areas. Bootstrapped mean acoustic density is the mean of these 1000 bootstrap estimates, and confidence limits can be obtained as quantiles of that distribution.

Figure 1 shows the results of this exercise with the data from the 2007 survey. Mean acoustic density over the survey area is 729 m^2/nm^2, with 95% confidence interval being 553…845 m^2/nm^2. Relative to the mean, the approximate 95% confidence limits are –20%...+22%, and 50% confidence limits are –7.6%...+7.2%. This suggests that we might as well have estimated the blue whiting biomass to be one million tons more or less, and even errors in the magnitude of 2 million tons are not too unlikely. The origin of this high uncertainty is the fact that the majority of blue whiting are observed in very small areas. A single stretch of cruise track with the school shown in Figure 7 in the main text contributes 13% to the total cumulative acoustic density (Figure 2) and about 4.3% to estimated mean acoustic density; the difference mostly originates from the fact that this observation represents only 2 nm stretch of cruise track. This observation gave acoustic density at 140 000 m^2/nm^2, which has to be compared against the stratum level means shown in Figure 5 in the main text. In other words, if we did not happen to cover this particular school, the stock estimate would have been significantly less than currently estimated.

For 2006 the situation is much less extreme (Figure 1), as no single observation is as influential as in 2007 (Figure 2); the highest observation makes 2.7% of the cumulative sum. The approximate 95% confidence limits relative to the mean are –10%...+11%, and 50% confidence limits are –3.8%...+3.6%. Year 2005 is an intermediate case, with the approximate 95% confidence limits being –13%...+16%, and 50% confidence limits –5.8%...+5.5%. The highest observation makes 5.7% of the cumulative sum in 2005. Results from 2004 are almost as precise as those from 2006, and the approximate 95% confidence limits are –11%...+13%, and 50% confidence limits –4.1%...+3.7%. The highest observation makes 4.5% of the cumulative sum in 2004.

Figure 3 summarizes these results and puts them in the biomass context. Acoustic uncertainty was relative stable in 2004–2006, but exploded in 2007. This is caused by a few very high density estimates: in 2007, three highest values account for more than 20% of total cumulative acoustic density, while in other years the cumulative distribution is initially much less steep.

The practical consequence of these results is that we cannot say with any confidence that stock size has increased from 2006 to 2007, despite the best estimates reported on page 6 suggesting a modest increase of about 8%. Indeed, we cannot say that the estimate is different from the estimates in any of the years before.

Sensitivity of results to few observations is unavoidable when observing a spatially highly heterogeneous stock. The best way to combat this is to maintain sufficiently high sampling effort, in particular in areas where dense aggregations can be expected.

References:

Heino, M. 2004: Norwegian acoustic surveys on blue whiting spawning stock. In: *Improvement of instrumental methods for stock assessment of marine organisms. Proceedings of the Russian-Norwegian Workshop on Hydroacoustics, 11-14 November 2003, Murmansk, Russia* (ed. Chernook, V.), pp. 76-83. PINRO Press, Murmansk.

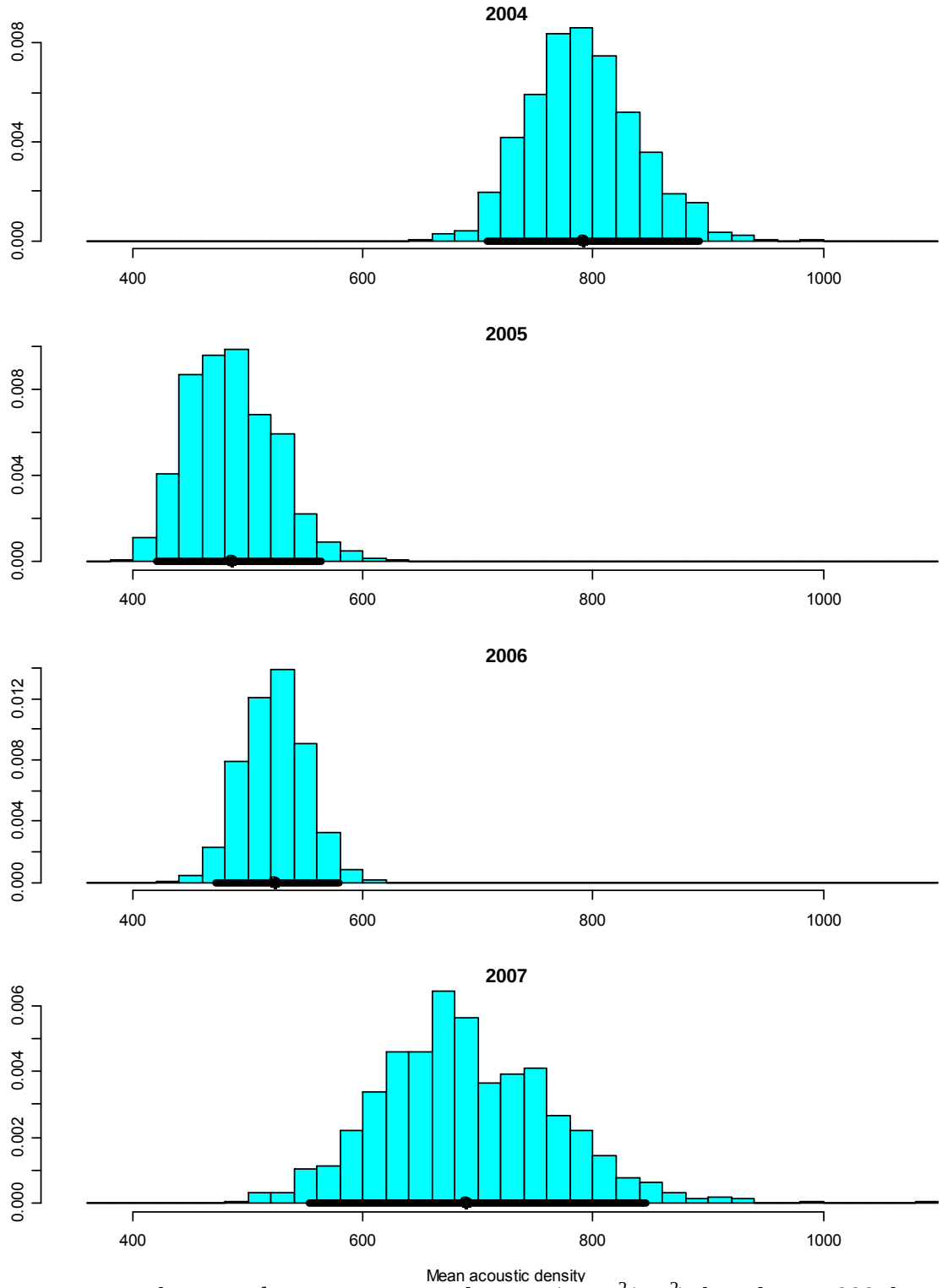


Figure 1. Distribution of mean acoustic density (in m^2/nm^2) based on 1000 bootstrap replicates of acoustic data from blue whiting surveys. Mean acoustic density is indicated with a black dot on the x-axis, while the horizontal bar shows 95% confidence limits.

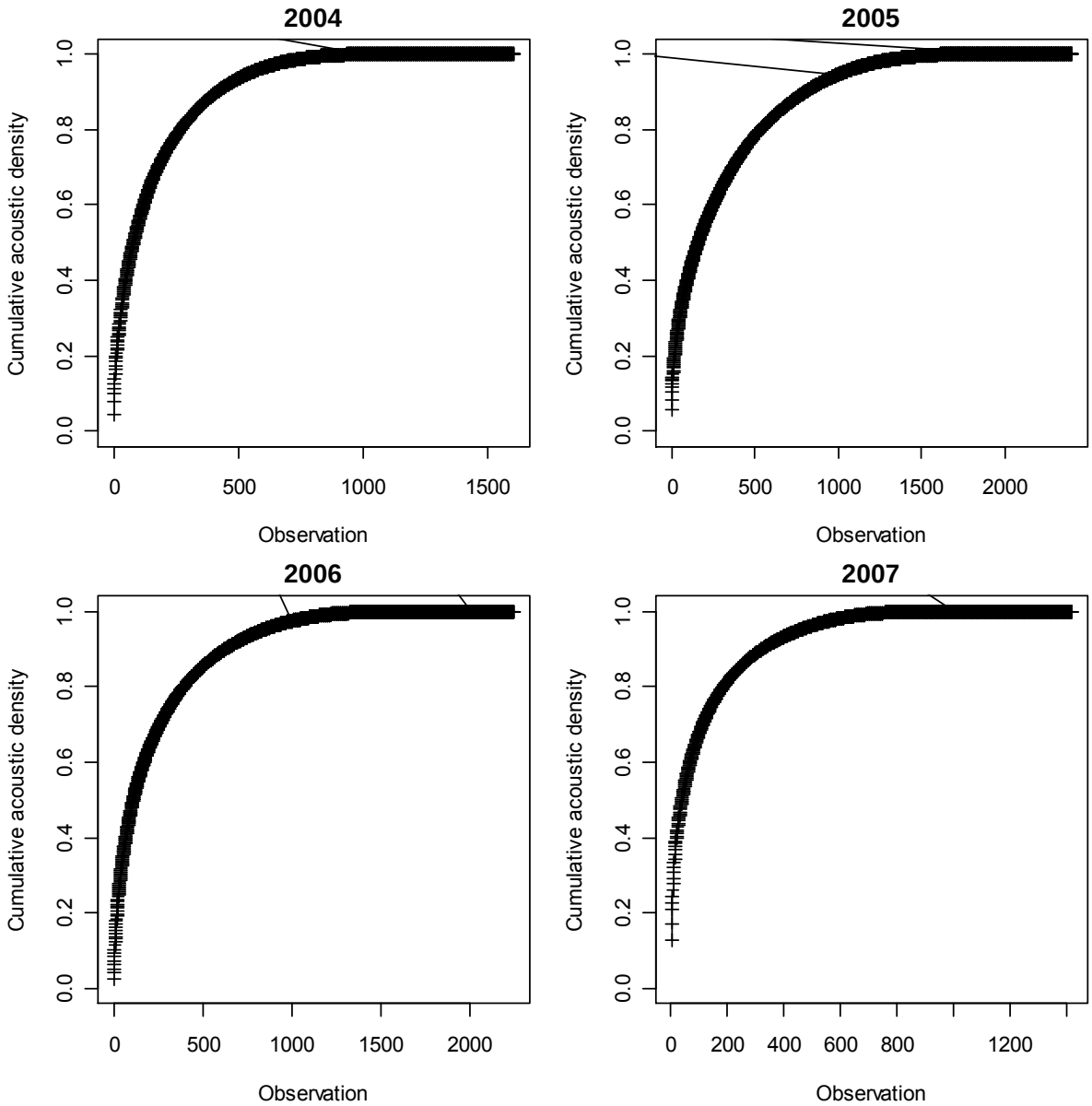


Figure 2. Normalized cumulative distribution of acoustic values sorted in decreasing order. Initial steepness of these curves indicates how influential single observations are. Notice that in these graphs, variation in length of survey track behind each observation is not considered, nor is the stratification of the survey area.

