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

19–22 August 2008

Hirsthals, Denmark

ICES International Council for the Exploration of the Sea

CIEM Conseil International pour l'Exploration de la Mer

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## Contents

## Executive Summary

This present report was prepared by the Planning Group on Northeast Atlantic Pelagic Ecosystem Surveys (PGNAPES) in Hirtshals, Denmark, from 19–22 August 2008 and contains the results of the acoustic, hydrographic, plankton and fish sampling from two international ICES coordinated survey in 2008. The **International blue whiting spawning stock survey** on the spawning grounds west of the British Isles in March-April 2008 with participation of Dutch, Irish Norway, Faroes, and Russia, 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 2008 with participation of Denmark (EU coordinated), Faroes, Iceland; Russia and Norway. In addition the scientific study of mackerel was performed in the Norwegian Sea in the July-August with the chartered commercial vessels. 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 2008. The abundance estimates are used in the fish stock assessment of Norwegian spring-spawning herring and blue whiting in ICES Working Group on Widely distributed Stocks (WGWIDE). The collection of environmental data further improves the basis for ecosystem modelling of the Northeast Atlantic. Broad plans for the ICES coordinated surveys for 2009 are also outlined with descriptions of the relevant protocols, preliminary participants and suggested survey designs.

# 1 Introduction

## 1.1 Terms of Reference 2008

The **Planning Group on Northeast Atlantic Pelagic Ecosystem Surveys** [PGNAPES] (Chair: A. I. Krysov, Russian Federation) will meet in Hirtshals, the Denmark, from 19–22 August 2008 to:

**2007/2/RMC05** The **Planning Group on Northeast Atlantic Pelagic Ecosystem Surveys** [PGNAPES] (Chair: Alexander Krysov, Russian Federation) will meet in Hirtshals, Denmark, from 19–22 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.

e ) plan, and as relevant coordinate, surveys in the Northern Norwegian Sea to observe abundance and distribution of pelagic redfish.

PGNAPES will report by 1 September 2008 for the attention of the Resource Management the Living Resource Committees and ACOM.

## 1.2 List of participants

| | |
|---|---|
| Alexander Krysov (Chair), | Russia |
| Karl-Joahn Staehr | Denmark |
| Jan Arge Jacobsen, | Faroe Islands |
| Leon Smith, | Faroe Islands |
| Høgni Debes | Faroe Islands |
| Guðmundur Oskarsson | Iceland |
| Ciaran O'Donnell, | Ireland |
| Sytse Ybema | Netherlands |

| | |
|---|---|
| Matthias Kloppmann | Germany |
| Are Salthaug, | Norway |
| Erling Stenevik | Norway |
| Øyvind Tangen, | Norway |
| Webjørn Melle | Norway |
| Jens Cristian Holst | Norway |

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 continued in 2004 through 2006, and especially in 2007 the fishery has continued in the southwestern 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 four 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 which 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 the spawning location and oceanographic conditions. The northward drift spreads the major part of the 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 food 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 other pelagic fish stocks in the Norwegian Sea. Additionally, in 2005 the joint survey on blue whiting in 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 in 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 currently going on. ICES recommends that a coordinated survey be organized covering the main spawning grounds of blue whiting.

In 2008 a series of surveys were carried out by vessels from Denmark, Faroe Islands, Iceland, Norway, Ireland, the Netherlands, and Russia, coordinated by the PGNAPES. In contradiction to previous years the survey did not cover the western part of the Barents Sea (18° E – 30° E) and so excluded a potential important habitat of the Norwegian spring-spawning herring and blue whiting. In addition the Norwegian Sea was covered only partly during July and August 2008 for the purpose of mackerel investigations. The international surveys were grouped into the two main areas covered in 2008:

a ) in 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** (IBSS, 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** (IESNS, 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.

The main objectives of these surveys are 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 in the blue whiting spawning grounds and in the Norwegian Sea and adjacent waters and describe how migration of blue whiting, herring and other pelagic fish are influenced by this. The results are presented for the different periods and areas in the same sequence as indicated above.

In addition the Norwegian Sea was covered during June-August 2008 on a national basis:

# 2 Material and methods

PGNAPES plans to carry out two international surveys and in addition results from a number of additional surveys are reported. Technical details of all participating vessels are given in the survey report as annex to this report.

***International Blue whiting spawning stock survey***. Five vessels participated, the Dutch RV "Tridens", the Irish RV "Celtic Explorer", the Russian RV "Fridtjof Nansen", the Faroese RV "Magnus Heinason" and the Norwegian F/V "Gardar" Annex 2 Table 1. The surveyed area (cruise tracks) in March-April 2008 is shown in Annex 2 Figure 1. More details are given in the combined cruise report (Annex 2).

***International ecosystem survey in the Nordic Seas.*** Six vessels participated, the Danish RV "Dana", the Norwegian RVs "G.O. Sars" and "Nibo", the Icelandic RV "Árni Fridriksson", the Faroese RV "Magnus Heinason" and the Russian RV "Fridtjof Nansen". The surveyed area (cruise tracks) in May–June 2008 is shown in Figures 1 and 2. Map showing area I to III used in the acoustic estimate of herring and blue whiting is shown in Figure 3.

#### Other relevant surveys

In addition to the surveys that are dealt with by PGNAPES, national surveys on mackerel are also carried out. Information from some of these surveys has been reported to the group.

## 2.1 Hydrography

The hydrographic observations were made using CTD-Probes. Details of the hydrographic sampling intensity during the ***International ecosystem survey in the Nordic Seas*** are given in this report and ***International Blue whiting spawning stock survey*** are given in the combined survey report in Annex 2.

## 2.2 Plankton

Sampling intensity of plankton and spatial coverage made by the participating vessels are shown in Figure 3.2.1.2. During the International ecosystem survey in the North East Atlantic in 2008 a total of 252 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 $m^{-2}$. Some Icelandic net hauls on standard sections were taken from 50 m depth to the surface. Biomass on these stations were multiplied by 1.98 based on a regression analysis of biomass on stations with hauls to from both 50 and 200 m. Russian vessel used Djedy net. 62 plankton stations were conducted. The data also are presented as g dry weight $m^{-2}$.

## 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. In most cases fishing was carried out on fish traces identified on the echosounders. 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 but small trawls such as used on board DANA in previous years prove to have a much lower catch efficiency at depth. The trawls could also be 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. The codends used varied among vessels which may be of influence when collecting herring scales or taking into account deep-sea species in the future.

Each trawl catch was sorted and weighed 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 30–150 specimens of herring and blue whiting were taken for further biological analyses. Standardisation is required here. 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. In the North Sea age reading is done by taking otoliths whereas scales are taken in the Nordic Seas. In an attempt to compare these two methods 100 herring from the Nordic Seas were aged by taking both otoliths and scales. Results are documented in a working document circulated to the group.

## 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 backscattering 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 estimates 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, Arni Fridriksson], 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-rectangles (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 rectangle, the unit area density of fish ($\rho_A$) 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 rectangle and then summed for all the statistical rectangles 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 2008. Five vessels participated in the survey: RV "Fridtjof Nansen", RV "Celtic Explorer", FV "Gardar", RV "Magnus Heinason" and RV "Tridens". This represents the fifth international survey in the current time-series. The results from the international blue whiting spawning stock survey have been described in detail in the joint cruise report (O'Donnell *et al.*, 2008) reproduced as Annex 2 in this report, as well as in national reports from individual vessels (Celtic Explorer: O'Donnell *et al.*, 2008; Gardar: Salthaug *et al.*, 2008; Magnus Heinason: Jacobsen *et al.*, 2008, Tridens: Ybema *et al.*, 2008, Fridtjof Nansen: Oganin *et al.*, 2008).

### 3.1.1 Hydrography

CTD stations are shown in Figure 2 of Annex 2 for all vessels. Unfortunately, again in 2008 as in 2007 there was not sufficient interest to analyse the hydrographic data.

### 3.1.2 Blue whiting

Blue whiting were recorded all areas surveyed relating to a combined coverage of 127 thousand square nautical miles (Figures 4–6 in Annex 2). The highest concentrations were recorded in the area between the Hebrides, Rockall and Faroe Banks and this is consistent with the results from previous surveys. Schools with the greatest recorded density were observed by the Magnus Heinason to the north of the Rosemary Bank in the Hebrides subarea (Figure 7, Annex 2) but overall less variability in school density was detected this year compared to 2007. 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 7.9 million tonnes and $67 \times 10^9$ individuals, relating to a decrease of 29% in observed total-stock biomass and a decrease in total stock numbers of 34% when compared to 2007 results.

The age-disaggregated total stock estimate is presented in Table 4 of Annex 2, showing that the stock is now dominated by blue whiting of 5–4 years in age (2003–2004 year classes respectively). These age classes made up 52% of spawning-stock biomass. Over 98% of the recorded total-stock biomass was represented by mature blue whiting.

Mean age (5.1 years), length (28.5 cm) and weight (117 g) are the highest on record in the international survey time-series (2004–2008) bolstered by the 5–4 year old individuals. Numbers of older blue whiting, ages 6 to 8 years, are the highest on record tracking the progression of high recruitment years through the stock. Recruitment to the spawning stock remains low with no signals of improvement in the short term.

The survey time-series from the International spawning stock survey is presented in Table 3.1.1. Indicative confidence limits presented by Mikko Heino, and used as a measure of uncertainty in the estimate, are only known for total biomass estimates (see Figure 2 of Annex 4 in Annex 2 of this report), results suggest that changes in total stock from 2006-2007 and 2008 is more than could be expected from uncertainty arising from spatial heterogeneity. Within the considered domain of uncertainty, the decline is statistically significant.

## 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 2008 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 3): Area I (Barents Sea), Area II (northern and central Norwegian Sea), and Area III (southwestern area, i.e. Faroese and Icelandic zones and southwestern 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", Iceland, RV "G.O. Sars" and RV "Nybo", Norway and RV "Fridjof Nansen", Russia. The high vessels effort in this survey with such a broad international participation allowed for broad spatial coverage as well as a relatively dense net of trawl stations (Figure 1 and 2) and CTD stations (Figure 3.2.1.2). As the Russian vessel could not enter the Norwegian EEC due to missing permissions from Russian authorities the area from about 20 degrees east and eastwards to the disputed area in the Barents Sea was not covered. This means that there is a discontinuity in the data in the Barents Sea and the Russian survey will be reported separately, as opposed to last year when all surveys were combined.

The results of the surveys are described in this report and there is no separate survey report this year. The reason for this was several problems with getting the data available before the PGSPFN meeting and thus time constraints in writing both a separate survey report and this report.

In general the weather conditions were good during the entire survey.

### 3.2.1 Hydrography

In winter 2008 the NAO index was larger than the long-term average (see Figure 3.2.1.1) and was close to the value in 2007. Hence, there were stronger southwesterlies in winter 2008 than normal.

CTD stations are shown in Figure 3.2.1.2. Figure 3.2.1.3 shows the temperature and salinity together with anomalies in the Svinøy section for 23-25 May. The influence of the EIC is seen in the intermediate layer lying under the Atlantic layer. The intermediate water is of Arctic origin and is characterized by salinities below 34.90 and temperatures between -0.5°C and 0.5°C. In 2008 the surface temperatures in the AW were higher than compared to the long-term mean. Subsurface both temperature and salinity were lower than normal in the west indicating a stronger influence of Arctic water in the west. In the middle of the section the water was warmer and saltier than the means partly due to a deeper Atlantic layer there compared to the long-term-mean.

Figures 3.2.1.4-3.2.1.9 shows the horizontal temperature distributions at surface, 20, 50, 100, 200 and 400 m depth in May/June 2008. The distribution of the waters carried into the Norwegian Sea by the EIC is clearly indicated at all depths. A body of relatively cold and fresh water extends eastward from the Iceland Sea. Arctic waters are separated from Atlantic by the Arctic Front, which is indicated by closely spaced isotherms. The temperature distribution in 2008 looks in general similar as in 2007 (comparing Figures 3.2.1.4–3.2.1.9 with Figures 4–9 from 2007 report). Some differences are however observed at deeper depths. Below the upper layer (from 100 m and below) the water in the southern part is colder in 2008 than compared to 2007. At some location the differences can be 1°C (for instance at 200 m, 65°N). This difference can be explained by increased intrusion of Arctic water there. In the Lofoten Basin lower temperature at 400 m depth in 2008 compared to 2007 is also seen where the difference can be close to 1°C. The conditions can also be compared with an average from 1995 to 2006 (figures not shown). At the deeper depths (for instance 200 m and 400m) the western parts of the Norwegian Sea seems to be colder than the average while near the Norwegian coast it is warmer than the average. At the surface the temperature in 2008 was warmer than the average for most of the Norwegian Sea (figures not shown).

### 3.2.2 Zooplankton

Zooplankton biomass was highest in the cold water of the East Icelandic current (Figure 3.2.2.1), as is consistent with previous survey results. Higher biomass was observed in the waters dominated by the East Icelandic current of the western Norwegian Sea. Higher concentrations along the Arctic front further north was not obvious as opposed to earlier years. Increased biomass of zooplankton was observed in the Northeastern Norwegian Sea, compared to 2007. Sampling stations were relatively evenly spread over the area. Average biomass of zooplankton in May 2008 was lower than in 2006 and 2007, and the lowest measured since 1997 (Table 3.2.2.1). Recorded zooplankton biomass in the two areas west and east of 2°W was lower than the mean for the time-series in both areas (see text table below showing average zooplankton biomass [g dry weight $m^{-2}$]). Increased biomass was observed in the eastern region, while biomass in the western region decreased abruptly from 2007 to 2008. The biomass in the western region was much lower than any previous recordings.

In the Barents Sea highest zooplankton biomass were observed in eastern part survey area (Figure 3.2.2.2). Average biomass was higher than 2007 but lover then 2005.

### 3.2.3 Norwegian spring-spawning herring

Survey coverage in the Norwegian Sea was considered adequate in 2008. There was a gap in the coverage in the Barents Sea between 18°E and 30°E. Therefore, the Barents Sea results are presented separately, based only on the Russian survey, and are not considered representative since only a fraction of the herring stock in this area was covered.

Herring were recorded throughout most of the surveyed area in the Norwegian Sea as shown in Figure 3.2.3.1. Distribution was similar to that observed in 2007 with some minor differences. The highest values were like in 2007 recorded at the eastern edge of the cold waters of the East Icelandic Current (Figure 3.2.3.1) but slightly farther to the northeast compared to 2006 and 2007. Contrary to last year the recorded concentrations of herring in the central Norwegian Sea (Area II) were therefore higher compared to the recordings in the southwestern part (Area III) of the surveyed area. Still, there was a southwestern displacement reflected in a more southwestern centre of gravity of the acoustic recordings in 2008 as compared to 2007 and 2006 (Figure 3.2.3.2). It was mainly older herring that appeared in the southwestern areas (1998, 1999 and 2002 year classes now at ages 10, 9 and 6). The distribution of herring in the Barents Sea based on the Russian survey is shown in figure 3.2.3.3.

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 3.2.3.4).

The age-disaggregated total stock estimate for 2008 is presented in Table 3.2.3.1. The herring stock is now dominated by 6 year old herring (2002 year class) representing 36% in weight.

The time-series of abundance (in numbers) since 1996 is shown in Table 3.2.3.2. 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. In addition, the numbers for the 2004 year class is relatively high, indicating that this year class is relatively strong and comparable to the 1998 and 1999 year classes.

The total number of herring recorded was 908 million individuals in the partly covered Area I (Barents Sea), 30.2 billion in Area II (North-east) and 15.7 billion in Area III (South-west). This corresponds to a total acoustic herring estimate for the Norwegians Sea in the Areas II and III in May 2008 of 10.0 million tons and for the part of the Barents Sea that was covered the estimate was 49,000 tons. This biomass is lower than the estimated biomass in 2007of 12.3 million tons.

### 3.2.4 Blue whiting

The total biomass of blue whiting registered during the May 2008 survey was 1.1 million tonnes (Table 3.2.4.1), which is very low (the corresponding estimates from 2006 and 2007 were 6.2 and 2.4 mill. tonnes, respectively). The stock estimate in number for 2008 is 8.2 billion, which is about 35 % of the 2007 estimate. The reduction in estimated abundance is most severe for ages 1–3, but estimates of ages 4–5 are also significantly lower in 2008 than in previous years.

An estimate was also made from a subset of the data; A “standard survey area” between 8°W–20°E and north of 63°N (Figure 3.2.4.1) 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 WGWIDE. The age-disaggregated total stock estimate in the “standard area” is presented in Table 3.2.4.2, showing that the part of the stock in this index area is dominated by 4 year old blue whiting. Time series from the “standard survey area” is presented in Table 3.2.4.3.

Blue whiting were observed in most of the survey area with the highest concentrations northwest of the Faroes (Figure 3.2.4.1). Relative age and size distributions for the total survey area and standard survey area are shown in Figure 3.2.4.2. The mean length of blue whiting is shown in Figure 3.2.4.3. 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

### 3.3.1 Faroese survey in July in the Norwegian Sea

In early July 2008 the central part of the Norwegian Sea was surveyed by the Faroese RV “Magnus Heinason” (Jacobsen *et al.* 2008), the main aim was to investigate the distribution and stock composition of salmon post-smolts during the early part of their feeding migration in the open ocean. However, in later years the mackerel has widened its distribution in the north and northwest to cover practically the whole Norwegian Sea during it summer feeding migrations. As a result, mackerel was caught in every haul made in the area (Figure. 3.3.1), and sometime in large quantities, considering the small trawl operated (only 10 m vertical opening towed for 1–2 hours in the surface).

During calm days the mackerel could be seen "boiling" on the surface in large schools. The mean length was 32 cm and mean weight was 230 g (Figure 3.3.2). Most of the mackerel were between 2 and 4 years of age (Figure 3.3.3).

# 4 Discussion

## 4.1 Hydrography

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

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

It has been shown that atmospheric forcing largely controls the distribution of the water masses in the Nordic Seas. Hence, the lateral extent of the NWAC, and consequently the position of the Arctic Front in the Norwegian Basin, is correlated with the large-scale distribution of the atmospheric sea level pressure. This is clearly indicated for example by the correlation with the winter index of the North Atlantic Oscillation (NAO). Current measurements south in the Norwegian Sea have also shown that high NAO index gives larger Atlantic inflow, along the shelf edge, in the eastern part of the Norwegian Sea.

During winter 2008 strong westerlies (high NAO index) resulted in an increased influence of Arctic water in the southern Norwegian Sea for 2008 compared to 2007. Also compared to the average 1995–2006 an increased Arctic influence is observed, especially in the western part. After some years with large westerly extension of Atlantic water and additional warm Atlantic water in the Norwegian Sea, especially in 2003 and 2004, a temperature reduction in the western Norwegian Sea is observed the last years. This is due to a less extension of Atlantic water and the occurrence of an increased transport of Arctic water to the area. Thus, the temperature in the western Norwegian Sea in 2008 is close to and in some areas less than the 1995-2006 average. However, in the eastern part, near the Norwegian coast, the water is still warmer than the average due to that the inflow of Atlantic water through the Faroe-

Shetland Channel is warmer than normal. At the surface, the air-sea heat flux during April-June 2008 was higher than normal causing the relatively warm surface water.

## 4.2 Plankton

The average biomass in the total area has been on a decreasing trend since 2002, and reached in 2008 a record low level since the measurements started in 1997. In the region west of 2°W, zooplankton biomass usually is somewhat higher than in the region east of 2°W. However, in 2008 the average biomass was the same in both areas, primarily due to a decrease to the lowest biomass on record in the western area, but also due to a slight increase in the biomass in the eastern area. The biomass in the eastern Norwegian Sea was, however, still low compared to the long-term mean for the area, but it has been increasing somewhat since the record low level in 2006. The increase in the zooplankton biomass in the eastern area was primarily due to an increase in the northeastern area compared to 2007.

The overall distribution pattern of the zooplankton biomass in 2008 resembles largely the distribution during previous years with the highest biomass in the cold water of the EIC. However, further north along the Arctic front the biomass was markedly lower in 2008 compared to previous years and especially compared to 2007.

Average biomass in the Barents Sea was higher than in 2007 but lower than 2005.

## 4.3 Norwegian spring-spawning herring

Similarly to the previous four years, it was decided not to draw up a suggested herring migration pattern for 2008 due to lack of data. However, the general migration pattern is believed to resemble that of 2003 with the exception that the herring as in the previous years had a somewhat more southerly distribution in 2008 than in 2003. There was, however, a slight northeastward shift of the main concentration in 2008 compared to 2007, which could partly be due to the fact that the survey in the main distribution area took place one week earlier in 2008 compared to 2007.

The Norwegian spring-spawning herring is characterized by 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 2008 the strong 2002 and average 2003 and 2004 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 2004 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 3.2.3.2). 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 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 2007. 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 2008. About 40% 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 previously been shown to have a higher condition factor than the rest of the stock.

Underestimation of herring evidently was occurred due to gap in the coverage in the Barents Sea and due to vessel avoidance during the acoustic survey in the Norwegian Sea 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

In general the blue whiting stock is decreasing; not only the spawning-stock biomass but also recruitment signals continue to be weak and lower than expected. However it’s important to note that the abundance estimate from these surveys should be interpreted as relative indices of abundance.

The international blue whiting spawning stock survey (2004–2008) 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).

The 2008 international blue whiting spawning stock survey shows a significant decrease in total-stock biomass (29%) and a related decrease in stock numbers (34%) compared to the 2007 survey. The estimate is comparable to the 2005 estimate in terms of biomass only. However, abundance in 2005 was bolstered by a series of strong year classes, a situation that does not exist in 2008. The 5 and 4 year old fish that currently dominate the stock and represent over half of the spawning-stock biomass in 2008 are not supported by younger recruits.

Uncertainties in spawning stock estimates have been assessed again in 2008 by Mikko Heino. At present, only one source of uncertainty is considered, spatio-temporal variability in acoustic recordings. In 2008 mean acoustic density is similar to that observed in 2004–2006 over the entire survey area, and much less as observed in 2007. This was caused by a few very high density observations in 2007, with three highest values accounting for more than 20% of total cumulative acoustic density. In other years there are no observations that are as influential. Relating these data to the stock estimate results show that the observed decline in biomass between 2006–2007 and 2008 is more than could be expected from uncertainty arising from spatial heterogeneity alone. In other words, within the considered domain of uncertainty, the decline is statistically significant.

The International Ecosystem Survey in the Nordic Seas shows a drastic reduction 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). 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). The survey indicates that the 2005-2007 year classes are very poor, and that the number of 4 and 5 year old fish is much lower than in previous years (possibly reflecting increased mortality on these cohorts). Results from the Barents Sea bottom-trawl survey in January-March also indicate that the 2005-2007 year classes are poor, which is in line with the observations from the International Ecosystem Survey in the Nordic Seas.

# 5 Planning

## 5.1 Planned acoustic survey of the NE Atlantic blue whiting spawning grounds in 2009

It is planned that five parties; Ireland (EU-coordinated), Faroe Islands, the Netherlands (EU-coordinated), Norway and Russia, will contribute to the survey of blue whiting stock survey in March-April 2009.

Survey timing and coverage were discussed in some detail. It was decided to maintain the traditional timing, from mid-March to mid-April, with an emphasis on keeping the temporal effort to within a three week window. It was again emphasized that duration of the survey should be compressed in time, such that maximally synoptic coverage is obtained. 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) | Survey time (days) | Preliminary survey dates | Primary target area [secondary] |
|---|---|---|---|---|---|
| Celtic Explorer | EU (Ireland) | 21 | 18 | 26/3–13/4 | 1 [2b] |
| G. O. Sars | Norway | 14 | 12 | 25/3–5/4 | 1 [2b] |
| Magnus Heinason | The Faroes | 14 | 12 | 1/4–14/4 | 2c [1, 2b] |
| Tridens | EU (Netherlands) | 21 | 14 | 19/3–1/4 | 2a [1,3a, 2b] |
| RV | Russia | 45 | 21 | 24/3-14/4 | 2a [1, 2c] |

Preliminary cruise tracks for this scenario are presented in Figure 5.1.2. Tracks will be finalized as early in 2009 as possible to facilitate planning by national participants. In 2009 Russia will provide the PINRO vessel RV to participate in the survey. IMR will supply the RV "G.O. Sars" as the survey platform in 2009 and will cover the core areas in collaboration with the RV "Celtic Explorer". Both the RV "G.O. Sars" and the RV "Celtic Explorer" have cruise tracks crossing the Rockall Bank. This design was implemented to ensure equal temporal progression throughout the designated core target areas. It is envisaged that the RV "Vilnus" will cover historical cruise tracks focused on the shelf break areas from the south Porcupine Bank northwards to 61°N.

As survey coordinator Ciaran O'Donnell (Ireland) has been tasked with communicating cruise tracks and survey coverage to the group. Detailed cruise lines for each ship will be provided by participant nations and circulated by the coordinator as soon as final vessel availability and dates have been decided.

The survey will be carried according to survey procedures described in the "Manual for Acoustic Surveying in the North East Atlantic", version 2.1 (PGNAPES report 2008).

## 5.2 Planned International ecosystem survey in the Nordic Seas, spring/summer 2009

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 2009.

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

The areas to be covered during the survey in May 2009 are given in Figure 3.

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

Øyvind Tangen, Norway has been appointed as coordinator of the survey for 2009. Final dates and vessels shall be communicated to the coordinater no later than 15 January 2009. Each participating vessel shall also inform the coordinator on harbour for departure and embarkation together with date and harbour for eventual exchange of crew during the survey. Detailed cruise tracks for each ship will be provided by the coordinator by the end of January 2009.

It is proposed that the Danish vessel starts its survey in the beginning of May. Prior to surveying the proposed area all the acoustic equipment will be calibrated. The survey with then start in the area north of 62°N and east of 2°W on latitudinal transects. The Norwegian vessel(s) will also start their cruises in the beginning of May (the date(s) and name(s) of vessel(s) will be decided by mid November 2008) by conducting the Svinøy hydrographic section. After this the area north of 66°N will be surveyed by the Norwegian vessel(s). The Faroes will start at the same time as the other vessels and survey the area north of 62°N chiefly the Faroese area. The Icelandic vessel has planned to conduct their survey at the same time covering mostly Icelandic waters.

The Russian vessel will start the survey in the middle of May in the Barents Sea and cover the area between 38° and 20° E 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 proposed vessels and dates are shown in the text table below.

The following subjects 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 utilized, and if possible the codend of the trawls should be equipped with some device (soft inlet or other) for reduction of scale losses.

The surveys will be carried according to survey procedures described in the "Manual for Acoustic Surveying in the North East Atlantic", vers. 2.1(PGNAPES report 2008).

It is important that intercalibration of acoustic and trawl equipment between the vessels takes place. It has been agreed that during the May 2009 survey intercalibration will be attempted carried out between the Faroes, Danish and Norwegian vessels. No intercalibration did take place since the 2005 survey. It is recommended, that effort should be put into intercalibrations at the 2009 survey. Furthermore it should be taken into consideration when detailed cruise tracks for participating vessels are planned by the survey coordinator. Fishing would also be carried out during this intercalibration exercise in order to compare the trawl efficiency.

It is recommended that communications between vessels operating in the same area shall be established on a daily basis during the Norwegian Sea Survey. The communication shall preferably be made by e-mails or, alternatively, by radio communication. Cruise tracks, acoustic findings and catches (position, fishing depth, species composition by weight and numbers, and if desired the length distribution of the target species) shall be communicated daily by each vessel. Email addresses for cruise leaders for all participating vessels shall be distributed by the survey coordinator together with the cruise tracks.

| Ship | Nation | Vessel time (days) | Active survey time (days) | Preliminary dates |
|---|---|---|---|---|
| Johan Hjort | Norway | 30 | 28 | 1/5 – 30/5 |
| RV | Russia | 15 | 15 | 15/5 – 30/5 |
| Dana | Denmark (EU) | 30 | 23 | 29/4 – 29/5 |
| Magnus Heinason | Faroes | 14 | 12 | 2/5 – 16/5 |
| Arni Fridriksson | Iceland | 26 | 23 | 28/4 – 24/5 |

Final dates will be decided by the end of the year 2008.

# 6 Survey protocol and standardization

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 2.1, August 2008, was presented and adopted by the group. Besides a thorough update of most paragraphs the main focus in this new version was on readability and usability of the document.

As in previous years, acoustic and biology experts were exchanged between member vessels resulting in a step forward to standardization. New scrutiny approaches were discussed at the 2008 meeting and it was decided to organize a scrutiny workshop early 2009 to compare and present methods.

## 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 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.

### 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 concluded that krill could not be caught efficiently with a vertically towed WP2 net. The group recommends that retrieval speed is maintained at 0.5m/s.

### 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 programme 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 are currently being reviewed and participants will be contacted to update datasets where necessary.

## 7 PGNAPES database

#### Internet database

A PGNAPES Internet database (Oracle 10g Express platform) was established at the Faroese Fisheries Laboratory before the post-cruise meeting in IJmuiden, April 2007.

#### Data from the International Blue Whiting Spawning Stock Survey

Data from all participating countries, very satisfactory, where received and uploaded to the database in Faroe Islands, before the post cruise meeting in Kaliningrad. This is the same experience as last year, where the submission of data from the April survey was flawless.

#### Data from International Ecosystem Surveys in the Nordic Seas

As we experienced last year, data from the May survey was not fully submitted by the start of the PGNAPES meeting. So the group was occupied getting the last pieces of data into the database the first 1 ½ day of the meeting.

This is very frustrating, and measures have to be taken to get the data ready before the meeting.

### Species code table

Countries are still encouraged to deliver names in their own language. The 3-letter ASFIS code is still a key value in the database, making it easier to allocate species to acoustic values during the scrutinizing operations.

The species list includes the TSNs (Taxonomical Serial Number) and NODC-codes and results can be obtained using either code from the database.

The species list will evolve over time, as countries submit “new” species are introduced.

### 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 can easily 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.

There is ongoing contact between the groups. At the SEAFACTS symposium Bergen 2008, Teunis Jansen informed about the latest developments in FishFrame. He was expecting to get funds to continue the work later this year.