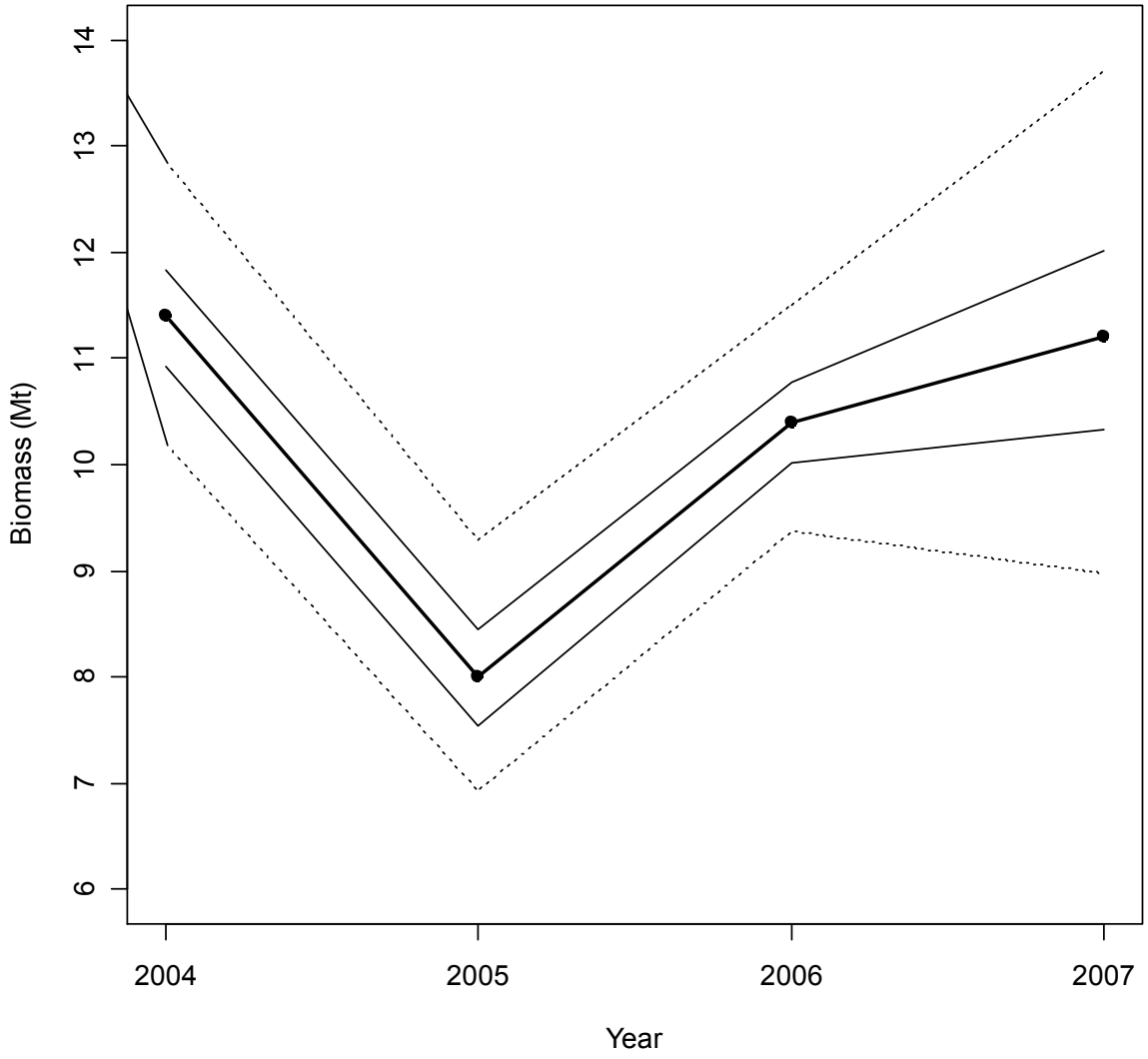


Figure 3. Approximate 50% and 95% confidence limits for blue whiting biomass estimates. The confidence limits are based on the assumption that confidence limits for annual estimates of mean acoustic density can be translated to confidence limits of biomass estimates by expressing them as relative deviations from the mean values. These confidence limits only account for spatio-temporal variability in acoustic observations.

Annex 3: International survey in the Nordic Seas report

International survey in the Nordic Seas report.

Working Document

Planning Group on Northeast Atlantic Pelagic Ecosystem Surveys
IJmuiden, the Netherlands, 14–17 August 2007

The Northern Pelagic and Blue Whiting Fisheries Working Group
Vigo, Spain, 27 August – 1 September 2007

International ecosystem survey in the Nordic Seas 2007

Introduction

In May-June 2007, six research vessels; R/V Dana, Denmark (joined survey by Denmark, Germany, Ireland, The Netherlands, Sweden and UK), R/V Magnus Heinason, Faroe Islands, R/V Arni Friðriksson, Island, R/V G.O. Sars and R/V Håkon Mosby, Norway and R/V Smolensk, Russia participated in the International ecosystem survey in the Nordic Seas (Fig. 1). The survey area was split into three Subareas: Area I (Barents Sea), Area II (northern and central Norwegian Sea), and Area III (south-western area, i.e. Faroese and Icelandic zones and south-western part of the Norwegian Sea). Håkon Mosby only carried out plankton and hydrography sampling. The aim of the survey was to cover the whole distribution area of the Norwegian Spring Spawning herring with the objective of estimating the total biomass of the herring stock, in addition to collect data on plankton and hydrographical conditions in the area. The survey has been conducted as an international survey since 2004. This report is based on national survey reports from each survey (Dana: DFH 2007, Magnus Heinason: Jacobsen et al. 2007, Arni Friðriksson: MRI 2007, G.O. Sars and Håkon Mosby, Smolensk).

Material and methods

Coordination of the survey was initiated at 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 2006 (ICES 2006/RMC:08), and continued by correspondence until the start of the survey. The participating vessels together with their effective survey periods are listed in the table below:

Vessel	Institute	Survey period
Dana	Danish Institute for Fisheries Research, Denmark	2/5-31/5
Håkon Mosby	Institute of Marine Research, Bergen, Norway	21/4-21/5
G. O. Sars	Institute of Marine Research, Bergen, Norway	27/4-31/5
Smolensk	PINRO, Russia	29/5-9/6
Magnus Heinason	Faroese Fisheries Laboratory, Faroe Islands	4/5-16/5
Arni Friðriksson	Marine Research Institute, Island	3/5-30/5

Fig. 2 shows the cruise tracks and the CTD stations and Fig. 3 the cruise tracks and the trawl stations. Survey effort by each vessel is detailed in Table 1. Frequent contacts were maintained between the vessels during the course of the survey, primarily through electronic mail.

Periods of bad weather hampered 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 the survey. Salient acoustic settings are summarized in the text table below.

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

	Dana	G. O. Sars	Arni Friðriksson	Magnus Heinason	Smolensk
Echo sounder	Simrad EK 60	Simrad EK 60	Simrad EK 60	Simrad EK 500	ER 60
Frequency (kHz)	**38**, 18, 120	**38**, 18, 120, 200	**38**, 18, 120	**38**	**38**
Primary transducer	ES38BP	ES 38B - Serial	ES38B	ES38B	ES38B
Transducer installation	Towed body, hull	Drop keel	Drop keel	Hull	Hull
Transducer depth (m)	3 (when hull 6)	8.7	8	3	5
Upper integration limit (m)	5	15	15	7	10
Absorption coeff. (dB/km)		9.6	10	10	10
Pulse length (ms)	Medium	1.024	1.024	Medium	Medium
Band width (kHz)	Wide	2.425	2.425	Wide	Wide
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)	-20.5	-20.6	-20.9	-20.9	-20.9
Sv Transducer gain (dB)				27.22	27.3
Ts Transducer gain (dB)		27.64	24.64	27.4	27.64
s_A correction (dB)		-0.73	-0.84	None	
3 dB beam width (dg)					
alongship:	6.8	6.9	7.31	7.05	6.9
athw. ship:	6.86	6.8	6.95	6.83	6.8
Maximum range (m)	750	750	750	750	750
Post processing software	Simrad BI500	Sonardata Echoview	Simrad BI500	Sonardata Echoview 4.1	BI 60

Post-processing software and procedures differed among the vessels. On the Dana during the first half of the survey data was scrutinized regularly during the survey using Simrad BI500 software. At the beginning of the second half of the survey, 18th May, the BI500 broke down and the database structure was damaged. Data for the remaining part of the survey were stored as raw files on the EK60 system. These data were replayed to a BI500 system ashore for scrutinisation. Due to the brake down of the BI 500 system acoustic data from 68º 35N, 3º 58W until 68º 35N, 0º 41E were damaged and could not be scrutinized.

On G. O. Sars, acoustic recordings were scrutinized using the Bergen Echo Integrator (LSSS) once or twice per day. Herring and 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.

On Magnus Heinason, acoustic data were scrutinised every 24 hrs on board using Sonar data's Echoview (V 4.1) post processing software. Data were partitioned into the following categories: plankton (<200 m depth layer), mesopelagic species, herring, blue whiting and krill. Partitioning of data into the above categories was based on trawl samples.

On Arni Friðriksson acoustic scatters were recorded continuously using a Simrad EK500 echo sounder and post-processed using a BI500 integrator with a plankton sieve threshold of -70 dB. The remaining echoes were stored in their respective categories (mainly herring and blue whiting) as 1 nm averages and again averaged over every 5 nm. In order to judge the performance of the echo sounder in relation to recording herring densities, a Kaijo Denki low and high frequency sonar ran continuously throughout the survey.

On Smolensk post processing software BI60 was used as the primary post-processing tool for acoustic data. Data was partitioned into the following categories, blue whiting, herring, haddock, capelin, plankton and other species. The acoustic recordings were scrutinized once or twice 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:

	Dana	G. O. Sars	Arni Friðriksson	Magnus Heinason	Smolensk
Circumference (m)		586	640	640	
Vertical opening (m)		25-35	45-50	45-55	40-50
Mesh size in codend (mm)		22	40	40	16
Typical towing speed (kn)		3.0-4.0	3.0-4.0	3.0-4.0	3.5-4.5

Catches from trawl hauls was sorted and weighed; fish were identified to species level, when possible, and other taxa to higher taxonomic levels. Normally a sub-sample of 50-100 herring and blue whiting were sexed, aged, and measured for length and weight, and their maturity status were estimated using established methods. An additional sample of 50-250 fish was measured for length.

Acoustic estimates of herring and blue whiting abundance were obtained during the surveys. This was carried out by visual scrutiny of the echo recordings using post-processing systems. The allocation of sA-values to herring, blue whiting and other acoustic targets were based on the composition of the trawl catches and the appearance of echo recordings. To estimate the abundance, the allocated sA-values were averaged for ICES-squares (0.5° latitude by 1° longitude). For each statistical square, the unit area density of fish (? A) in number per square nautical mile (N*nm-2) was calculated using standard equations (Foote et al., 1987; Toresen et al., 1998). Traditionally the following target strength (TS) function has been used:

Blue whiting: $TS = 21.8 \log(L) - 72.8$ dB
Herring: $TS = 20.0 \log(L) - 71.9$ dB.