### 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.

*The members of the working group are urged to collect their PGNAPES data into a local (MS Access) copy of the PGNAPES database, to ensure that the integrity and consistency of the dataset is perfect, before the data are submitted to the coordinator.*

*This will facilitate the upload of data into the database.*

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

Data overview

| COUNTRY | YEAR | VESSEL | CRUISE | LOGBOOK | CATCH | BIOLOGY | HYDROG. | ACOUSTIC | AC. VALUES | PLANKTON |
|---|---|---|---|---|---|---|---|---|---|---|
| DK | 2008 | OXBH | 308 | 193 | 71 | 2379 | 48625 | 559 | 850 | 54 |
| FO | 2006 | OW2252 | 624 | 36 | 58 | 1598 | 1359 | 260 | 4196 | |
| FO | 2007 | OW2252 | 724 | 27 | 42 | 1948 | 729 | 337 | 5222 | |
| FO | 2007 | OW2252 | 732 | 76 | 29 | 1109 | 2994 | 359 | 4925 | 31 |
| FO | 2008 | OW2252 | 816 | 51 | 32 | 1199 | 1890 | 1249 | 16954 | 13 |
| FO | 2008 | OW2252 | 824 | 77 | 43 | 2656 | 2619 | 1670 | 19172 | 27 |
| IE | 2006 | EIGB | 403 | 45 | 15 | 2961 | 545 | 516 | 2637 | |
| IE | 2007 | EIGB | BWAS07 | 45 | 72 | 2700 | 534 | 2445 | 12368 | |
| IE | 2008 | EIGB | BWAS08 | 70 | 48 | 2250 | 2647 | 2002 | 11048 | |
| IS | 2007 | TFEA | B08-2007 | 50 | | | | | | 50 |
| IS | 2007 | TFNA | A08-2007 | 130 | 39 | 9873 | 363 | 4005 | 26405 | 68 |
| IS | 2008 | TFEA | B8-2008 | 20 | | | | | | 20 |
| IS | 2008 | TFNA | A6-2008 | 137 | 27 | 5386 | 43240 | 4271 | 43923 | 98 |
| NL | 2006 | PBVO | BWHTS2006 | 41 | 10 | 400 | 14778 | 1363 | 1363 | |
| NL | 2007 | PBVO | BWHTS2007 | 27 | 8 | 420 | 7958 | 897 | 8760 | |
| NL | 2008 | PBVO | BWHTS2008 | 35 | 19 | 982 | 9988 | 1419 | 14569 | |
| NO | 2006 | LMEL | 2006104 | 131 | 53 | 2576 | 57743 | 3515 | 7582 | |
| NO | 2007 | LIVA | 2007845 | 30 | 36 | 656 | 1580 | 1491 | 19460 | |
| NO | 2007 | LMEL | 2007106 | 274 | 409 | 8871 | 5749 | 4478 | 111484 | |
| NO | 2008 | LJBD | 2008834 | 107 | 117 | 2712 | 2319 | 2235 | 43796 | 29 |
| NO | 2008 | LMEL | 2008103 | 118 | 39 | 551 | 3735 | 686 | 24537 | 24 |
| NO | 2008 | LMOG | 2008809 | 65 | 29 | 842 | 10335 | 1399 | 1657 | |
| RU | 2006 | UHOB | 2006048 | 102 | 30 | 371 | 701 | 2512 | 2512 | |
| RU | 2007 | UALU | 2007046 | 21 | 10 | 377 | 190 | 919 | 919 | |
| RU | 2008 | UANA | 2008067 | 105 | 18 | 1393 | 909 | 2461 | 2461 | |
| RU | 2008 | UANA | 2008068 | 186 | 64 | 669 | 602 | 456 | 2844 | 64 |

**The table shows number of records in Logbook, catch, Biology, Hydrography, acoustic, acousticvalues and plankton tables pr. Cruise, vessel, year, nation by 21. of august 2008.**

# 8 Agreement and Recommendations

### Achievements:

- Manual thoroughly revised and adopted by the group.
- Deep sea species photo guide initiated.
- Snake pipefish paper published with data of both IESNS and IBWSS (van Damme & Couperus 2008).
- Annual update of database status at the PGNAPES meeting realized.

### Agreements:

The "Manual for hydro acoustic surveying in the North-East Atlantic" Version 2.1 was adopted by the group and will be circulated among all members of both PGNAPES and PGHERS.

In 2002 ICES officially declared ITIS, the Integrated Taxonomic Information System, as the standard taxonomic reference system for entering fish data into databases. It is therefore decided that the respective Taxonomic Serial Number (TSN) codes are adopted for PGNAPES surveys to aid the flow of data within the group and for common databases. This has been adopted for survey data exchange formats within the group.

Acoustic log interval distance in the exported data shall be set to 1 nautical mile and 50m depth channels as recommended by the group in 2007.

The location of the next postcruise meeting of the International Blue whiting spawning stock survey will be in Galway, Ireland and will take place 22–24 April, 2009.

#### Recommendations:

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

The next PGNAPES meeting will take place in Torshavn, Faroe Islands from the 18–21 August, 2009.

The group elected Sytse Ybema (the Netherlands) as the new PGNAPES Chair in 2009.

**General recommendations:**

- Scrutinization workshop to be carried out after future consultation with the local institution. New methods will be presented and standard methods need to be discussed. It is recommended that this workshop should take place in February 2009 at XXXX (date and place to be confirmed).
- Official change of survey names within the ICES forum.
- The need for hydrographic and plankton specialists to become full time members of the group was only partly achieved by the presence of 2 zooplankton specialists. The untenable absence of a full time hydrographic specialist remains.
- The status of the PGNAPES database should be made available to the chair prior to the PGNAPES meeting.
- A follow up meeting to the NISE-PGNAPES joint session on hydrography should be held in the near future.
- Standardisation of gear types should be achieved in the future with special emphasis on the use of a standardized codend.
- Otolith exchange between members should be continued annually in order to standardization.

**Survey recommendations:**

- It was recommended to include methods for sampling and determination of deep-sea fish species in the manuals of the respective PGNAPES surveys.
- Each survey participant is requested to send digital images of bycaught deep-sea fish in order to supplement the photo guide on pelagic deep-sea fish.

- During future IESNS surveys in addition to scales for age readings, representative samples of otoliths should be taken in herring in order to enable comparisons between both methods.
- During the coming IESNS surveys intercalibrations between vessels should be carried out following the procedures described in the Manual for hydro acoustic surveying in the Northeast Atlantic. The use of a standard analysis tool was agreed upon that is to be made available to the group.
- Acoustic log interval distance in the exported data should be set to 1 nautical mile and in 50m vertical depth channels by all participating vessels.
- During future Blue Whiting Spawning Stock Surveys it was agreed upon to use a mapping tool to distribute planned and executed cruise tracks for use in the 2009 survey season.
- It was agreed upon to share Echoview templates prior to both IESNS and IBSSS. These templates will be made available to the group.
- Daily communication (e-mail or radio) about progress of cruise and recent catch information should be maintained in 2009. The survey coordinator is to initiate survey progression updates to all members at sea on a regular basis.
- In order to differentiate between Norwegian spring-spawning herring and North Sea herring otoliths should be collected from the herring in the potential area of mixing. This will be planned for 2009 with the ultimate aim of getting two separate estimates from this area.

**New suggested chair tasks:**

- Circulating an annual update of the PGNAPES database status prior to meetings
- Initiate survey coordination throughout the year and keeping track of responsibilities
- Appointing reporting tasks to individual members prior to the planning group meeting.
- Collecting ongoing issues and requests from working or other groups.

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# 10 Tables and Figures

**Table 1.3.1. Organisational frame of the coordinated herring investigations in the Norwegian Sea, 1995–2008.**

| 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 2006/RMC:08) |
| 2007 | Faroe Islands, Iceland, Norway, Russia, EU | 4 | Reykjavik (ICES CM 2006/ RMC:08) + correspondence | IJmuiden (ICES CM 2007/ RMC:07) |
| 2008 | Faroe Islands, Iceland, Norway, Russia, EU | 3 | IJmuiden (ICES CM 2007/ RMC:07) + correspondence | Hirtshals (this report |

**Table 3.1.1. Estimated total stock numbers and biomass from the International blue whiting spawning stock survey, 2004–2008.**

## 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 |
| 2008 | 956 | 1672 | 4443 | 17814 | 20144 | 11710 | 6418 | 3093 | 791 | 908 | | 67948 |

## 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 |
| 2008 | 40 | 98 | 409 | 1786 | 2273 | 1501 | 976 | 521 | 178 | 176 | | 7958 |

**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 | 2008 | 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 3.2.3.1: Age and length-stratified abundance estimates of Norwegian spring-spawning herring in May 2008 for subareas II and III.**

| Length/age | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15+ | Number | Biomass | Weight |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10 | | | | | | | | | | | | | | | | 0 | 0 | |
| 11 | | | | | | | | | | | | | | | | 0 | 0 | |
| 12 | | | | | | | | | | | | | | | | 0 | 0 | |
| 13 | | | | | | | | | | | | | | | | 0 | 0 | |
| 14 | | | | | | | | | | | | | | | | 0 | 0 | |
| 15 | | | | | | | | | | | | | | | | 0 | 0 | |
| 16 | | | | | | | | | | | | | | | | 0 | 0 | |
| 17 | | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 0.5 | 43 |
| 18 | | 74 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 74 | 3.7 | 50 |
| 19 | | 195 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 195 | 11.5 | 59 |
| 20 | | 255 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 255 | 16.4 | 64 |
| 21 | | 169 | 24 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 193 | 14.9 | 77 |
| 22 | | 131 | 82 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 213 | 18.5 | 87 |
| 23 | | 219 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 219 | 20.6 | 94 |
| 24 | | 80 | 121 | 40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 241 | 26.4 | 109 |
| 25 | | 36 | 108 | 434 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 581 | 70.8 | 122 |
| 26 | | 22 | 154 | 1124 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1300 | 172.8 | 133 |
| 27 | | 0 | 33 | 1519 | 33 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1585 | 231.4 | 146 |
| 28 | | 0 | 19 | 2038 | 381 | 19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2457 | 403.5 | 164 |
| 29 | | 0 | 22 | 2284 | 1380 | 216 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3902 | 711.1 | 182 |
| 30 | | 0 | 24 | 744 | 2513 | 1280 | 24 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4585 | 904.8 | 197 |
| 31 | | 0 | 0 | 114 | 2704 | 5218 | 97 | 0 | 122 | 49 | 24 | 0 | 0 | 0 | 0 | 8328 | 1770.8 | 213 |
| 32 | | 0 | 0 | 35 | 996 | 6406 | 296 | 240 | 95 | 81 | 0 | 0 | 21 | 0 | 0 | 8170 | 1866.1 | 228 |
| 33 | | 0 | 0 | 0 | 263 | 2755 | 531 | 446 | 756 | 446 | 28 | 0 | 0 | 0 | 0 | 5225 | 1294.5 | 248 |
| 34 | | 0 | 0 | 0 | 0 | 418 | 323 | 646 | 1423 | 741 | 72 | 12 | 0 | 0 | 12 | 3647 | 996.5 | 273 |
| 35 | | 0 | 0 | 0 | 0 | 30 | 110 | 451 | 1122 | 716 | 129 | 0 | 32 | 0 | 0 | 2590 | 752.4 | 291 |
| 36 | | 0 | 0 | 0 | 0 | 0 | 0 | 108 | 361 | 325 | 48 | 179 | 12 | 60 | 120 | 1213 | 381.9 | 314 |
| 37 | | 0 | 0 | 0 | 0 | 0 | 0 | 29 | 57 | 120 | 72 | 29 | 72 | 91 | 101 | 571 | 191.9 | 337 |
| 38 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 22 | 22 | 43 | 22 | 22 | 43 | 70 | 244 | 85.3 | 352 |
| 39 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 23 | 105 | 128 | 49.5 | 384 |
| 40 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.3 | 427 |
| 41 | | | | | | | | | | | | | | | | | | |
| 42 | | | | | | | | | | | | | | | | | | |
| 43 | | | | | | | | | | | | | | | | | | |
| 44 | | | | | | | | | | | | | | | | | | |
| 45 | | | | | | | | | | | | | | | | | | |
| Number 10^6 | 0 | 1193 | 587 | 8332 | 8270 | 16345 | 1381 | 1920 | 3958 | 2500 | 416 | 242 | 159 | 217 | 408 | 45928 | 9996 | |

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15+ | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total area** | | | | | | | | | | | | | | | | | |
| Biomass 10^3 t | 0 | 93.1 | 72.3 | 1358.7 | 1685.4 | 3670.3 | 345.9 | 517.7 | 1087.3 | 699.9 | 124 | 77.6 | 49.5 | 74.1 | 140.1 | | 9996 |
| Length cm | | 21.6 | 25.5 | 28.4 | 30.9 | 32.2 | 33.5 | 34.4 | 34.7 | 34.9 | 35.7 | 36.7 | 36.5 | 37.6 | 38 | mean length | 31.6 |
| Weight g | | 78 | 123.5 | 163.1 | 203.8 | 224.6 | 250.6 | 269.7 | 274.7 | 280 | 297.7 | 322 | 312 | 340 | 345 | mean weight | 218 |
| **Herring area II** | | | | | | | | | | | | | | | | | |
| Biomass 10^3 t | | 92.5 | 72.3 | 1315.7 | 1452.6 | 2172.3 | 188.2 | 204.6 | 222.6 | 187.9 | 34.5 | 45.9 | 4.9 | 12 | 14.6 | | 6020.6 |
| Length cm | | 21.6 | 25.5 | 28.3 | 30.8 | 32 | 33.3 | 34.2 | 33.9 | 34.1 | 34.5 | 36.5 | 32.5 | 37.5 | 38.8 | mean length | 30 |
| Weight g | | 77.9 | 123.5 | 162.4 | 203.4 | 223 | 249.9 | 268.3 | 264 | 267.9 | 277.9 | 321.7 | 231.1 | 354.5 | 380.6 | mean weight | 200 |
| **Herring area III** | | | | | | | | | | | | | | | | | |
| Biomass 10^3 t | | 0.6 | 0.1 | 43 | 232.9 | 1498 | 157.7 | 313.1 | 864.7 | 512 | 89.5 | 31.7 | 44.6 | 62.2 | 125.4 | | 3975.4 |
| Length cm | | 23.5 | 28 | 30.2 | 31.4 | 32.5 | 33.7 | 34.6 | 34.9 | 35.2 | 36.2 | 37 | 37.1 | 37.7 | 38 | mean length | 33.7 |
| Weight g | | 98.6 | 153.2 | 188.6 | 206.3 | 226.9 | 251.4 | 270.6 | 277.6 | 284.7 | 306 | 322.5 | 324.6 | 337.4 | 340 | mean weight | 253 |

**Table 3.2.3.2. Norwegian spring-spawning herring in the Norwegian Sea and Barents Sea estimated at the international ecosystem survey in the Nordic Sea in May given in numbers '000 and total biomass '000 tons for the period 1996-2008.**

| Survey year/Age | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008* | 2008** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 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 | 0 | 43 |
| 2 | 0 | 0 | 1,404 | 215 | 157 | 1,540 | 677 | 8,115 | 13,735 | 1,293 | 35,020 | 4,122 | 1,193 | 381 |
| 3 | 4,114 | 1,169 | 367 | 2,191 | 1,353 | 8,312 | 6,343 | 6,561 | 1,543 | 19,679 | 5,604 | 15,437 | 587 | 199 |
| 4 | 22,461 | 3,599 | 1,099 | 322 | 2,783 | 1,430 | 9,619 | 9,985 | 5,227 | 1,353 | 15,894 | 7,783 | 8,332 | 279 |
| 5 | 13,244 | 18,867 | 4,410 | 965 | 92 | 1,463 | 1,418 | 9,961 | 12,571 | 1,765 | 1,035 | 20,292 | 8,270 | 5 |
| 6 | 4,916 | 13,546 | 16,378 | 3,067 | 384 | 179 | 779 | 1,499 | 10,710 | 6,205 | 1,810 | 1,261 | 16,345 | |
| 7 | 2,045 | 2,473 | 10,160 | 11,763 | 1,302 | 204 | 375 | 732 | 1,075 | 5,371 | 6,336 | 1,992 | 1,381 | |
| 8 | 424 | 1,771 | 2,059 | 6,077 | 7,194 | 3,215 | 847 | 146 | 580 | 651 | 7,372 | 6,781 | 1,920 | |
| 9 | 14 | 178 | 804 | 853 | 5,344 | 5,433 | 1,941 | 228 | 76 | 388 | 558 | 5,581 | 3,958 | |
| 10 | 7 | 77 | 183 | 258 | 1,689 | 1,220 | 2,500 | 1,865 | 313 | 139 | 651 | 647 | 2,500 | |
| 11 | 155 | 288 | 0 | 5 | 271 | 94 | 1,423 | 2,359 | 367 | 262 | 171 | 486 | 416 | |
| 12 | 0 | 415 | 0 | 14 | 0 | 178 | 61 | 1,769 | 1,294 | 526 | 344 | 371 | 242 | |
| 13 | 3,134 | 60 | 112 | 0 | 114 | 0 | 78 | 0 | 1,120 | 1,003 | 807 | 403 | 159 | |
| 14 | 0 | 2,472 | 0 | 158 | 0 | 0 | 28 | 287 | 10 | 364 | 792 | 1,047 | 217 | |
| 15+ | 0 | 0 | 415 | 128 | 1,135 | 85 | 26 | 45 | 88 | 115 | 324 | 953 | 408 | |
| 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 | 45,928 | 908 |
| Biomass in '000 tons | NA | 9,141 | 8,053 | 6,392 | 5,798 | 4,714 | 5,027 | 8,562 | 8,869 | 7,045 | 10,342 | 12,373 | 9,996 | 49 |

*Norwegian Sea

**Barents Sea (western limit 30$^{o}$E)

**Table 3.2.4.1: Blue whiting total survey area. Age - and length-stratified abundance estimate of blue whiting in the International Ecosystem Survey in the Nordic Seas in May–June 2008, west of 20°E. Density is terms of sA-values (m2/nm2) based on combined 5 nm values reported by each of the research vessels "Dana", "Magnus Heinason", "Arni Fridriksson", "Nybo" and "G. O. Sars".**

| Length cm | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Number | Biomass | Weight |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 0.3 | 37 |
| 19 | 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 22 | 0.9 | 42 |
| 20 | 1 | 114 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 115 | 5.8 | 50.7 |
| 21 | 12 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 1.3 | 52.4 |
| 22 | 0 | 28 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 28 | 1.8 | 63.4 |
| 23 | 0 | 14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 14 | 1 | 73.5 |
| 24 | 0 | 22 | 73 | 22 | 0 | 0 | 0 | 0 | 0 | 117 | 10 | 85 |
| 25 | 0 | 0 | 176 | 213 | 36 | 0 | 0 | 0 | 0 | 425 | 40.6 | 95.5 |
| 26 | 0 | 0 | 364 | 569 | 104 | 30 | 0 | 0 | 0 | 1067 | 115.9 | 108.6 |
| 27 | 0 | 0 | 316 | 863 | 303 | 132 | 19 | 9 | 0 | 1642 | 196 | 119.4 |
| 28 | 0 | 0 | 106 | 1368 | 511 | 161 | 35 | 7 | 0 | 2188 | 292.4 | 133.6 |
| 29 | 0 | 0 | 61 | 576 | 466 | 129 | 55 | 6 | 0 | 1293 | 190.6 | 147.5 |
| 30 | 0 | 0 | 0 | 116 | 306 | 134 | 36 | 28 | 0 | 620 | 100.2 | 161.4 |
| 31 | 0 | 0 | 0 | 40 | 80 | 109 | 27 | 4 | 0 | 260 | 45.8 | 176.3 |
| 32 | 0 | 0 | 0 | 20 | 71 | 82 | 54 | 16 | 0 | 243 | 48.3 | 198.8 |
| 33 | 0 | 0 | 0 | 4 | 4 | 41 | 4 | 18 | 4 | 75 | 16.7 | 216 |
| 34 | 0 | 0 | 0 | 0 | 5 | 2 | 34 | 0 | 0 | 41 | 10.7 | 263.7 |
| 35 | 0 | 0 | 0 | 0 | 0 | 5 | 8 | 2 | 0 | 15 | 3.4 | 236 |
| 36 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 6 | 1 | 176 |
| 37 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 5 | 0 | 7 | 2.3 | 343.6 |
| 38 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 0 | 5 | 1.4 | 274.7 |
| 39 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | . |
| 40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 5 | 2.4 | 445 |
| 41 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 3 | 1.3 | 470 |
| 42 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | . |
| 43 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 5 | 3.1 | 580 |
| Number 10^6 | 42 | 191 | 1096 | 3792 | 1886 | 826 | 279 | 112 | 4 | 8228 | 1093.2 | |
| Biomass 10^3 t | 1.9 | 11.1 | 123.3 | 492 | 263.9 | 125.3 | 49.2 | 25.5 | 1 | | 1093.2 | |
| Length cm | 19.9 | 21.5 | 26.9 | 28.1 | 29 | 29.9 | 31.2 | 33 | 33.5 | | 28.3 | |
| Weight g | 44.9 | 58 | 112.5 | 129.7 | 139.9 | 151.9 | 176.9 | 222.6 | 217.6 | | 132.8 | |

**Table 3.2.4.2: 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 WGWIDE. Age - and length-stratified abundance estimate of blue whiting in the International Ecosystem Survey in the Nordic Seas in May–June 2008. Density is terms of sA-values (m2/nm2) based on combined 5 nm values reported by each of the research vessels "Dana", "Magnus Heinason", "Arni Fridriksson", "Nybo" and "G. O. Sars".**

| Length cm | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Number | Biomass | Weight |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 0.3 | 37 |
| 19 | 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 22 | 0.9 | 42 |
| 20 | 0 | 47 | 0 | 0 | 0 | 0 | 0 | 0 | 47 | 2.4 | |
| 21 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 13 | 0.7 | 50 |
| 22 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0.2 | 55 |
| 23 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0.4 | 81 |
| 24 | 0 | 6 | 23 | 6 | 0 | 0 | 0 | 0 | 35 | 3 | 86.7 |
| 25 | 0 | 0 | 56 | 100 | 0 | 0 | 0 | 0 | 156 | 15.4 | 98.8 |
| 26 | 0 | 0 | 211 | 335 | 18 | 18 | 0 | 0 | 582 | 65.1 | 112 |
| 27 | 0 | 0 | 186 | 550 | 112 | 30 | 0 | 0 | 878 | 108.8 | 124 |
| 28 | 0 | 0 | 37 | 740 | 202 | 52 | 7 | 0 | 1038 | 141.8 | 136.5 |
| 29 | 0 | 0 | 21 | 313 | 214 | 73 | 21 | 0 | 642 | 96.6 | 150.8 |
| 30 | 0 | 0 | 0 | 71 | 107 | 42 | 18 | 12 | 250 | 42 | 168.2 |
| 31 | 0 | 0 | 0 | 27 | 45 | 36 | 5 | 0 | 113 | 20.5 | 182 |
| 32 | 0 | 0 | 0 | 9 | 17 | 17 | 26 | 0 | 69 | 13.9 | 201.6 |
| 33 | 0 | 0 | 0 | 0 | 0 | 19 | 0 | 10 | 29 | 6.2 | 214.7 |
| 34 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 0 | 25 | 6.6 | 269 |
| 35 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 0 | 8 | 2 | 248.7 |
| 36 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 6 | 1 | 176 |
| 37 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 5 | 2 | 380 |
| 38 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 4 | 1.2 | 270 |
| 39 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | . |
| 40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 5 | 2.4 | 445 |
| 41 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 1.3 | 470 |
| 42 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | . |
| 43 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 5 | 3.1 | 580 |
| Number 10^6 | 29 | 75 | 534 | 2151 | 715 | 287 | 116 | 44 | 3951 | 537.8 | |
| Biomass 10^3 t | 1.2 | 4.2 | 62.5 | 282.9 | 105.2 | 44.9 | 22.7 | 14.1 | | 537.7 | |
| Length cm | 19.3 | 21.3 | 26.9 | 28 | 29.2 | 29.8 | 32.2 | 36.4 | | 28.2 | |
| Weight g | 40.8 | 55.8 | 116.9 | 131.5 | 147.4 | 156.8 | 198.6 | 314.8 | | 136.1 | |

**Table 3.2.4.3. 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 |
| 2008 | 29 | 75 | 534 | 2151 | 715 | 287 | 116 | 44 | | | | 3951 |

### 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 |
| 2008 | 1 | 4 | 63 | 283 | 105 | 45 | 23 | 14 | | | | 538 |

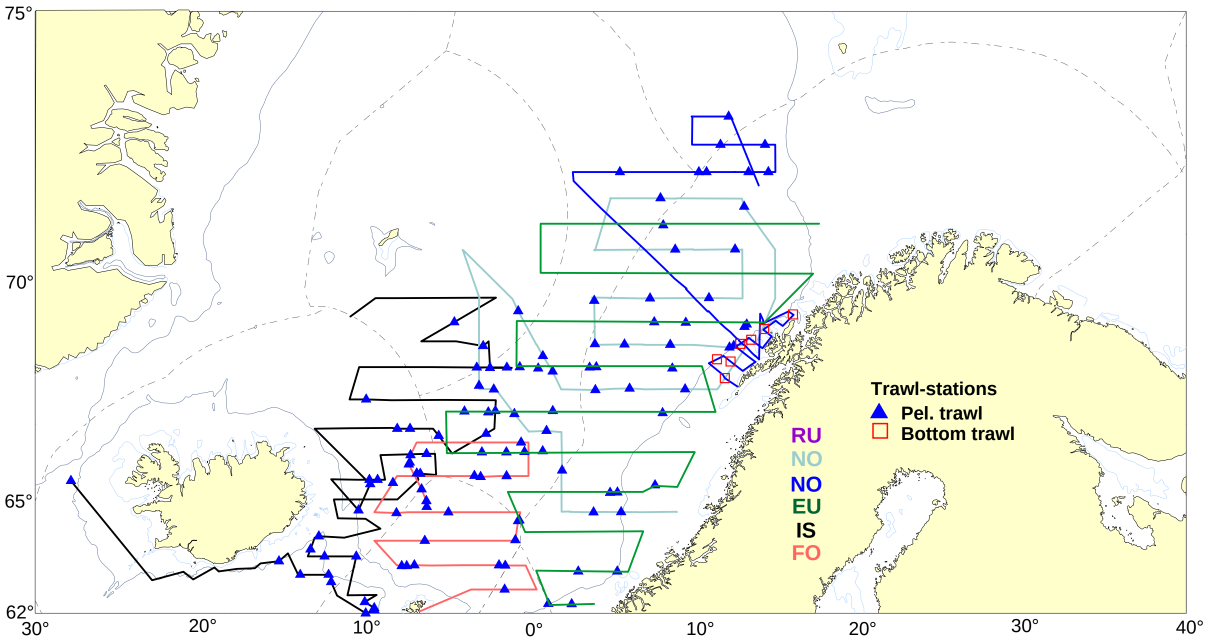


**Figure 1. Cruise tracks during the International Ecosystem Survey in the Nordic Seas in April-May 2008 and location of trawl stations.**

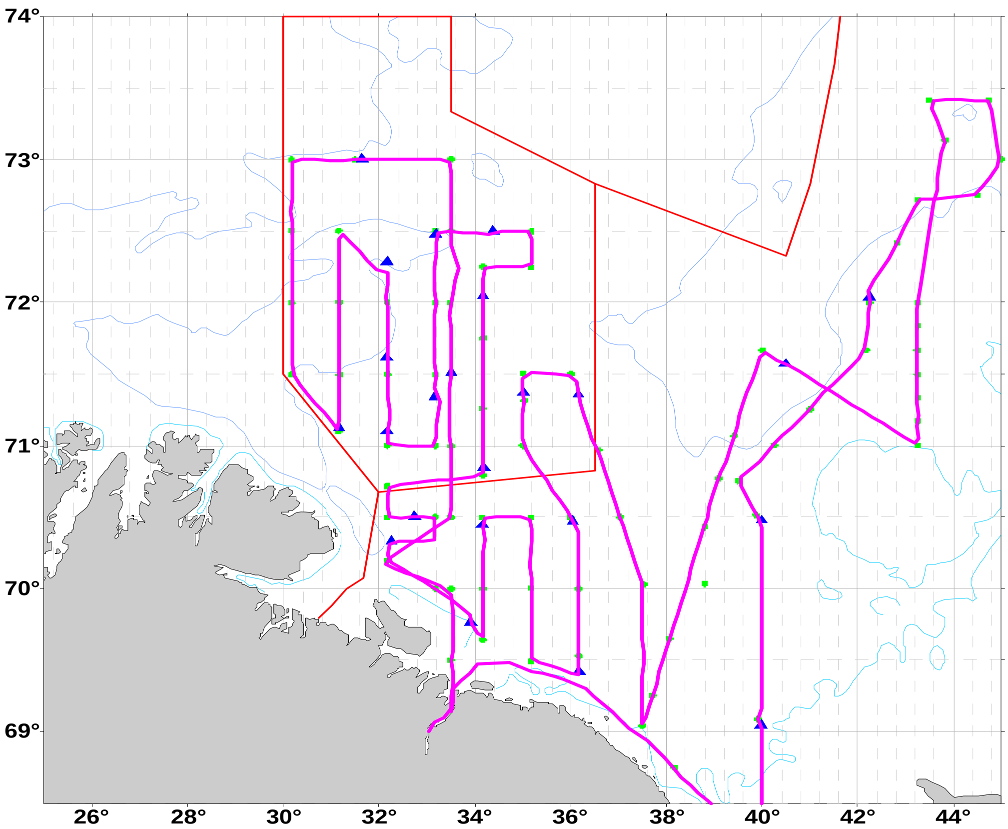


**Figure 2 Cruise tracks of "F.Nansen" during the International ecosystem survey in the Barents Sea in May 2008 and location of trawl and CTD stations.**

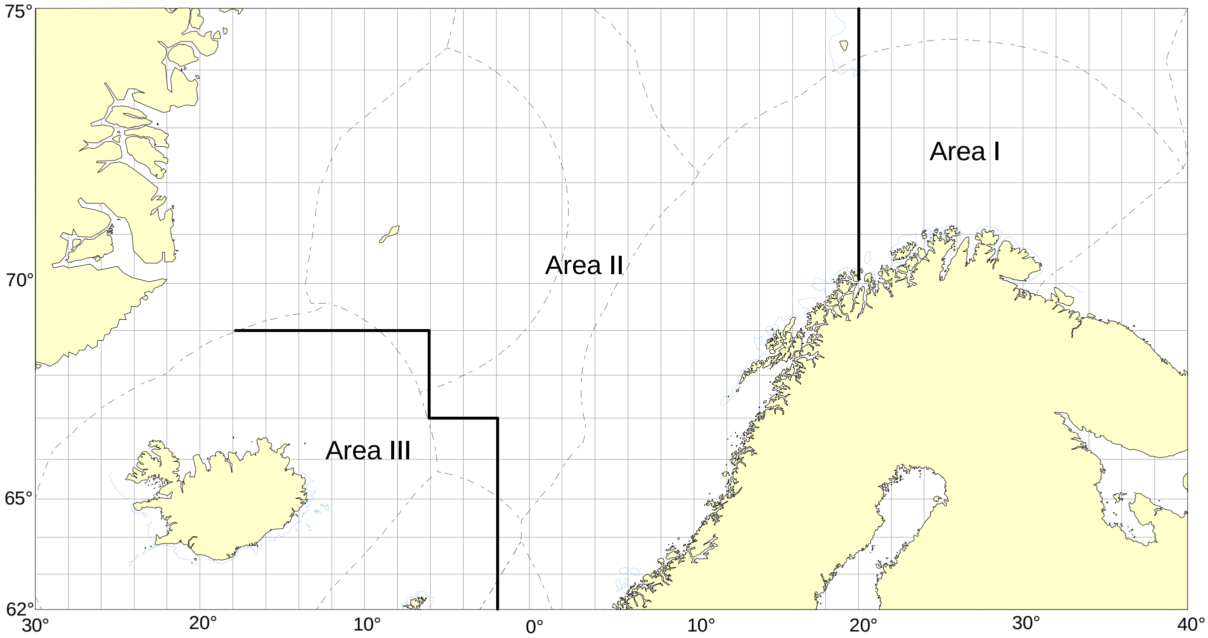


**Figure 3. Areas defined for acoustic estimation of blue whiting and Norwegian spring-spawning herring in the Nordic Seas.**