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 over 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 over 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.

The hydrographical results by survey are shown in Fig. 2. All vessels collected hydrographical data using a SBE 911 CTD.

Results

Hydrography
The temperature distribution in the ocean at various depths is shown in Figs 4-9.

The basic feature of the oceanographic situation in the Barents Sea in the end of May beginning of June 2007 is preservation of the increased thermal condition of waters of the basic warm currents. Thus, practically most of the southern part of the Barents Sea occupied waters with positive temperature anomalies, due to both intensive advection of warm Atlantic waters, and increased rates of spring warming. The thermal level of the Atlantic corresponds to warm years.

Temperature conditions in the surface layers in the Norwegian Sea (Fig. 4) changed from 1°? in the west and the north of the area, in a zone of influence of the East-Icelandic current and Polar front, up to 8°? in the south and the east, in waters of the Atlantic current. Waters of the Norwegian current were distributed in eastern part of the investigated area, extending from a surface down to 400 m depths with temperatures from 4 up to 8°?.

Zooplankton
Sampling intensity of plankton and spatial coverage made by the participating vessels are shown in Fig. 10. During the International ecosystem survey in the North East Atlantic in 2007 a total of 269 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 and the Norwegian vessels the samples for dry weight were size fractionated before drying. All data obtained by WP2 are presented as g dry weight m^2.

Zooplankton biomass was highest in the cold water of the East Icelandic current (Fig. 10), as is consistent with previous survey results. High biomass was observed along the Arctic front of the western Norwegian Sea, and in the Northern Norwegian Sea. Sampling stations were relatively evenly spread over the area, and increased ship time compared to previous years facilitated better coverage of most oceanographic regions. Average biomass of zooplankton in May 2007 was lower than in 2006 and in 2005, and the lowest measured since 1997 (see text table below). Recorded 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 low for the eastern region (see text table below showing average zooplankton biomass [g dry weight m^{-2}]).

YEAR	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	MEAN
Total area	8.2	13.4	10.6	14.2	11.6	13.1	12.4	9.2	9.2	8.9	8.0	10.8
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	10.3	12.3
Region E of 2°W	7.5	14.4	10.2	11.8	8.7	13.6	9	8	8.2	4.8	5.6	9.3

Norwegian Spring Spawning Herring

Herring were recorded throughout most of the surveyed area as shown in Fig. 11. Distribution was similar to that observed in 2006. In addition, in 2007 it was possible to survey the Barents Sea.

In the Barents Sea immature herring (Area I see Fig. 1) were generally distributed between longitudes 34° E and 23° E and extending about 150 nm offshore. The herring were mostly recorded as schools of varying densities, mainly in the upper 150 m layer of the water masses. In eastern part of surveyed area more small-sized and young herring dominated as compared to the western part of the Barents Sea.

Dense recordings of the herring were observed near Norwegian 12-mile zone. The length distribution is only known for the fish recorded outside the 12-mile zone. However, It may be assumed that these herring are of the same length and age classes as those recorded outside the 12-mile zone.

The herring in the Barents Sea were composed of the four year classes 2003, 2004, 2005 and 2006. Herring of the 2004-year class dominated (62 %) in this area. This indicates a strong 2004 year class. The 1 and 2 group constituted 10 and 18 percent respectively of the herring observed in the area. Others year classes were less abundant overall. Herring in the Barents Sea were estimated at 20.9 billion individuals corresponding to a biomass of 1.5 million tonnes (Table 2).

The recorded concentrations of herring in the central Norwegian Sea (Area II see Fig. 1) were limited compared to the recordings in the Barents Sea and in the south-western part (Area III see Fig. 1) of the surveyed area. The highest values were recorded at the eastern edge of the cold waters of the East Icelandic Current (Fig. 11). This southern displacement is further reflected in a more southern centre of gravity of the acoustic recordings in 2007 as compared to 2006 and 2005 (Fig. 12). It was mainly older herring that appeared in the Icelandic waters (the 1998 and 1999 year classes now at age 9 and 8), while in Faroese waters also the 2002 year class appeared in addition to the 1999 and 1998 year classes contributed equally to the biomass. Older herring from the 1991, 1992, and 1993 year classes were also observed in the south-western area.

The total number of herring recorded was 20.2 billion individuals in Area I (Barents Sea), 29.3 billion in Area II (North-east) and 19.7 billion in Area III (South-west). This corresponds to a total acoustic herring estimate for the whole area in May 2007 of 12.4 million tonnes, which was higher than the 2006 estimated biomass of 10.2 million tonnes. Details of the estimate are provided in Table 2. Age and length distributions are shown in Fig. 13 and the spatial distribution of the mean lengths is shown in Fig. 14. 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 were found to increase to the west and south (Fig. 14).

The high numbers (biomass) of the 2002-year class recorded during this years survey reconfirm that this year class is very strong and has now completed its annual migration west and south to join the adult herring in their annual migration.

Blue whiting
The total biomass of blue whiting registered during the May 2007 survey was very low, only 2.4 million tonnes (Table 3), as compared to the 2006 estimate, which was in the order of 50% greater, for the same area (ICES 2006/RMC:08). Blue whiting were distributed mainly along the shelf edges and open waters yielded little blue whiting biomass (Fig. 15). In the Norwegian Sea blue whiting extended westwards from the shelf edge to outside Northern Norway. In the south-western area blue whiting were found only along the shelf edges on the Iceland-Faroe Ridge and along the shelf south and west of Iceland (Fig 15).

In the report an estimate was made from a subset of the data. A "standard survey area" between 8°W-20°E and north of 63°N have been used as an indicator of the abundance of blue whiting in the Norwegian Sea because the spatial coverage in this are provides a coherent time series with adequate spatial coverage. This estimate is used as an abundance index in the NPBWWG. The estimate from this standard area is shown in Table 4 and Fig. 16.

The mean length of blue whiting is shown in Fig. 17. In the southern area, one year old fish dominated with up to one third in the Icelandic area, in addition to 3-6 year old fish. While in the northern area only 3-6 year olds were observed (Table 5). The number 2 year olds (2005 year-class) observed were low in the surveyed area, especially in the southern area (Table 5).

Discussion

In general the weather conditions were excellent during the survey with the exception of some short periods of bad weather in the eastern area.

Survey coverage was considered adequate and it was a huge benefit that the Barents Sea was again included in the coverage, as this allows complete spatial coverage of the whole distribution area of the Norwegian spring spawning herring.

It should be noted that the spatial survey design was not intended to cover the whole blue whiting stock during this period.

Some underestimation of herring due to vessel avoidance during the acoustic survey is likely to have occurred, mainly due to the distribution of herring in the upper surface layer above the depth of the hull mounted transducer. This was confirmed by surface trawling and sonar registrations at the surface layer. However it was not possible to quantify the significance of these observations.

Concluding remarks

- The sea-surface temperature in the Norwegian Sea should be considered as a warm year compared to previous years.
- The influence of the East Icelandic-Current appears strong in 2007, this was determined by its southerly extension this year.
- Recorded zooplankton abundance was low in 2007 (lowest on record since 1997).
- The 2004 year-class of herring was abundant in the Barents Sea.

- The southern progression of the centre of acoustic gravity has continued in 2007. The centre of gravity was distributed more to the south and west than in previous years.
- The 2002 year-class of herring seems to be strong and has joined the adult herring in the southwestern area (Area III).
- The abundance estimate of blue whiting was low in 2007 (half the amount observed in 2006).
- There were indications that the 2005 and 2006 year-classes appear weak, as the latter was only observed in the southwestern area.

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Table 1. Survey effort by vessel.

Vessel	Effective survey period	Length of cruise track (nm)	Trawl stations	CTD stations	Plankton station
Dana	6/5-27/5	4,961	35	47	47
Håkon Mosby	21/4-21/5	1500	0	101	40
G. O. Sars	27/4-31/5	5500	107	69	64
Smolensk	30/5-8/6	1751	18	18	51
Magnus Heinason	4/5-16/5	1817	12	32	32
Arni Friðriksson	3/5-27/5	4,194	42	47	35
Total	3/5-27/5	19,723	214	314	269

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Table 2: Age - and length -stratified abundance estimate of Norwegian spring-spawning herring in May-June 2007 for total area and abstracts of estimates for Subarea I, II, III and Subarea II+III combined.

Length\age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Number	Biomass	Weight
10																0		
11	199															199	1.9	9
12	1114															1114	12.9	12
13	587															587	7.9	14
14	158															158	2.9	18
15		291														291	6.8	23
16		1471														1471	40.6	28
17		918														918	28.6	31
18		760	63													823	29.5	36
19		137	0													137	5.8	42
20		404	0													404	22.2	55
21		139	762													901	54.3	60
22			1855													1855	130	70
23			5792	18												5810	469.6	81
24			4465	68												4533	412.1	91
25			1350	205												1555	167.6	108
26			665	1022	19											1706	212.5	125
27			365	1915	246											2526	352	139
28			71	1714	632	18										2435	380.6	156
29			47	1397	2579	15	15									4053	705.4	174
30				1101	5625	129	34	83								6972	1347.7	193
31				329	7927	315	151	240	76							9038	1889.9	209
32				0	2700	449	535	843	400				13			4940	1163.1	235
33				12	456	266	668	2124	1416	34	22	0	0	0	0	4998	1300.2	260
34					92	68	502	2407	1958	126	52	0	26	35	17	5283	1489	282
35					0	0	61	678	927	139	123	53	71	79	131	2262	689.8	307
36					16	0	26	405	792	348	246	272	195	732	651	3683	1229.8	337
37									0	0	35	47	59	171	146	458	162.6	354
38									10	0	10	0	39	31	57	147	53.8	384
39									3						3	6	2.1	321
40															5	5	2.6	452
N mill.	2058	4120	15435	7781	20292	1260	1992	6780	5582	647	488	372	403	1048	1010	69268	12372	

Total herring area

Biomass 10^3 t	25.5	139.6	1349.2	1202.8	4115.7	291.3	511.5	1845.8	1596.2	203.3	156	123.7	133.1	355.4	324.3		**12,372**	
Numbers '000	2058	4120	15435	7781	20292	1260	1992	6780	5582	647	488	372	403	1048	1010	**69,268**		
Length cm	12.8	17.7	24	28.5	31	32.3	33.3	34	34.5	35.7	36	36.5	36.4	36.6	37	Mean length		28.8
Weight g	12	34	87	155	203	231	257	272	286	314	319	333	330	339	321	Mean weight		179

Estimates by sub area I - III

Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+			
Herring area I (Barents Sea)																		
Biomass 10^3 t	25.5	116.8	1045.6	287.1													**1,475**	
Numbers '000	2058	3709	12546	1904												**20,217**		
Length cm	12.8	17.4	23.8	28.6												Mean length		21.9
Weight g	12	32	83	151												Mean weight		73
Herring area II (north-east)																		
Biomass 10^3 t		22.8	297.2	881.4	3052.3	151.4	178	503.5	277.9	39.7	25.6	16.3	19.4	4.9	17.8		**5,488**	
Numbers '000		411	2855	5697	15463	682	743	1972	1067	144	85	51	59	16	57	**29,302**		
Length cm		20.4	24.9	28.4	30.9	32.2	33.1	33.8	34.1	34.9	36.3	37.2	37.4	36.5	36.5	Mean length		30.2
Weight g		56	104	155	197	222	239	255	261	276	306	322	330	308	315	Mean weight		187
Herring area III (south-west)																		
Biomass 10^3 t			6.4	34.4	1063.4	139.9	333.5	1342.3	1318.4	163.6	130.4	107.3	113.7	350.5	324.3		**5,410**	
Numbers '000			34	180	4829	578	1249	4808	4515	503	403	321	344	1032	953	**19,749**		
Length cm			29.1	29.6	31.3	32.3	33.5	34.1	34.6	36	36	36.4	36.2	36.6	37	Mean length		33.8
Weight g			183	190	220	242	267	279	292	325	324	335	331	340	340	Mean weight		275
Herring area II and II combined (Norwegian Sea)																		
Biomass 10^3 t	0	23	304	916	4116	291	512	1846	1596	203	156	124	133	355	342		**10,916**	
Numbers '000		411	2889	5877	20292	1260	1992	6780	5582	647	488	372	403	1048	1010	**49,051**		
Length cm		20.4	24.8	28.4	31	32.3	33.3	34	34.5	35.8	36	36.4	36.3	36.6	37	Mean length		31.6
Weight g		56	103	156	202	230	255	272	284	316	320	332	329	335	338	Mean weight		222

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Table 3: Blue whiting total survey area. Age- and length-stratified abundance estimate of blue whiting in the North-east Atlantic Ecosystem Survey in May–June 2007, 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", "Smolensk" "Håkon Mosby" and "G. O. Sars".

LENGTH (CM)	1	2	3	4	5	6	7	8	9	10	11	12+	NUMBER	BIOMASS	WEIGHT
15	4												4	0	22
16	11												11	0	26
17	25												25	1	29
18	101												101	3	33
19	261												261	10	39
20	449												449	21	46
21	505	41											546	29	53
22	305	182	60										547	33	61
23	112	289	602	77									1080	76	71
24	33	127	1514	302	102	15							2093	167	80
25	13	22	2907	986	237	44							4209	379	90
26	15	0	2213	1564	297	63	31						4183	418	100
27			893	1865	568	118	23	6	6				3479	388	112
28			68	1542	721	119	23	17	0				2490	302	121
29			19	543	911	132	29	14	0				1648	223	135
30				121	645	154	35	0	0				955	143	149
31				43	207	240	38	0	5				533	86	161
32					49	176	78	0	12				315	56	176
33					11	97	82	0	19				209	41	195
34						28	16	7	0				51	11	221
35							0	21	10				31	8	236
36							0	2	0				2	0	215
37							7	1	0				8	3	318
38									14				14	4	307
39										7			7	2	329
40										0			0	0	
41										0			0	0	333
42										7			7	2	337
Number 10^6	1834	661	8276	7043	3748	1186	362	68	66	14	0	0	23258	2405	
Biomass 10^3t	94.3	45.5	758.8	764.8	474.7	176.7	60.4	12.1	14	4.4	0.1			2405.7	
Length cm	21.1	23.4	25.7	27.3	28.7	30.3	31.3	31.8	34	41	41.5			26.6	
Weight g	51.2	68.8	91.7	108.6	126.6	148.7	167.1	178.4	213.2	333	333			103.4	

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Table 4: Blue whiting "Standard area", i.e. the area between 8°W–20°E and north of 63°N, used as an biomass index of blue whiting in the NPBWWG. Age- and length-stratified abundance estimate of blue whiting in the North-east Atlantic Ecosystem Survey in May–June 2007. 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", "Smolensk" "Håkon Mosby" and "G. O. Sars".

LENGTH (CM)	1	2	3	4	5	6	7	8	9	10	11	12+	NUMBER	BIOMASS	WEIGHT
16	1	0	0	0	0	0	0	0	0	0	0	0	1	0	23
17	2	0	0	0	0	0	0	0	0	0	0	0	2	0	28
18	4	0	0	0	0	0	0	0	0	0	0	0	4	0.1	33
19	11	0	0	0	0	0	0	0	0	0	0	0	11	0.4	34
20	3	0	0	0	0	0	0	0	0	0	0	0	3	0.1	42
21	0	30	0	0	0	0	0	0	0	0	0	0	30	1.4	47
22	0	150	60	0	0	0	0	0	0	0	0	0	210	12.8	61
23	0	289	577	77	0	0	0	0	0	0	0	0	943	66.9	71
24	0	61	1437	303	91	15	0	0	0	0	0	0	1907	152.7	80
25	0	22	2248	857	211	45	0	0	0	0	0	0	3383	306.6	91
26	0	0	1123	1044	253	63	16	0	0	0	0	0	2499	255.5	102
27	0	0	338	796	338	80	23	6	6	0	0	0	1587	185.4	117
28	0	0	58	429	330	87	23	17	0	0	0	0	944	123.7	131
29	0	0	5	133	270	93	29	15	0	0	0	0	545	79.6	146
30	0	0	0	0	127	64	23	0	0	2	0	0	214	33.8	159
31	0	0	0	0	54	70	22	0	5	0	0	0	151	26.4	175
32	0	0	0	0	0	6	22	0	0	0	0	8	28	5.4	191
33	0	0	0	0	0	8	17	0	8	0	0	0	33	6.9	205
34	0	0	0	0	0	0	3	8	0	0	0	0	11	2.3	215
35	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	249
36	0	0	0	0	0	0	0	2	0	0	0	0	2	0.4	215
37	0	0	0	0	0	0	0	1	0	0	0	0	1	0.2	270
Number 10^6	21	552	5846	3639	1674	531	178	49	19	0	0	0	12509	1261	
Biomass 10^3t	0.7	37.9	526.1	382.6	204.1	71.2	27.4	7.5	3.3	0	0	0		1261	
Length cm	19.1	23.3	25.4	26.6	27.8	28.7	30.1	30.2	31.2	.	.	.		26.2	
Weight g	33.9	68.8	90	105.2	121.8	134.1	153.9	153.7	170.9	.	.	.		101	

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Table 5: Age-stratified abundance estimate of blue whiting in the North-east Atlantic Ecosystem Survey in May–June 2007 for the subareas shown in Fig. 1. 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", "Smolensk" "Håkon Mosby" and "G. O. Sars".

AGE	1	2	3	4	5	6	7	8	9	10	11	12+	TOTAL
Area I: Barents Sea (no estimate in 2007)													
Number 10^6													
Biomass 10^3 t													
Length cm													
Weight g													
Area II: central Norwegian Sea													
Number 10^6	8	550	5832	3611	1647	514	167	47	18	0	0	0	12394
Biomass 10^3 t	0.3	37.8	524.6	379.3	200	68.8	25.2	7.2	3.1	0	0	0	1246.3
Length cm	19.7	23.3	25.4	26.6	27.8	28.6	29.9	30.1	31.1				26.2
Weight g	35.3	68.8	90	105.1	121.5	133.4	151.9	152.7	169.2				100.6
Area III: SW Norwegian Sea and the Icelandic and Faroese EEZs													
Number 10^6	1826	111	2444	3433	2101	672	195	21	47	14	0	0	10864
Biomass 10^3 t	94	7.6	234.2	385.5	274.7	107.9	35.2	4.9	10.9	4.4	0	0	1159.4
Length cm	21.1	23.6	26.4	28	29.4	31.5	32.5	35.5	35.1	41			27
Weight g	51.3	68.9	95.8	112.3	130.7	160.5	180	236.2	230	333			107
All areas combined													
Number 10^6	1834	661	8276	7043	3748	1186	362	68	66	14	0	0	23258
Biomass 10^3 t	94.3	45.5	758.8	764.8	474.7	176.7	60.4	12.1	14	4.4	0	0	6167
Length cm	21.1	23.4	25.7	27.3	28.7	30.3	31.3	31.8	34	41			24.8
Weight g	51.2	68.8	91.7	108.6	126.6	148.7	167.1	178.4	213.2	333			84.1
"Standard" area													
Number 10^6	21	552	5846	3639	1674	531	178	49	19	0	0	0	12509
Biomass 10^3 t	0.7	37.9	526.1	382.6	204.1	71.2	27.4	7.5	3.3	0	0	0	1261
Length cm	19.1	23.3	25.4	26.6	27.8	28.7	30.1	30.2	31.2				26.2
Weight g	33.9	68.8	90	105.2	121.8	134.1	153.9	153.7	170.9				101

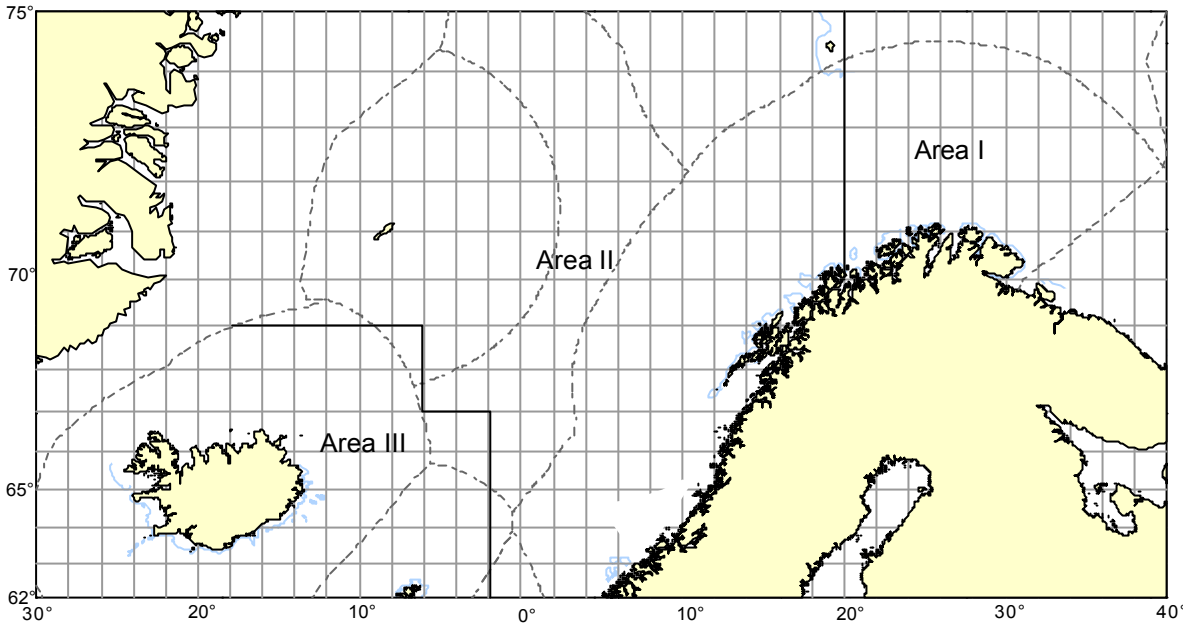

Figure 1. Areas defined for acoustic estimation of blue whiting and Norwegian spring spawning herring in the Nordic Seas.