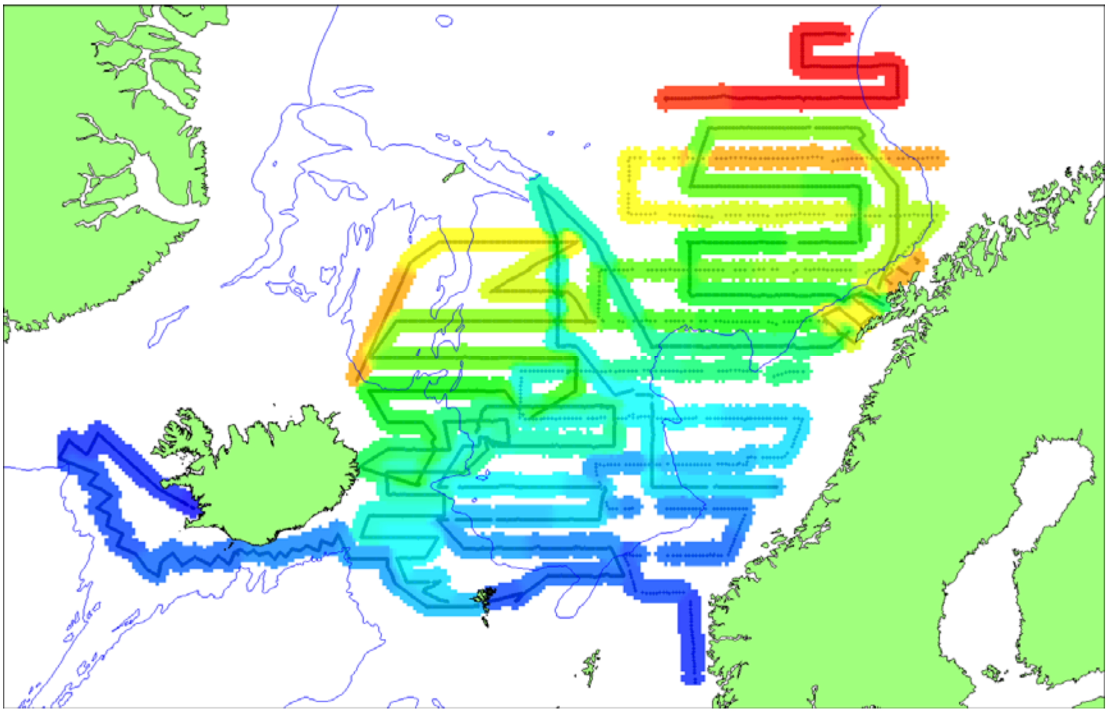

**Figure 4. Temporal progression of the International Ecosystem Survey in the Nordic Seas in May-June 2008.**

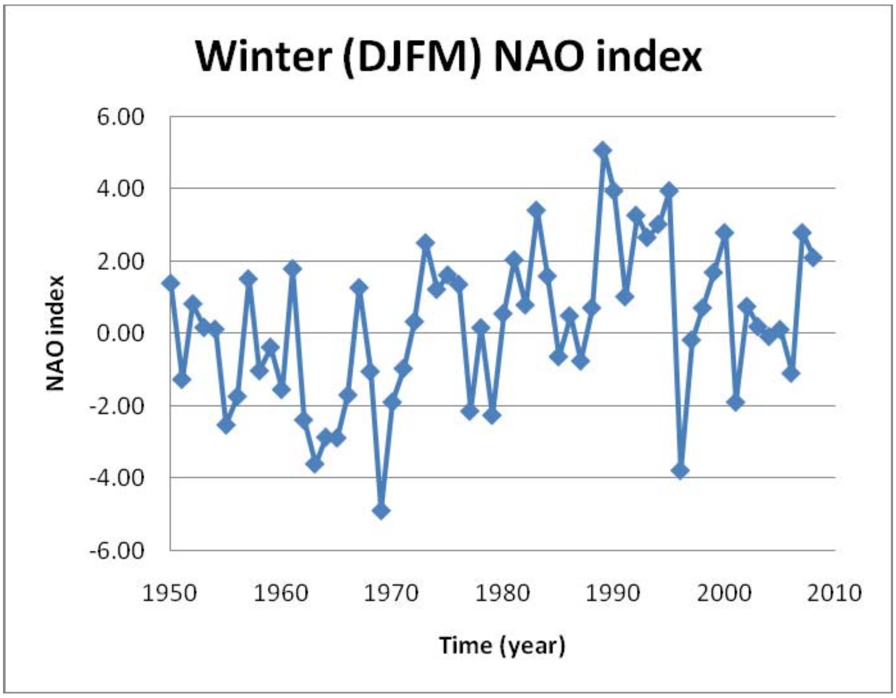


**Figure 3.2.1.1 Hurrell's winter (Dec-Mar) NAO index (the difference of normalized sea level pressure between Lisbon, Portugal and Stykkisholmur/Reykjavik, Iceland) from 1950 to 2008.**

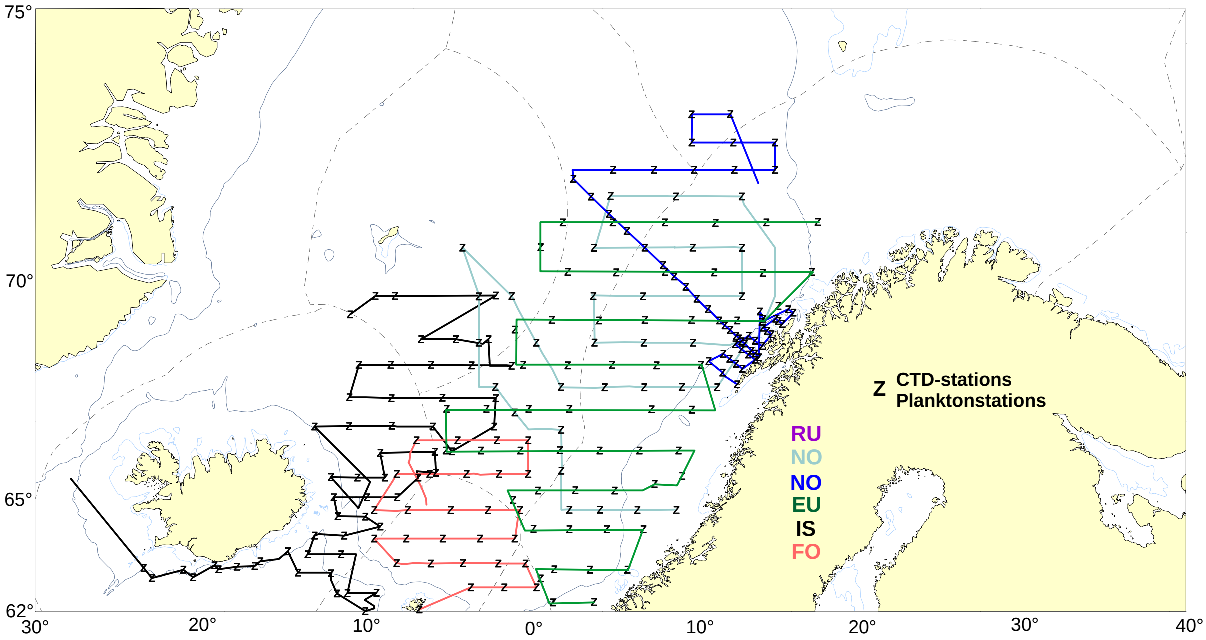


**Figure 3.2.1.2. Cruise tracks and CTD stations by country in the International Ecosystem Survey in the Nordic Seas in May-June 2008.**

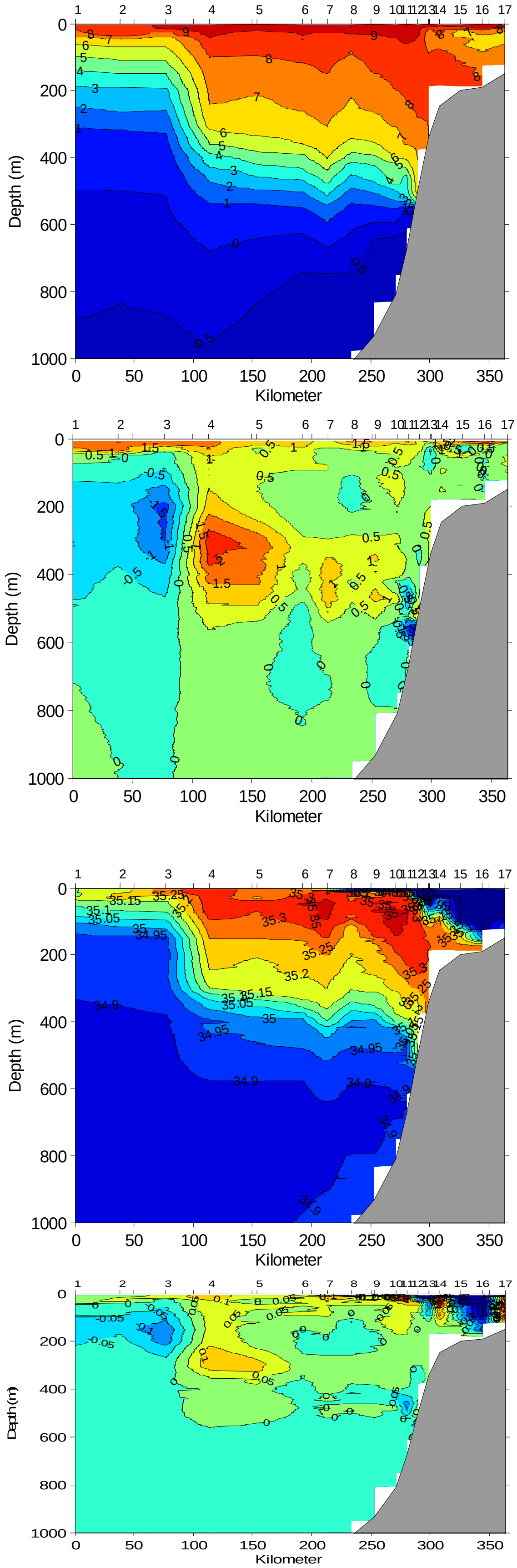


**Figure 3.2.1.3. Temperature and salinity (left figures) with anomalies (right figures) in the Svinøy section 23-25 May 2008.**