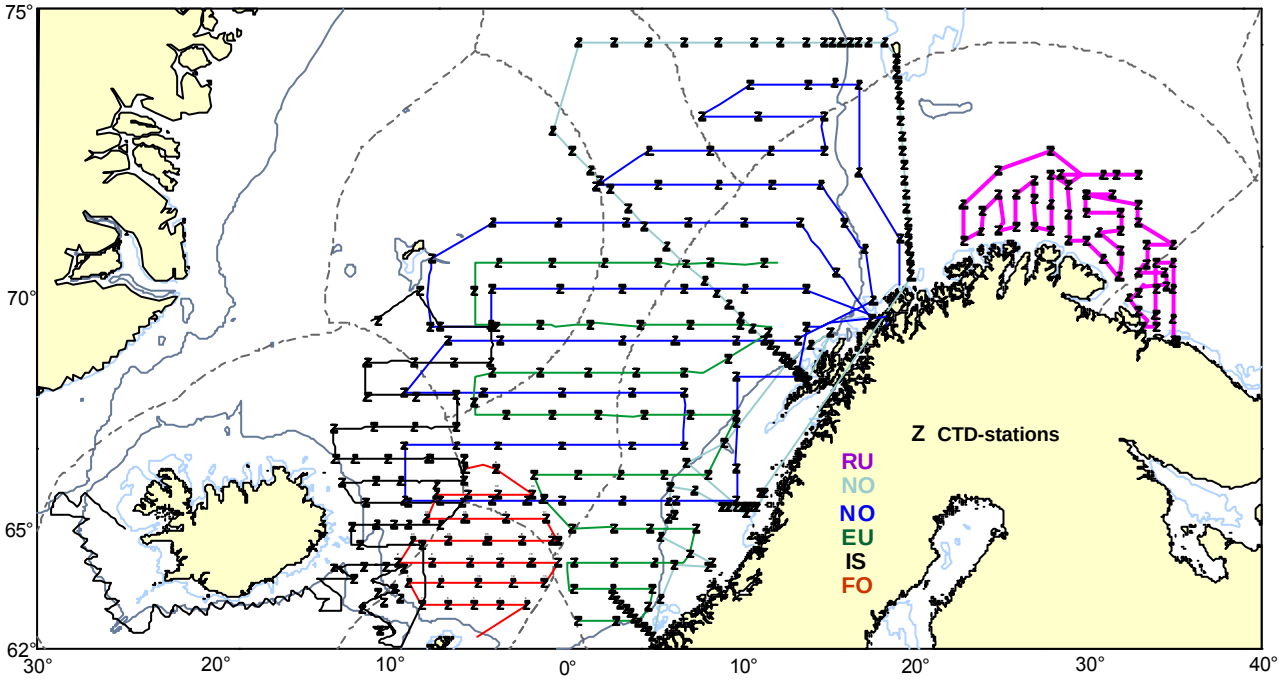

Figure 2. Cruise track and CTD stations by country for the International ecosystem survey in the Nordic Seas in May-June 2007.

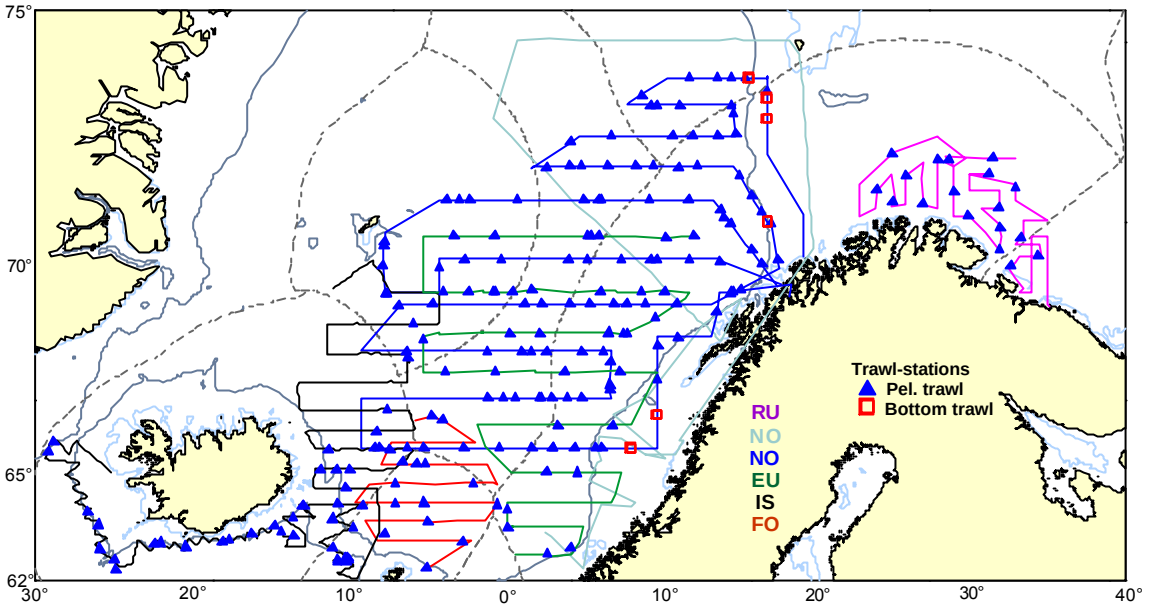

Figure 3. Cruise tracks during the International North East Atlantic Ecosystem Survey in April-May 2007 and location of trawl stations.

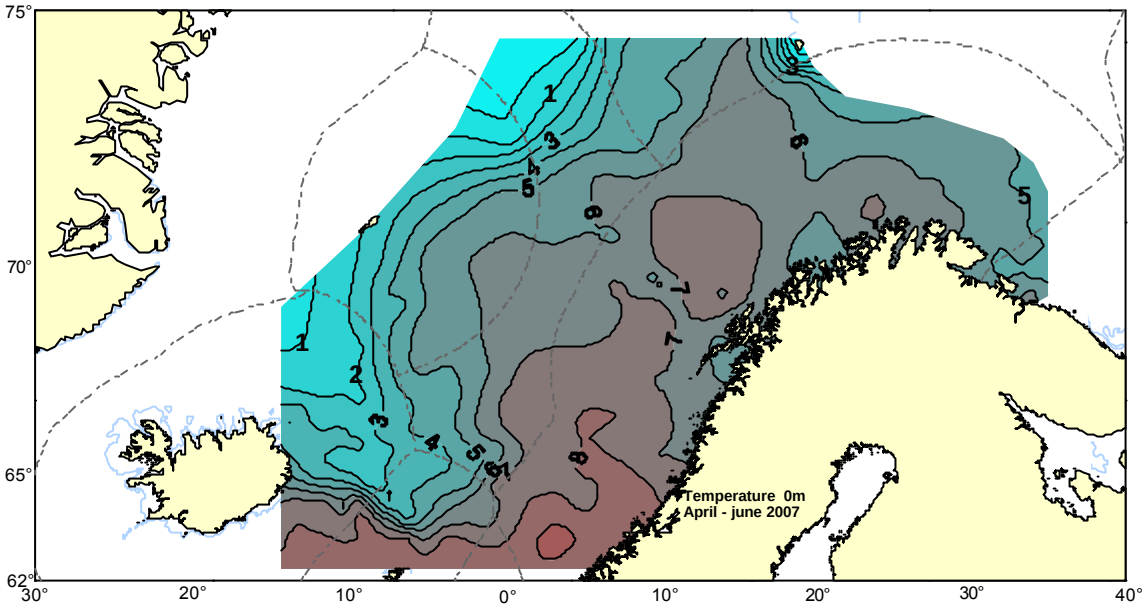

Figure 4. Temperature at the surface in May 2007.

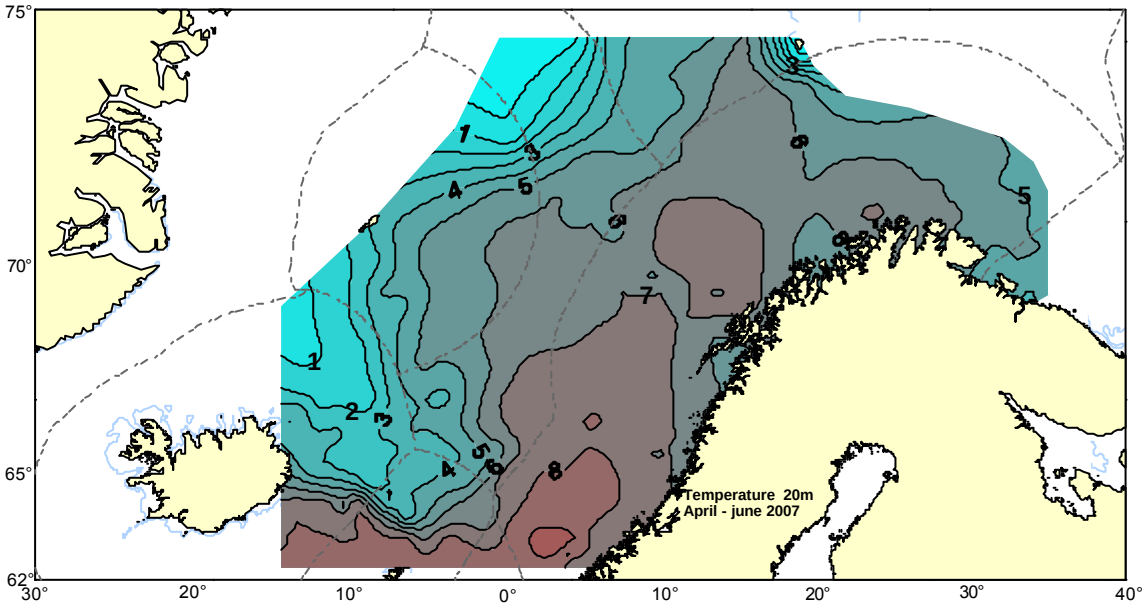

Figure 5. Temperature at 20 m depth in May 2007.

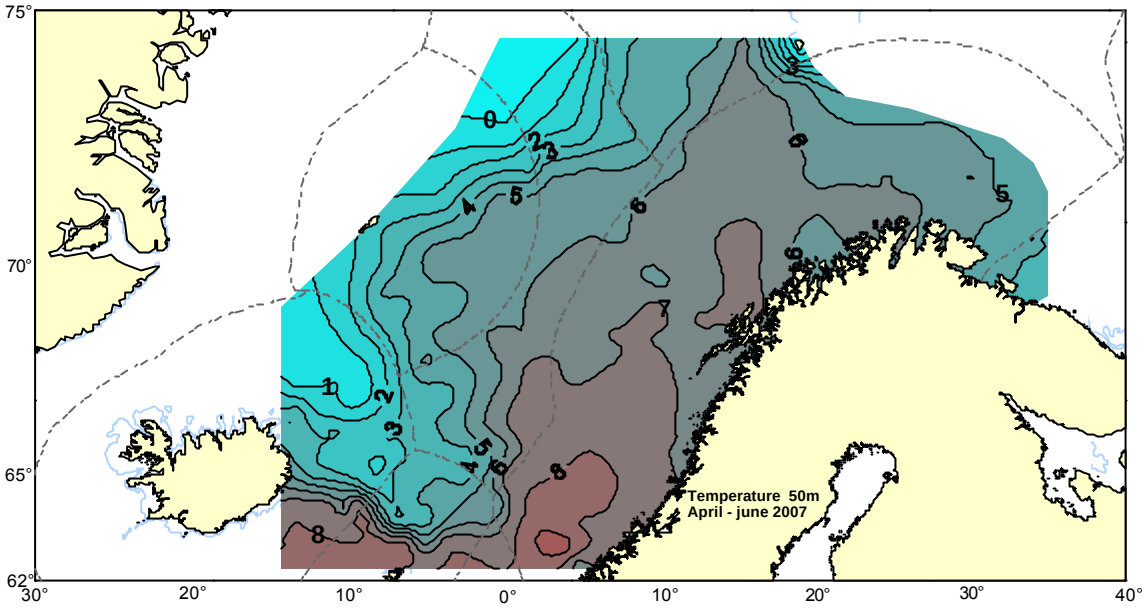

Figure 6. Temperature at 50 m depth in May 2007.

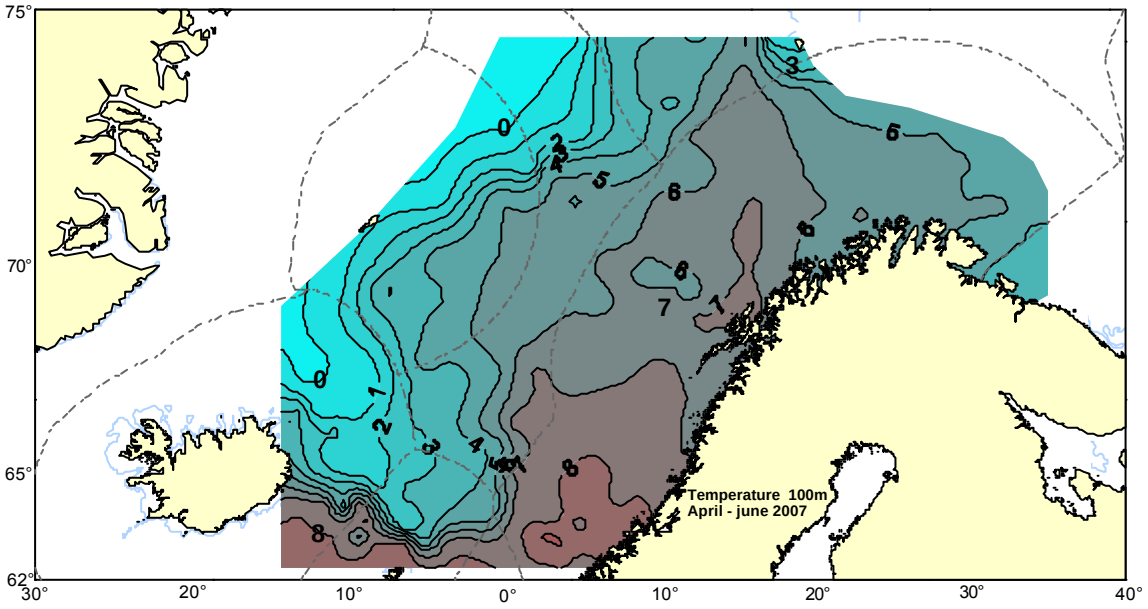

Figure 7. Temperature at 100 m depth in May 2007.

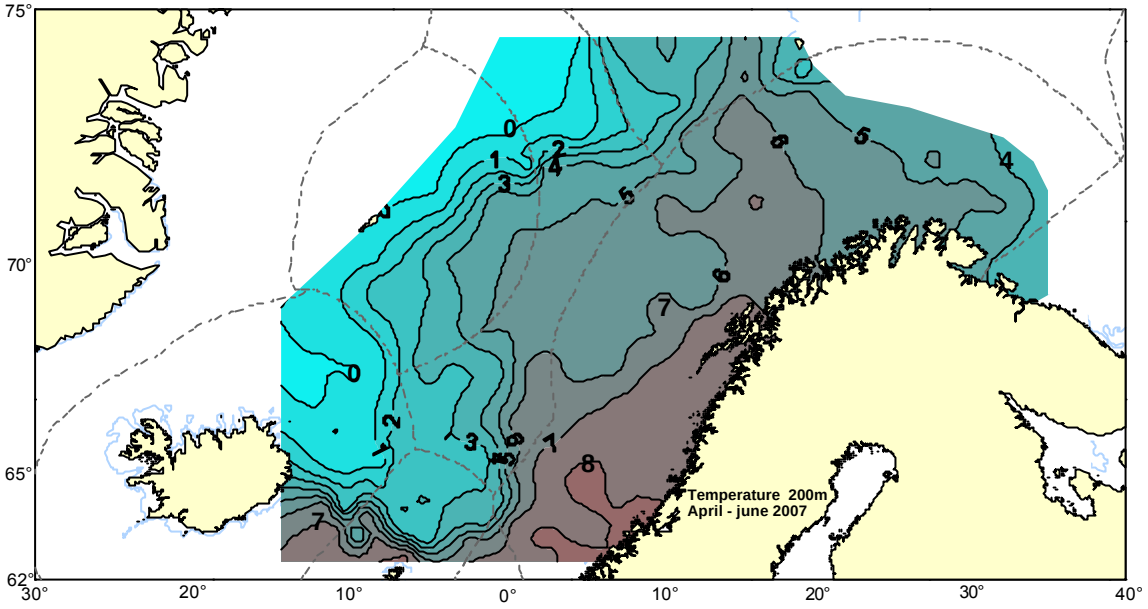

Figure 8. Temperature at 200 m depth in May 2007.

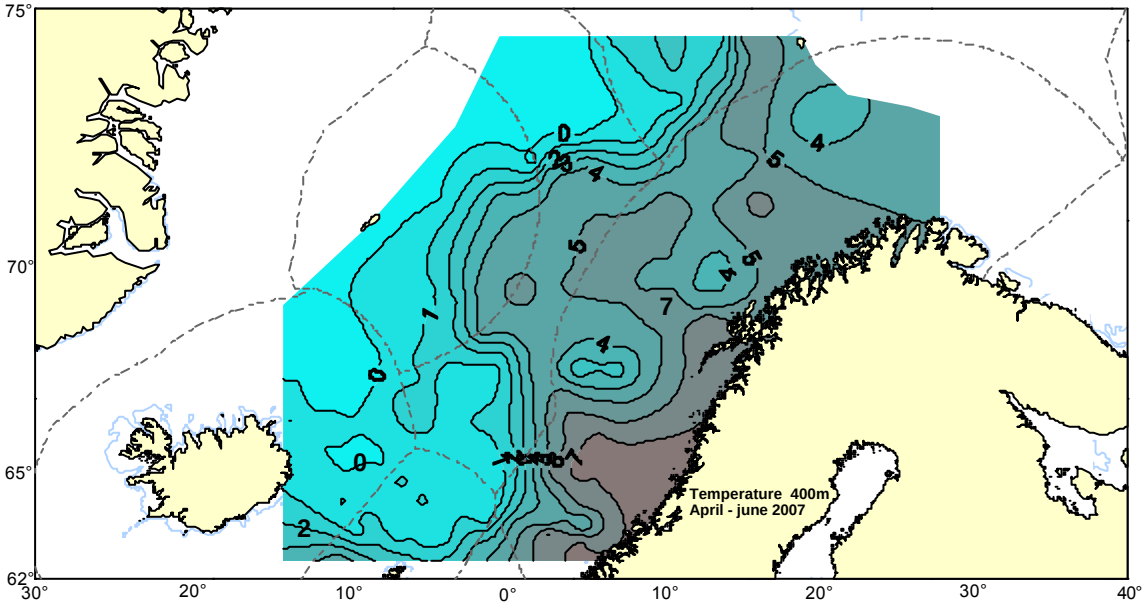

Figure 9. Temperature at 400 m depth in May 2007.

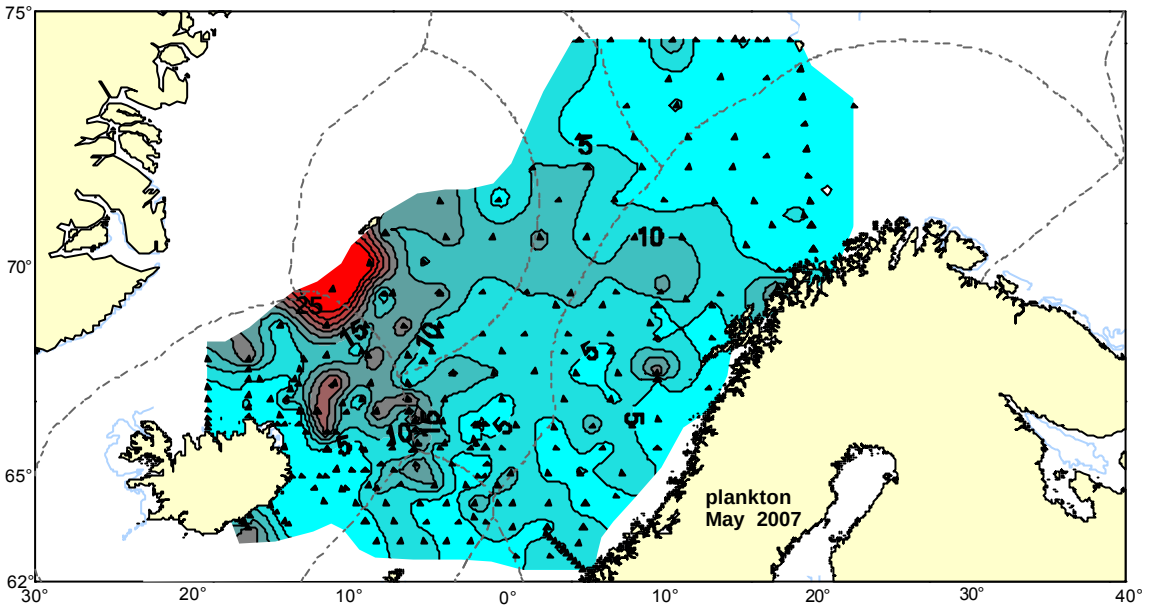

Figure 10. Zooplankton biomass (g dw m^{-2}) (200–0 m) (50–0 m in Icelandic standard sections) in May 2007.