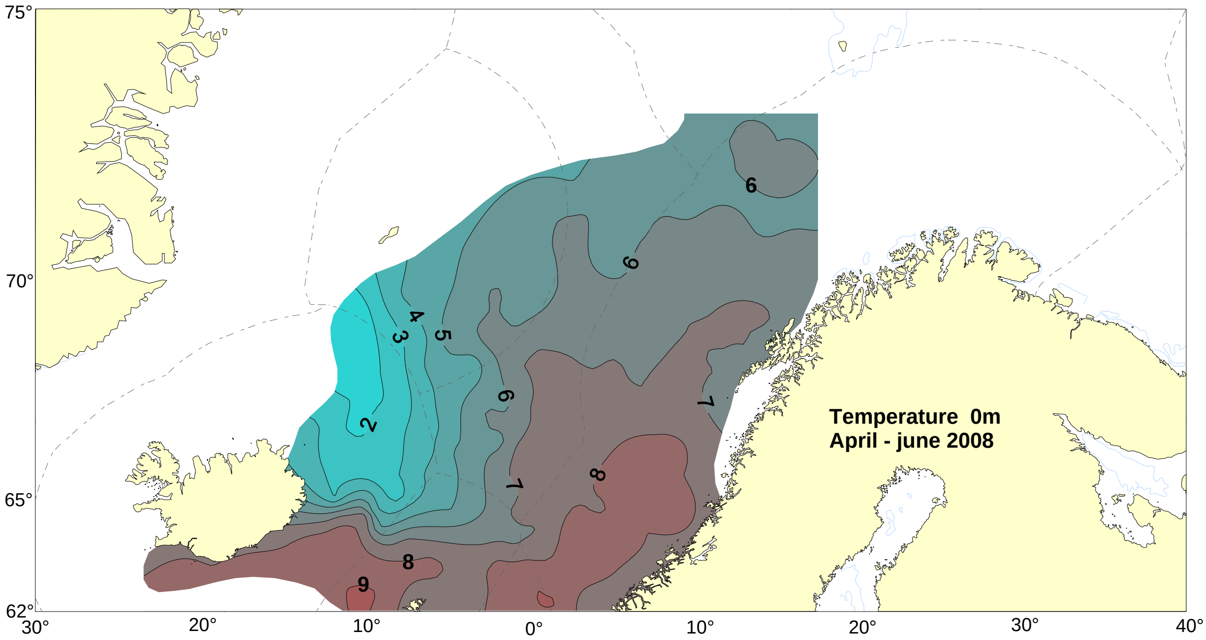


**Figure 3.2.1.4. Surface temperature in April-June 2008.**

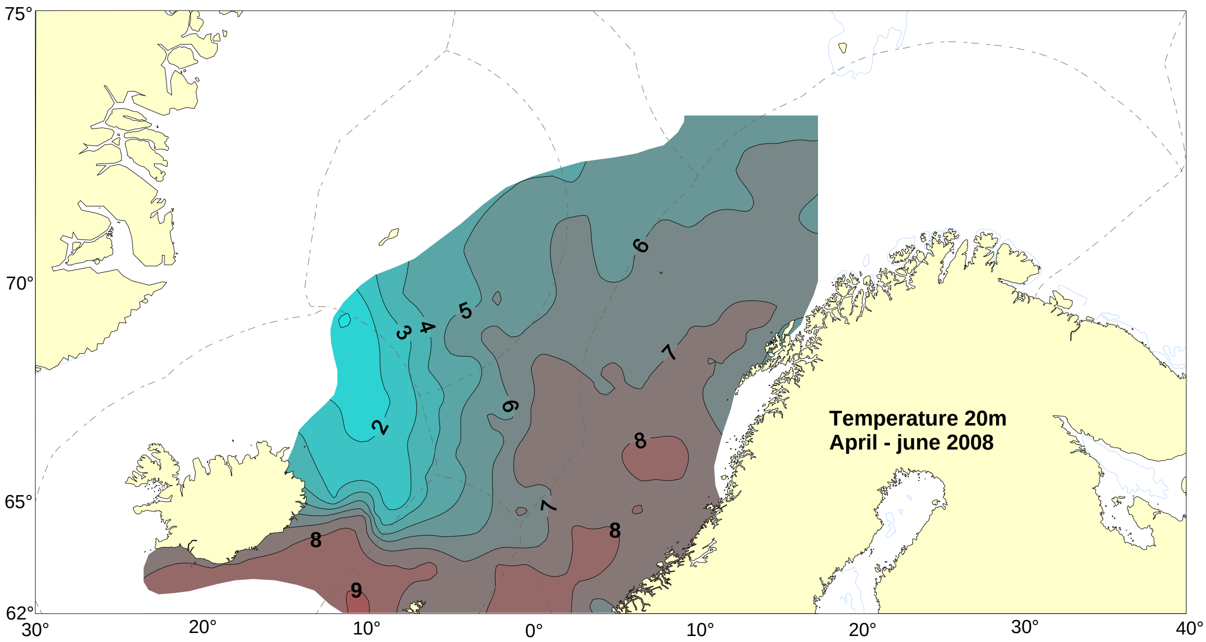


**Figure 3.2.1.5 Temperature at 20 m depth in April-June 2008.**

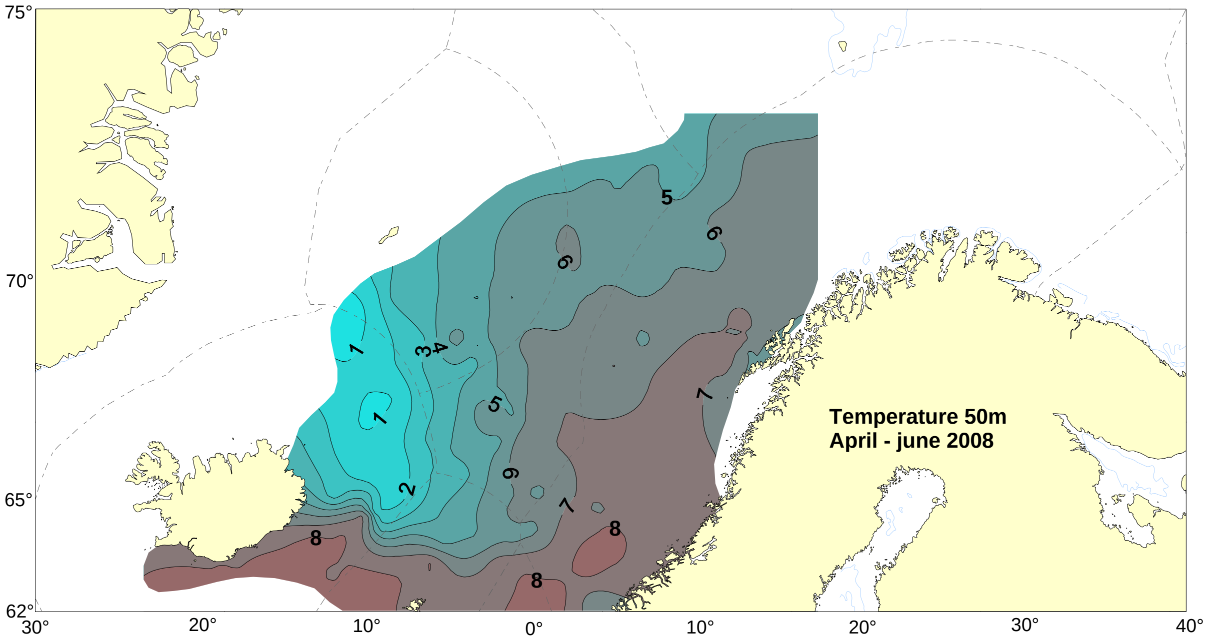


**Figure 3.2.1.6 Temperature at 50 m depth in April-June 2008.**

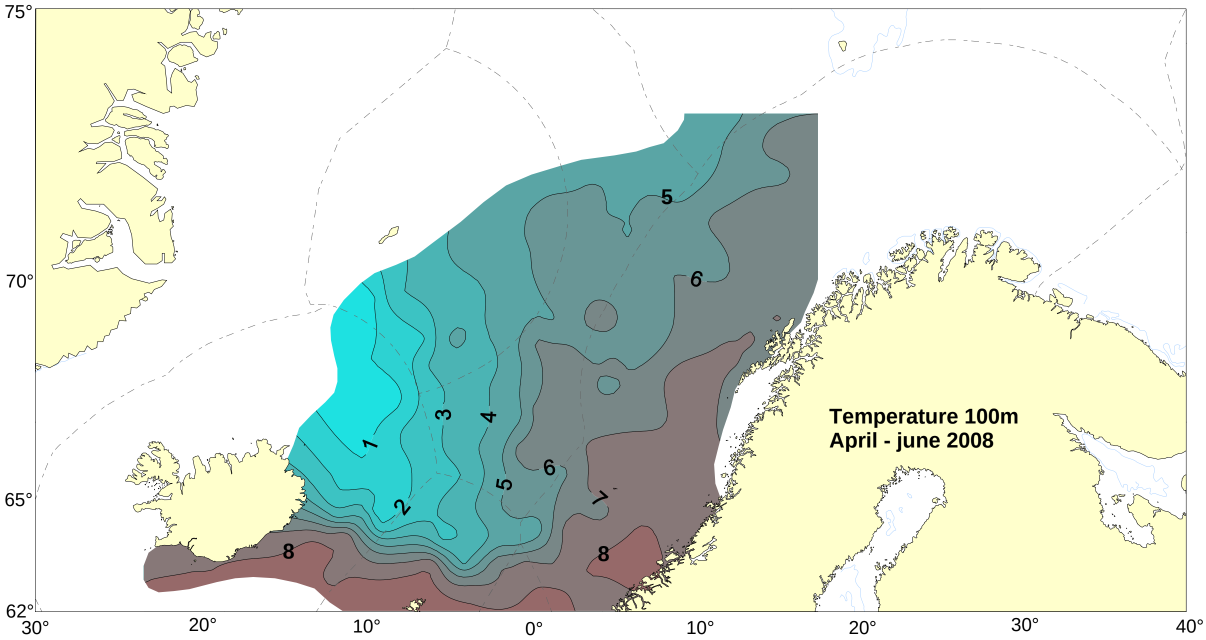


**Figure 3.2.1.7 Temperature at 100 m depth in April-June 2008.**

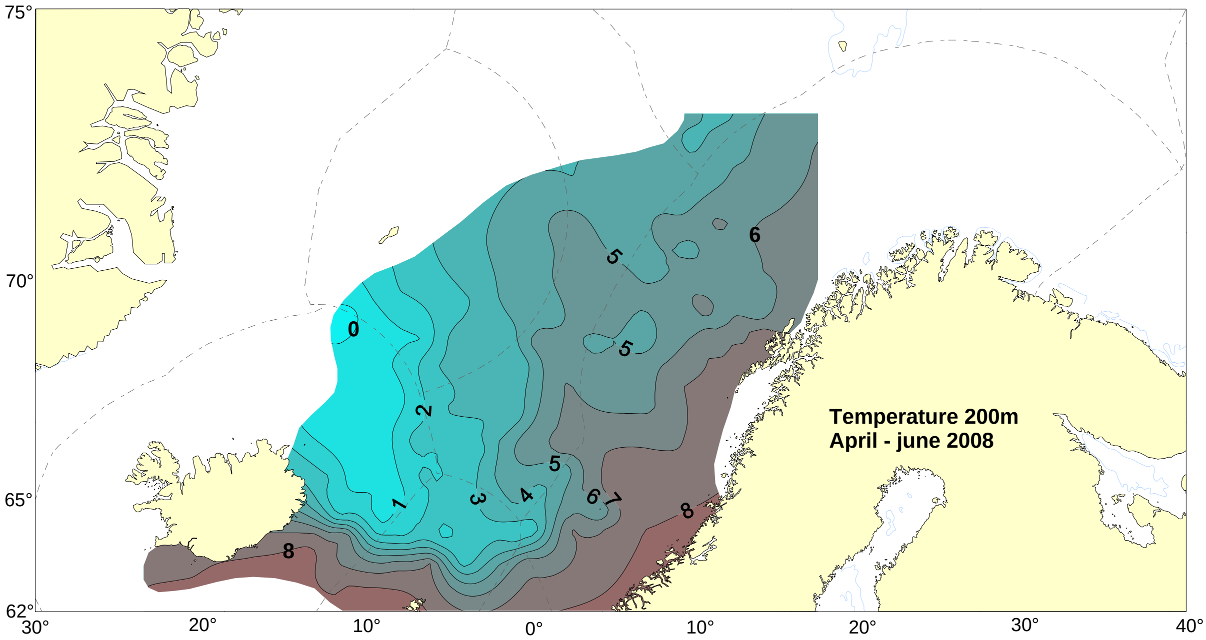


Figure 3.2.1.8 Temperature at 200 m depth in April-June 2008.

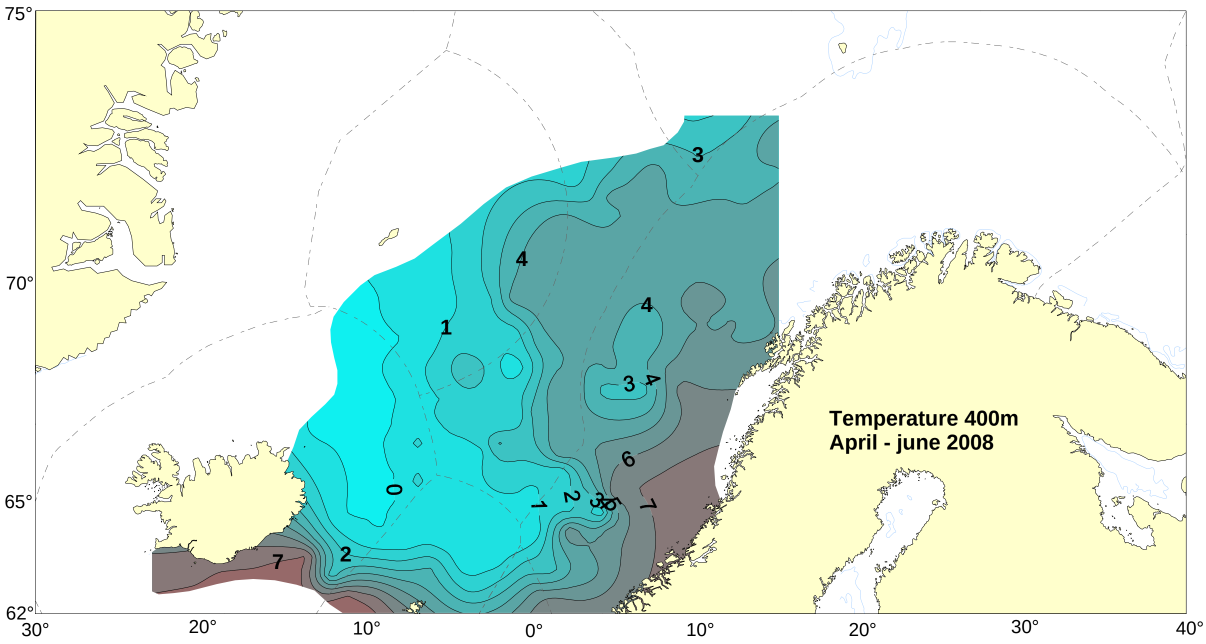


Figure 3.2.1.9. Temperature at 400 m depth in April-June 2008.

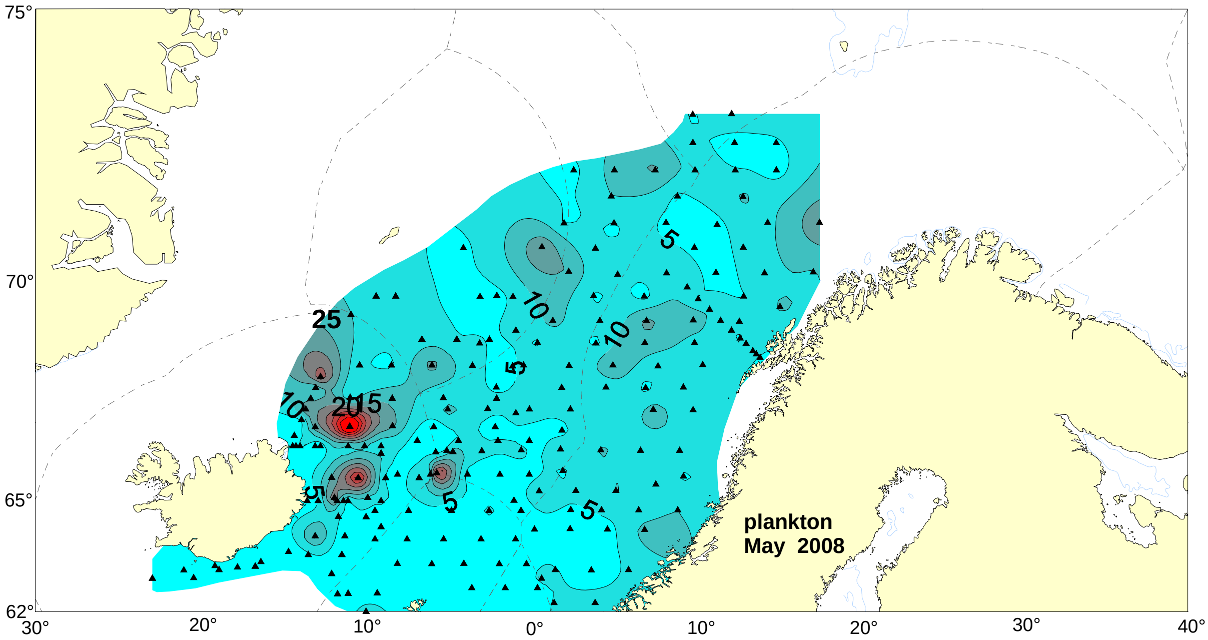


**Figure 3.2.2.1. Zooplankton biomass (g dw m-2) (200–0 m) (50–0 m) in May 2008.**

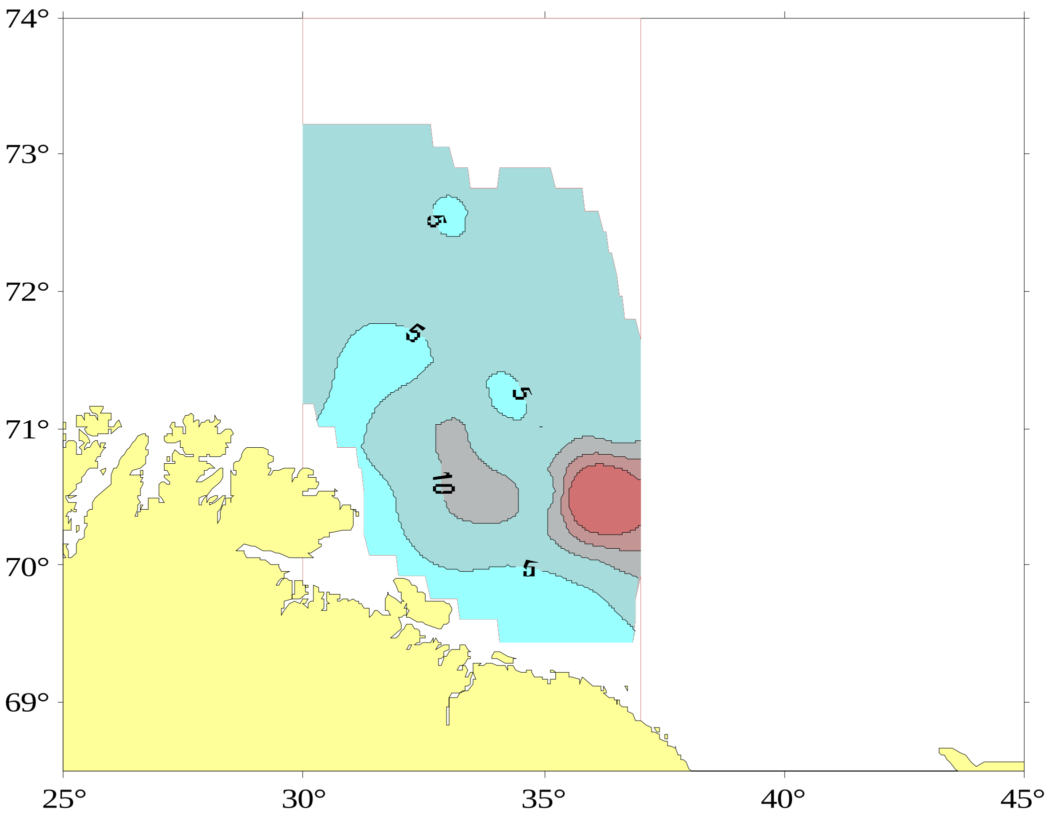


**Figure 3.2.2.2. Zooplankton biomass (g dw m²) in the upper 100 m by Juday net catches in the Barents Sea in may 2008.**

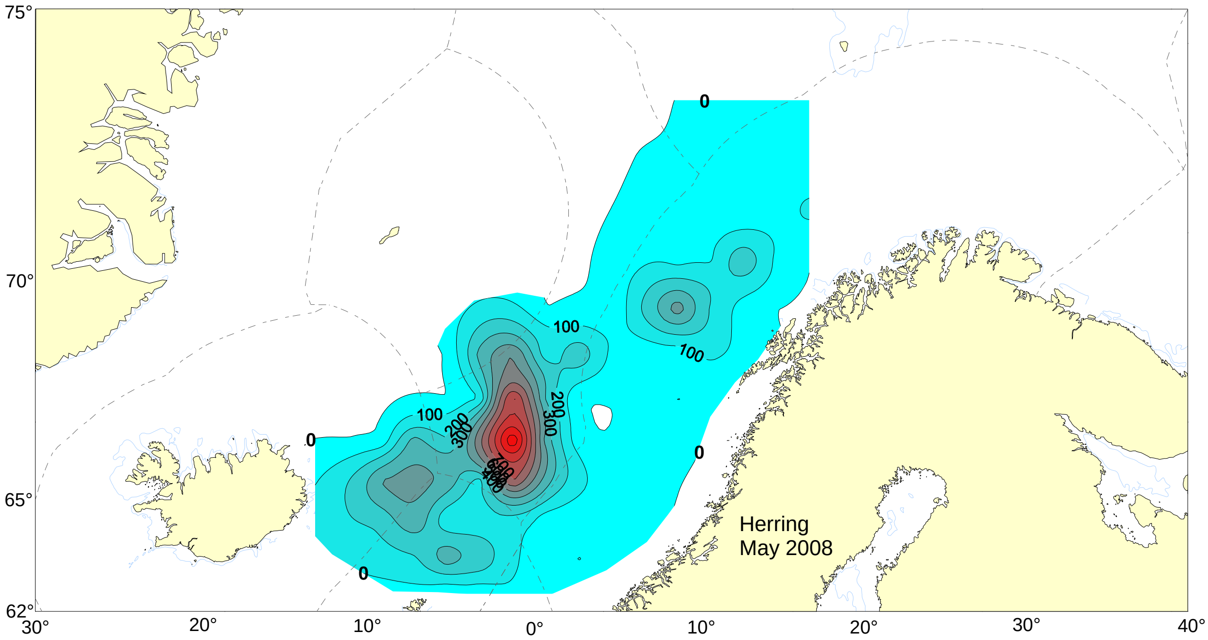


**Figure 3.2.3.1. Distribution of Norwegian spring-spawning herring as measured during the international survey in April-June 2008 in terms of sA-values (m2/nm2) based on combined 5 nm values.**

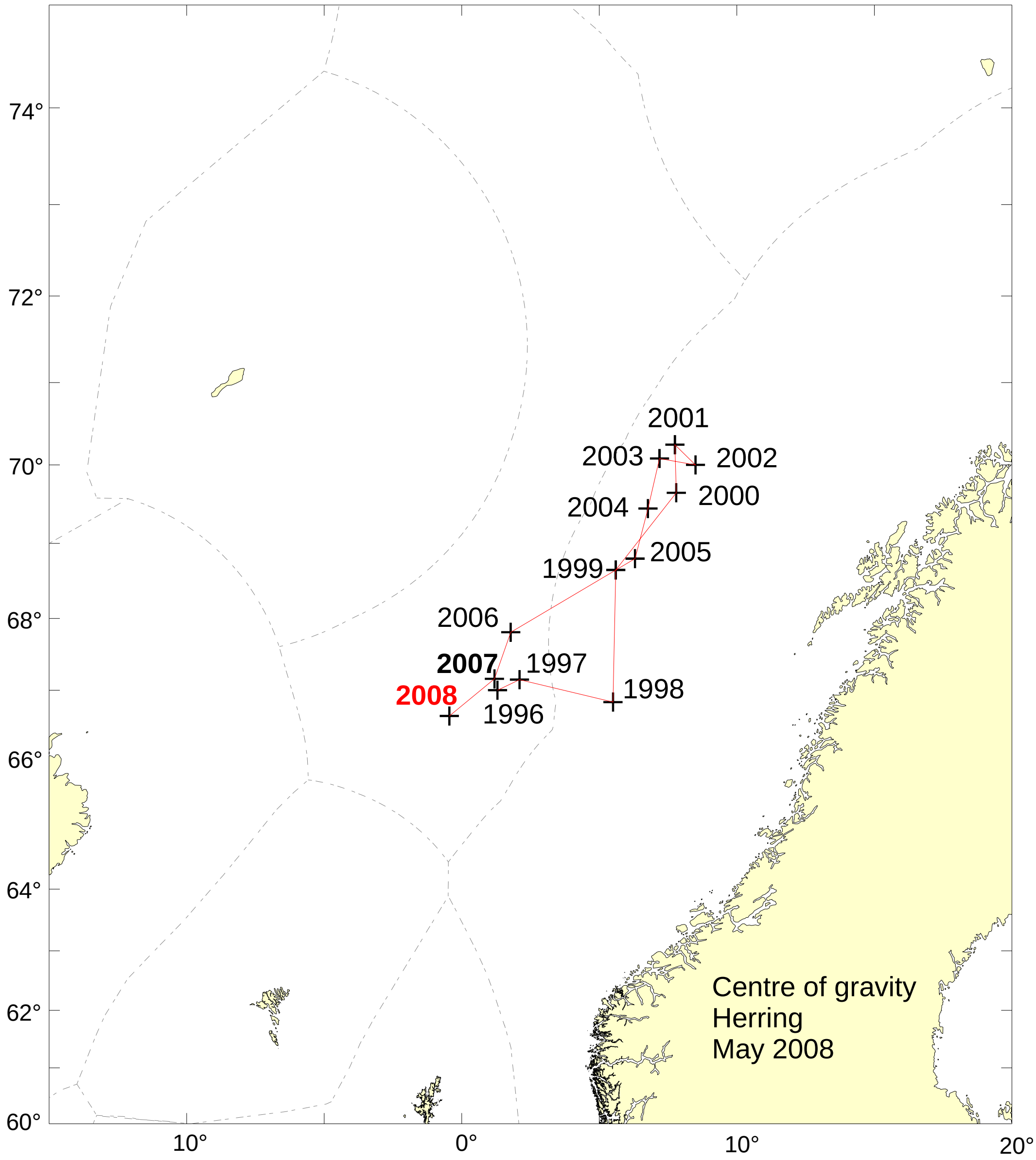


**Figure 3.2.3.2. Centre of gravity of herring during the period 1996-2008 derived from acoustic. Acoustic data from area II and III only, i.e. west of 20°E.**

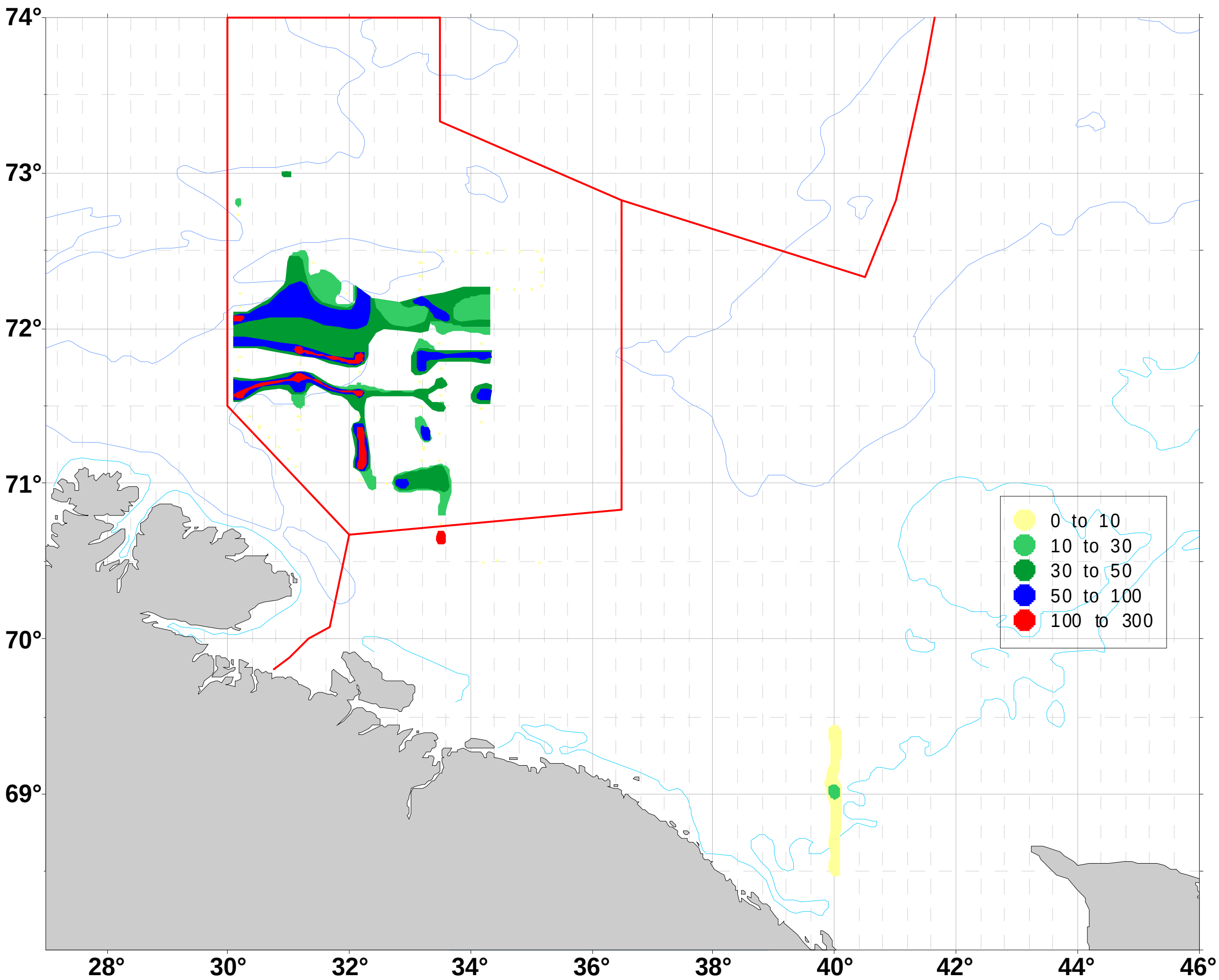


**Figure 3.2.3.3. Distribution of Norwegian spring-spawning as measured during the International ecosystem survey in the Barents Sea in May 2008 in terms of SA- values based on combined 5 nm values.**

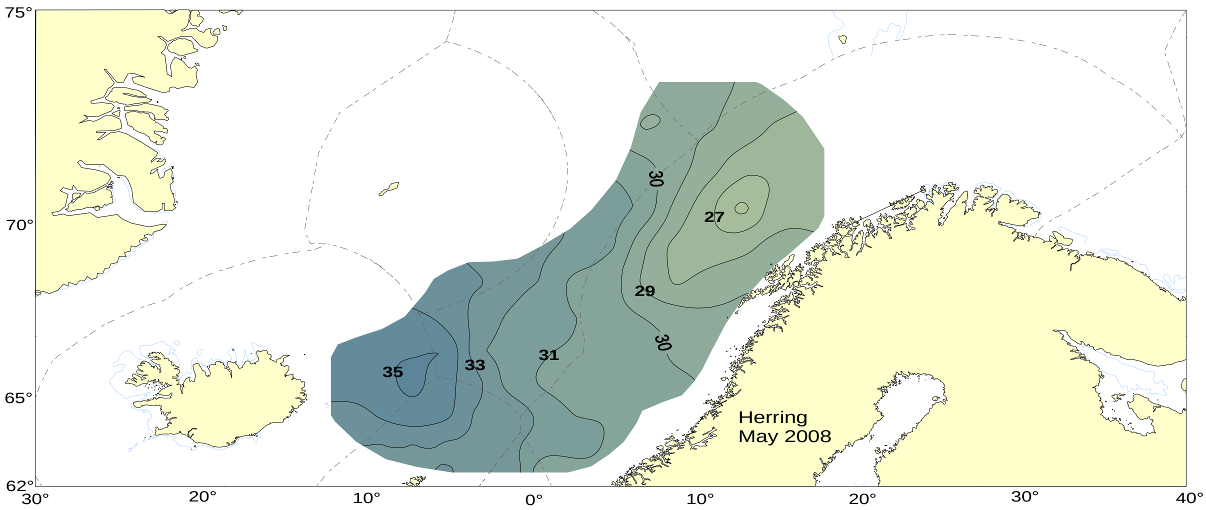


**Figure 3.2.3.4.Mean length by area for Norwegian spring-spawning herring derived from trawl samples in May 2008.**

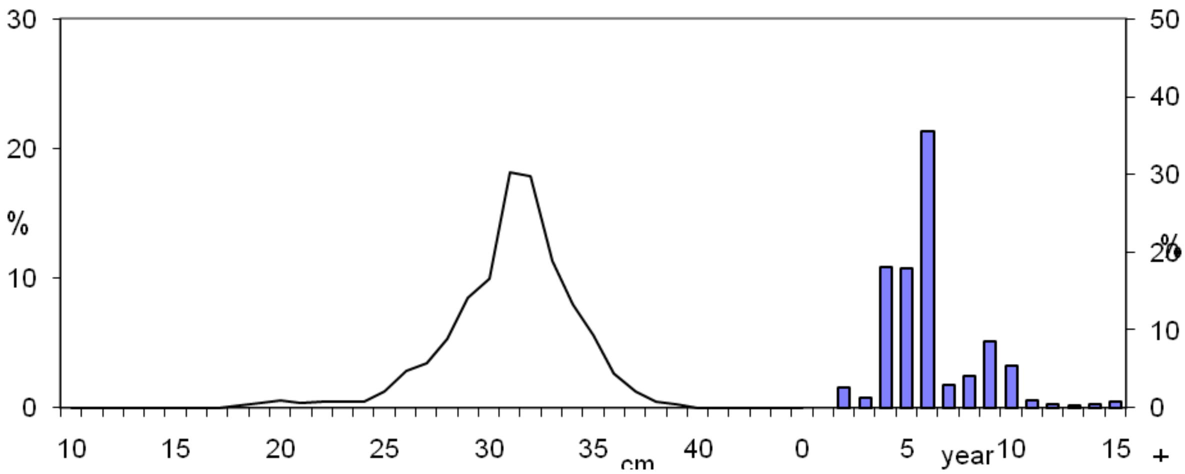


**Figure 3.2.3.5. Length and age distribution of Norwegian spring-spawning herring in May 2007 in the Norwegian Sea (areas II and III).**