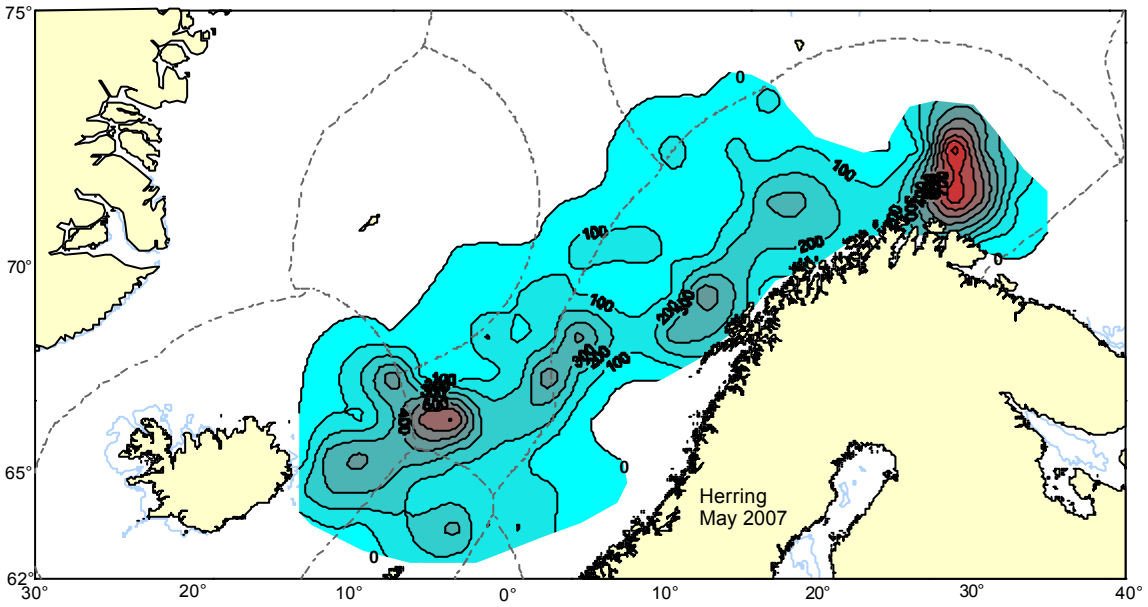

Figure 11. Distribution of Norwegian spring spawning herring as measured during the International survey in April-June 2007 in terms of s_A-values (m^2/nm^2) based on combined 5 nm values.

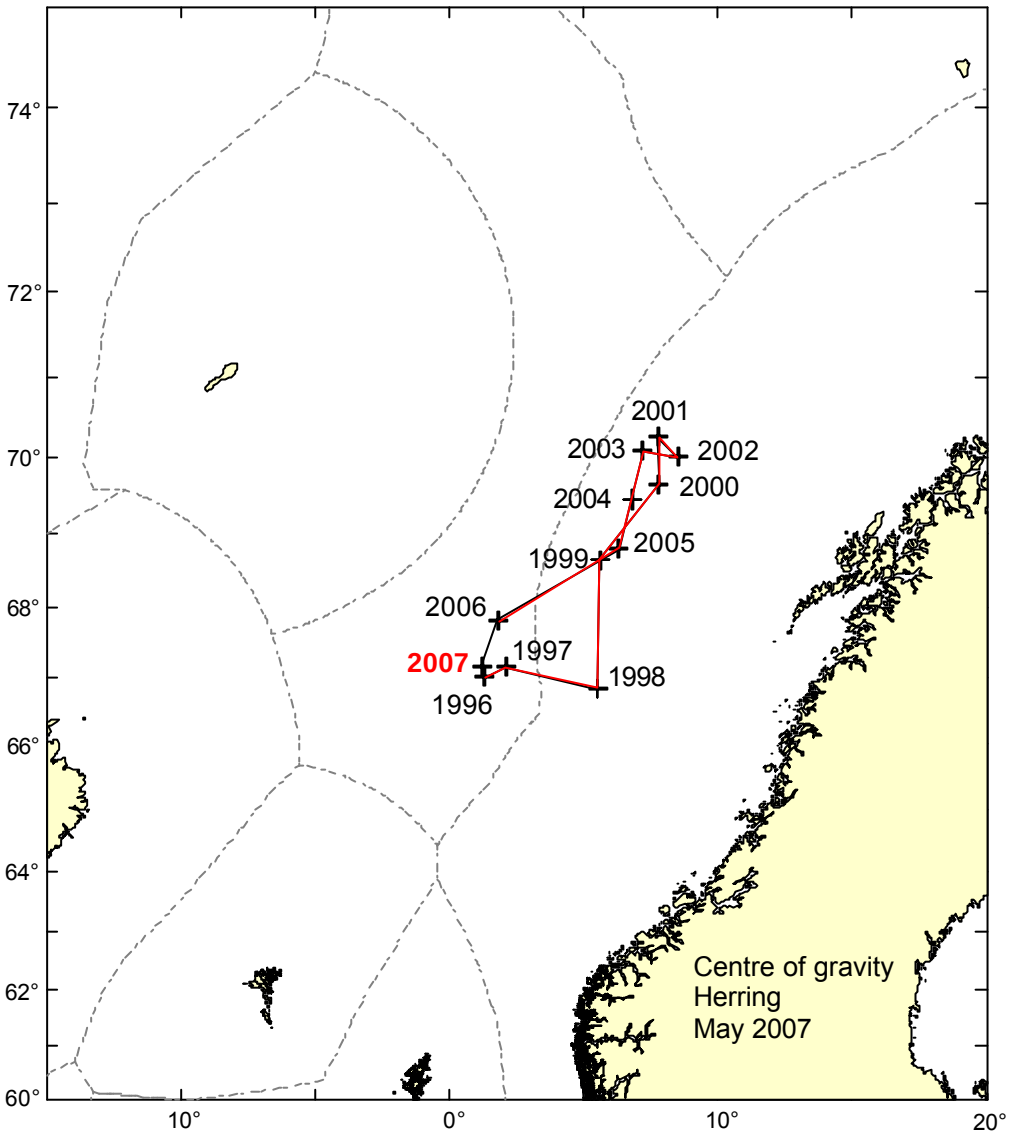

Figure 12. Centre of gravity of herring during the period 1996–2007 derived from acoustic (refer to Fig. 11). Acoustic data from Area II and III only, i.e. west of 20 E.

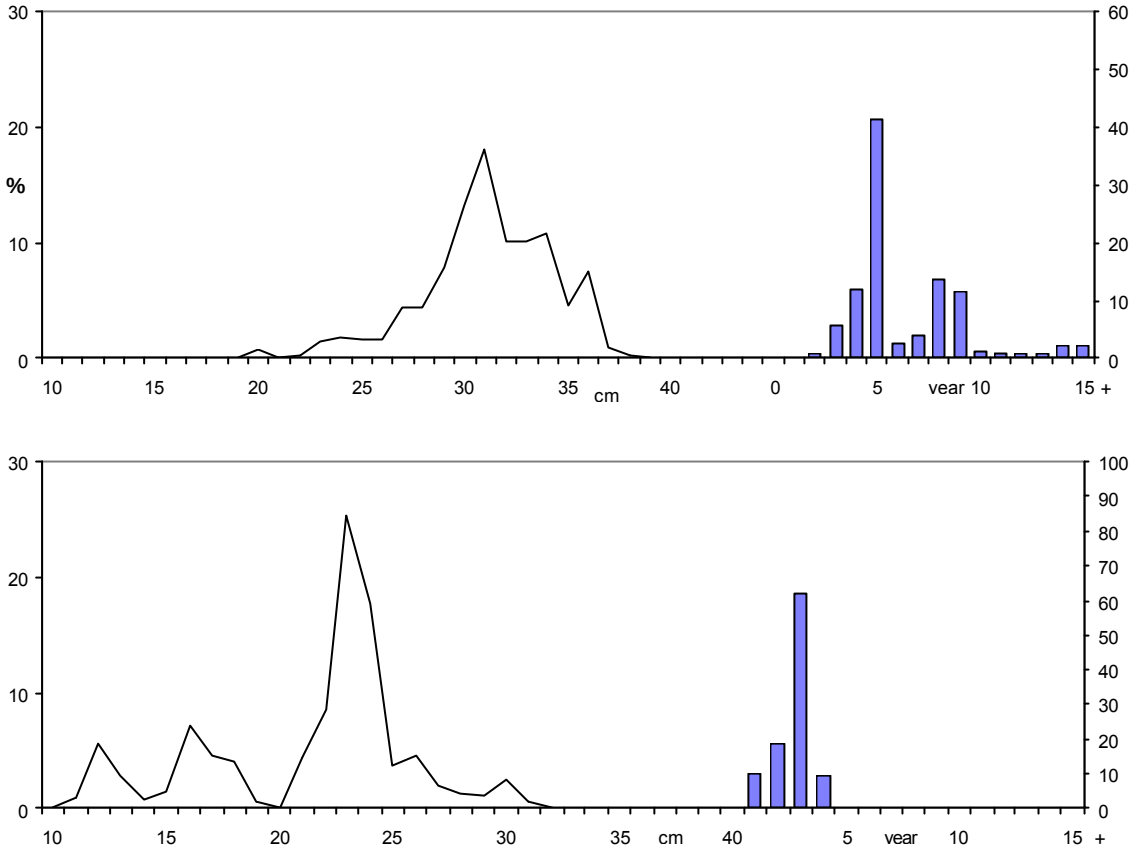

Figure 13. Length and age distribution of Norwegian spring spawning herring in May 2007 in the Norwegian Sea (upper panel, Area II and III) and the Barents Sea (lower panel, Area I).

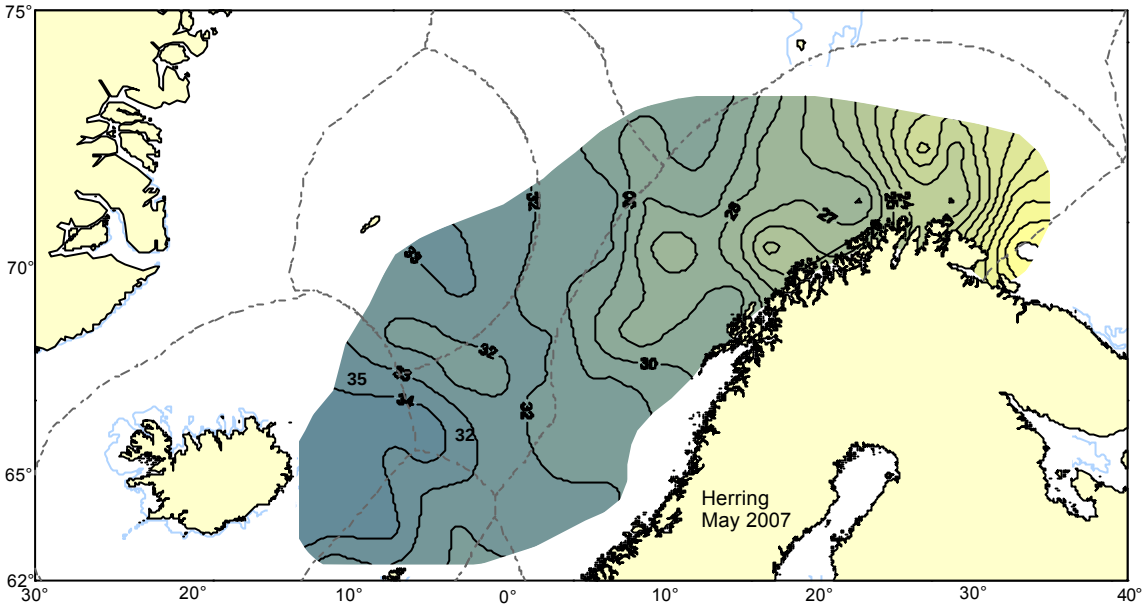

Figure 14. Mean lengths by area of Norwegian spring spawning herring derived from trawl samples in April-June 2007.

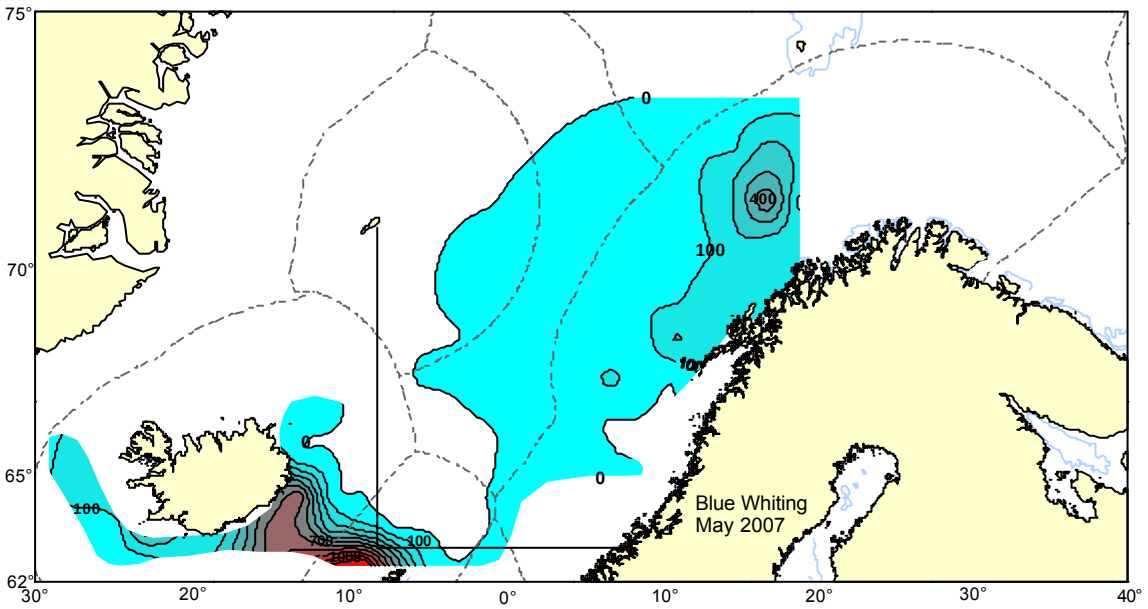

Figure 15. Distribution of blue whiting as measured during the International survey in April-June 2007 in terms of s_A-values (m^2/nm^2) based on combined 5 nm values. The standard area used in assessment (NPBWWG) is shown on the map.

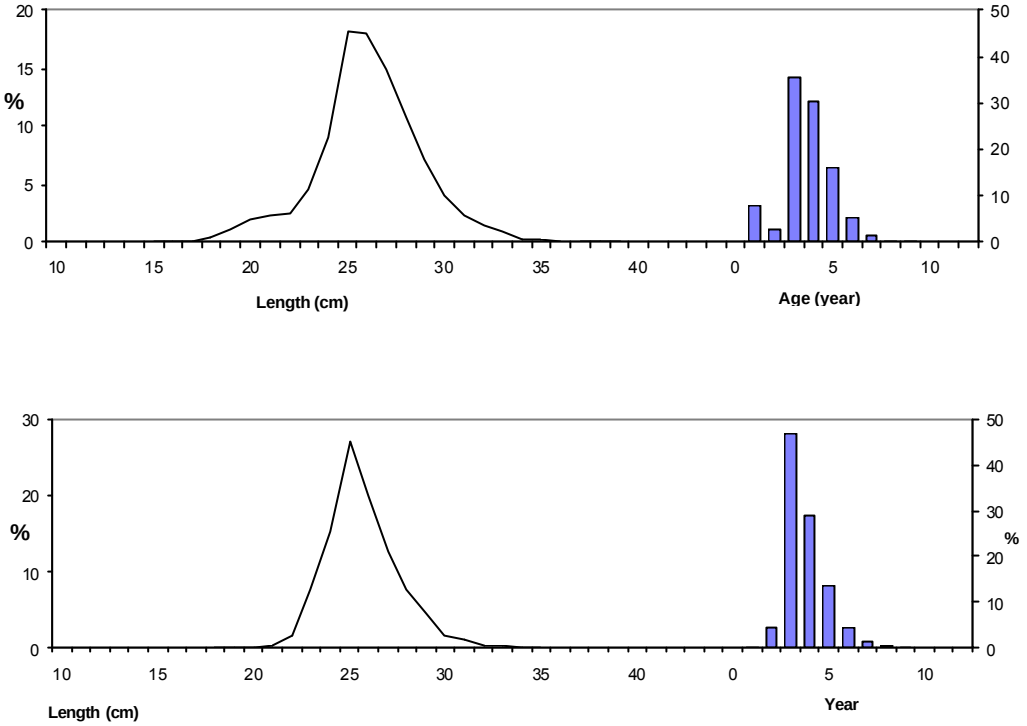

Figure 16. Estimated length and age distributions of blue whiting in the North-east Atlantic Ecosystem Survey in May–June 2007. The upper panel is based on the total survey area as shown in Figure 15; the lower panel is based on the "standard survey area" between 8°W-20°E and north of 63°N.

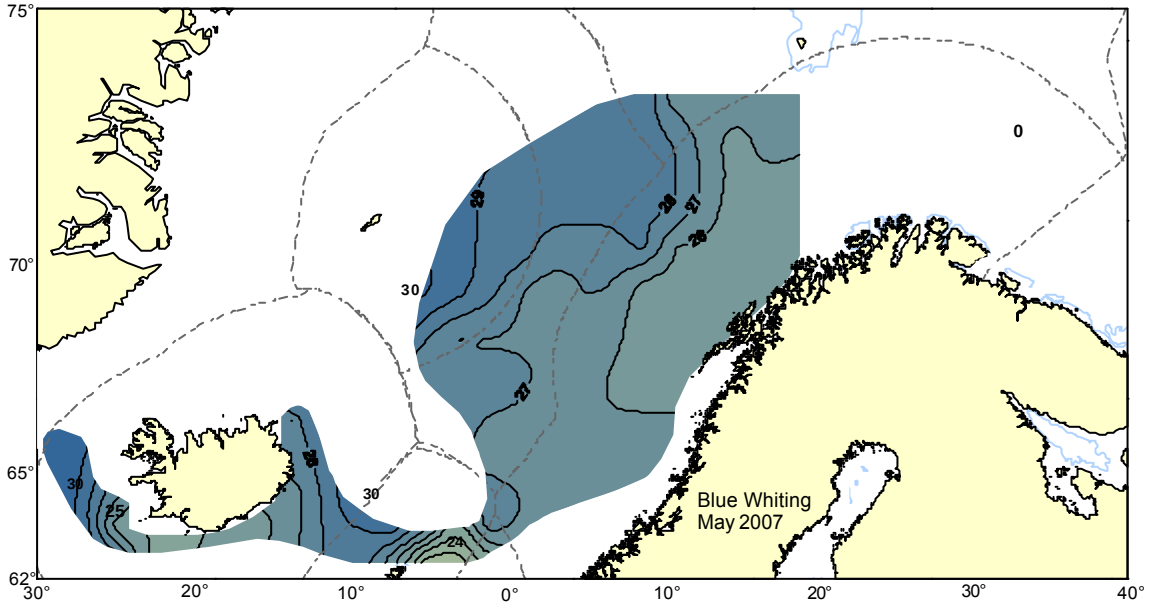

Figure 17. Mean length (cm) of blue whiting recorded in the North-east Atlantic Ecosystem Survey in May–June 2007

Annex 4: PGNAPES ToRs for 2008

The **Planning Group on Northeast Atlantic Pelagic Ecosystem Surveys** [PGNAPES] (Chair: Alexander Krysov, Russian Federation) will meet in Hirtshals, Denmark, from XX–XX August 2008 to:

a) critically evaluate the surveys carried out in 2008 in respect of their utility as indicators of trends in the stocks, both in terms of stock migrations and accuracy of stock estimates in relation to the stock – environment interactions;

b) review the 2008 survey data and provide the following data for the Northern Pelagic and Blue Whiting Working Group:

  i) stock indices of blue whiting and Norwegian spring-spawning herring.

  ii) zooplankton biomass for making short-term projection of herring growth.

  iii) hydrographic and zooplankton conditions for ecological considerations.

  iv) aerial distribution of such pelagic species as mackerel.

c) describe the migration pattern of the Norwegian spring-spawning herring and blue whiting stocks in 2008 on the basis of biological and environmental data;

d) plan and coordinate the surveys on the pelagic resources and the environment in the North-East Atlantic in 2009 including the following:

  i) the international acoustic survey covering the main spawning grounds of blue whiting in March-April 2009.

  ii) the international coordinated survey on Norwegian spring-spawning herring, blue whiting and environmental data in May-June 2009.

  iii) national investigations on pelagic fish and the environment in June-August 2009.

PGNAPES will report by XX September 2008 for the attention of the Resource Management and the Living Resource Committees, as well as ACFM and ACE.

Supporting Information

PRIORITY:	The coordination of the surveys has strongly enhanced the possibility to assess abundance and provide essential input to the assessment process of two of the main pelagic species in the Northeast Atlantic and describes their general biology and behaviour in relation to the physical and biological environment.
SCIENTIFIC JUSTIFICATION AND RELATION TO ACTION PLAN:	The Planning Group is a potential meeting place for inter-disciplinary discussion and considerations on ecosystem approach to management of fisheries. **ToR a)** Two international and some national surveys with coordinated by PGNAPES. The Planning Group describes the procedures for acoustic, hydrographic, plankton, and fish sampling to be used during the surveys. **ToR b)** The abundance indexes estimates of Norwegian Spring Spawning Herring and Blue Whiting produced from surveys are used in ICES Northern Pelagic and Blue Whiting Fishery Working Group (NPBWWG) in assessment. The collection of environmental data improves the basis for ecosystem modelling of the Northeast Atlantic. **ToR c)** The Planning Group describes the migrations of the stocks and consider possible stock – environment interactions. **ToR d)** The Planning Group contributes significantly to improving abundance surveys essential for fish stock assessment of herring and blue whiting and improving the collection of data for ecosystem modelling of the Northeast Atlantic. The Planning Group will identify existing procedures to ensure that the sampling gear and any instrumentation used to monitor its performance are constructed, maintained and used in a consistent and standardized manner. Where necessary, procedures and protocols should be established for intercalibration to take into account platform and sampling tools-survey gear differences. In general, the remit of this group addresses Action Numbers 1.2.2, 1.3 and

	1.11.
RESOURCE REQUIREMENTS :	None
PARTICIPANTS :	15
SECRETARIAT FACILITIES:	Standard report production.
FINANCIAL:	None
LINKAGES TO ADVISORY COMMITTEES:	ACFM, ACE
LINKAGES TO OTHER COMMITTEES OR GROUPS:	WGNPBW, WGMHSA and SGBYSAL
LINKAGES TO OTHER ORGANISATIONS:	None