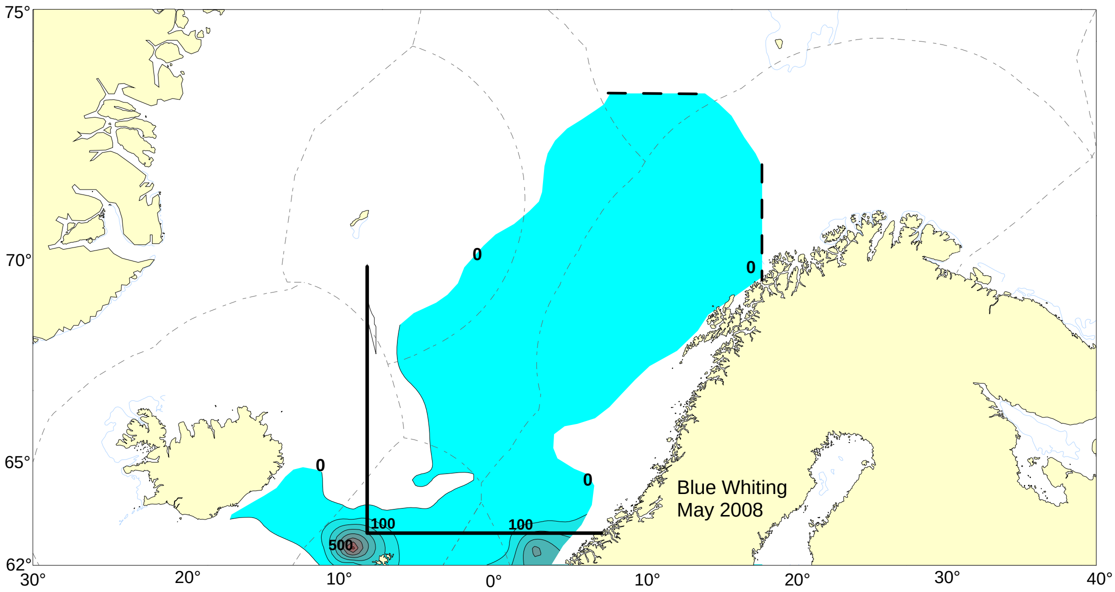


**Figure 3.2.4.1. Distribution of blue whiting as measured during International Ecosystem Survey in the Nordic Seas in May-June 2008 in terms of sA-values (m2/nm2) based on combined 5 nm values. The standard area used in assessment (WGWIDE) is shown on the map.**

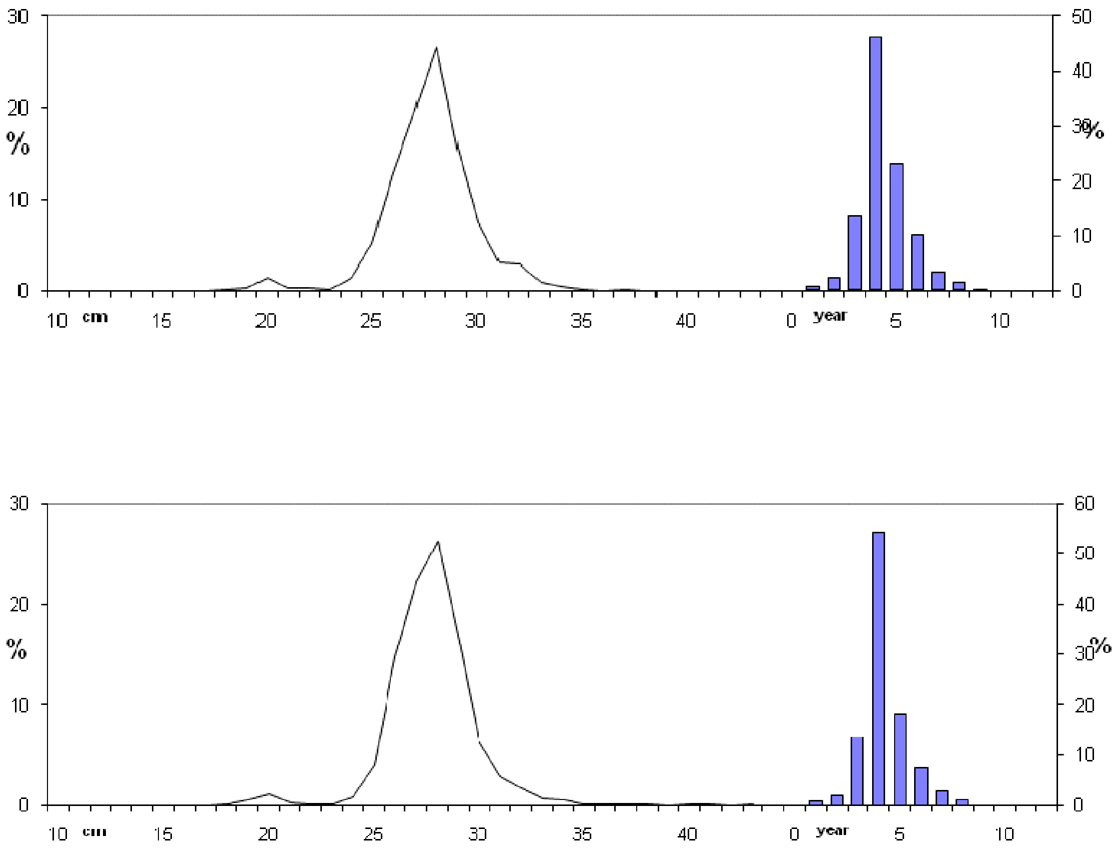


**Figure 3.2.4.2. Estimated length and age distributions of blue whiting in the International Ecosystem Survey in the Nordic Seas in May–June 2008. The upper panel is based on the total survey area and the lower panel is based on the "standard survey area" between 8°W-20°E and north of 63°N.**

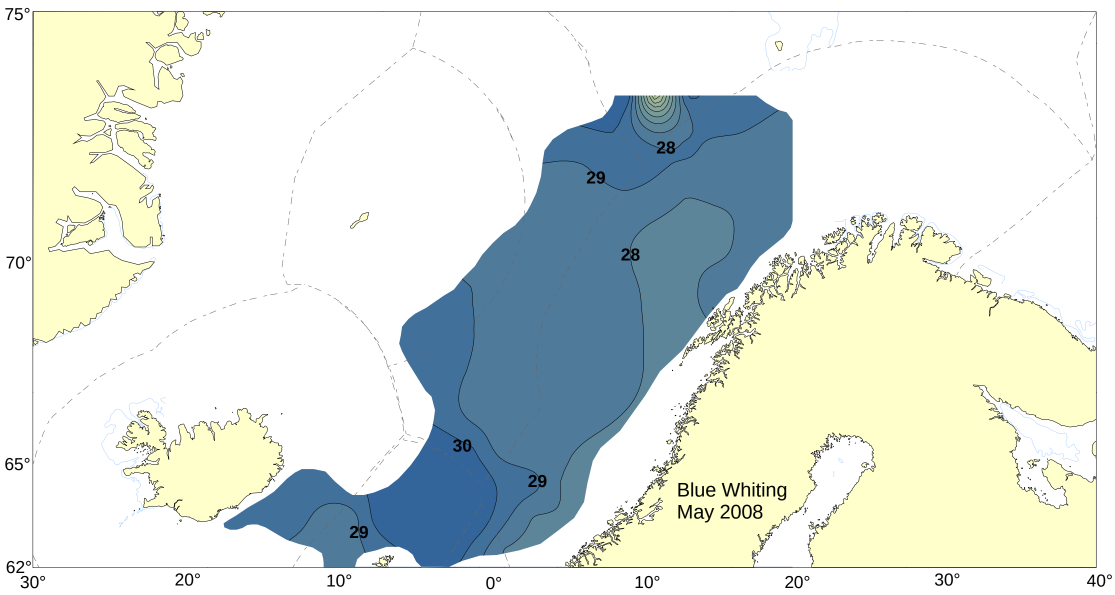


**Figure 3.2.4.3. Mean length (cm) of blue whiting recorded in the International Ecosystem Survey in the Nordic Seas in May–June 2008.**

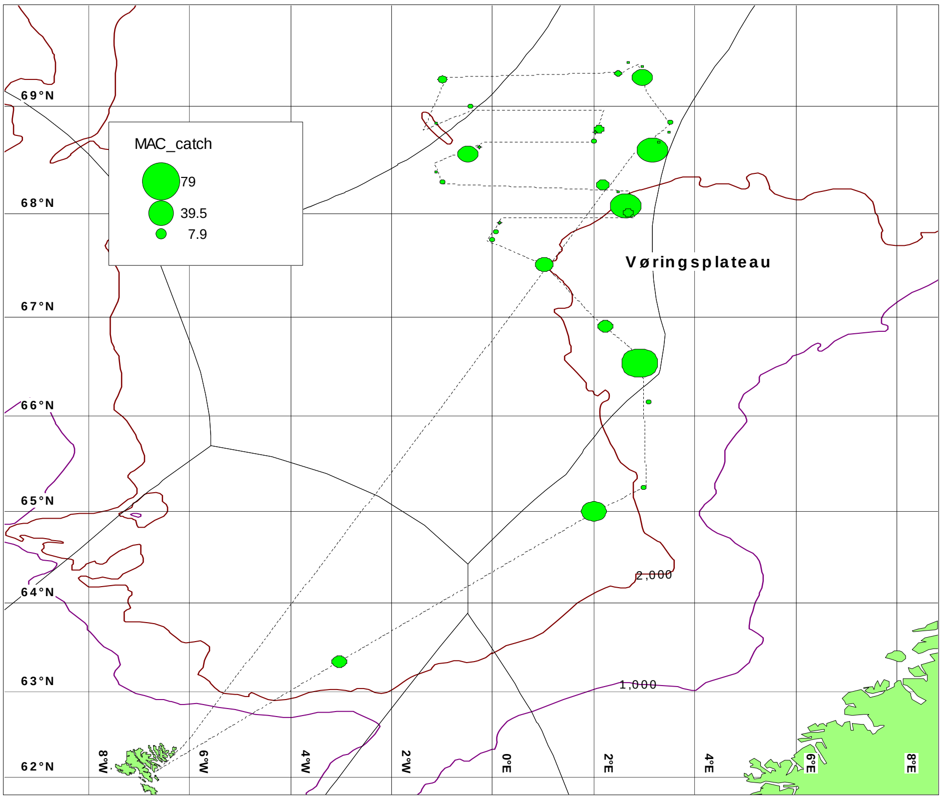


**Figure 3.3.1. Distribution of mackerel (kg per trawl hour) in the Norwegian Sea (international waters mostly) during the Faroese salmon cruise by *Magnus Heinason* in early July 2008.**

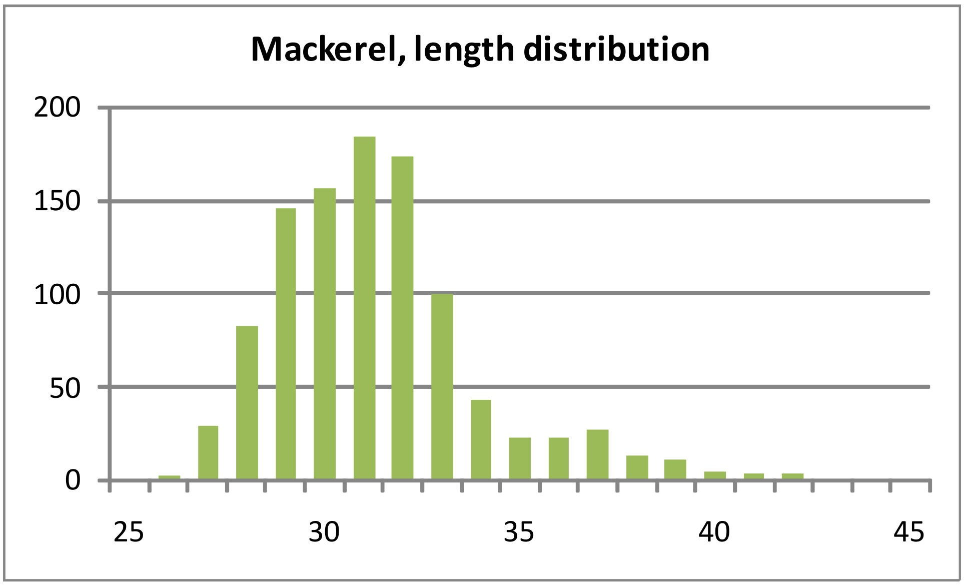


**Figure 3.3.2. Mackerel length distribution (cm) in the Norwegian Sea (international waters mostly), during the Faroese salmon survey by *Magnus Heinason* in early July 2008. Mean length was 32 cm and the mean weight 320 g.**

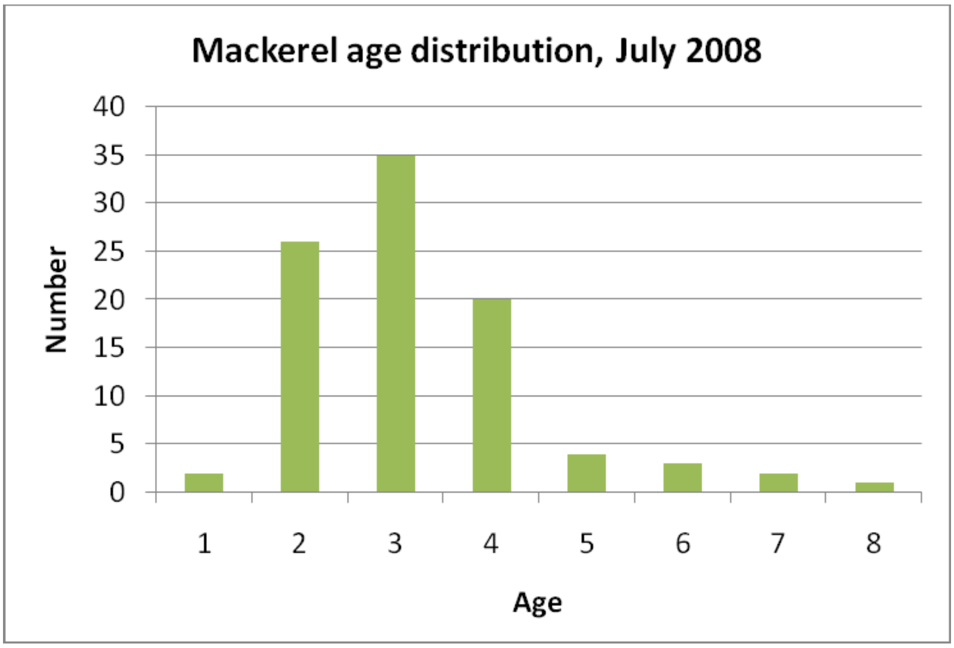


**Figure 3.3.3. Mackerel age distribution in the Norwegian Sea (international waters mostly), during the Faroese salmon survey by *Magnus Heinason* in early July 2008.**

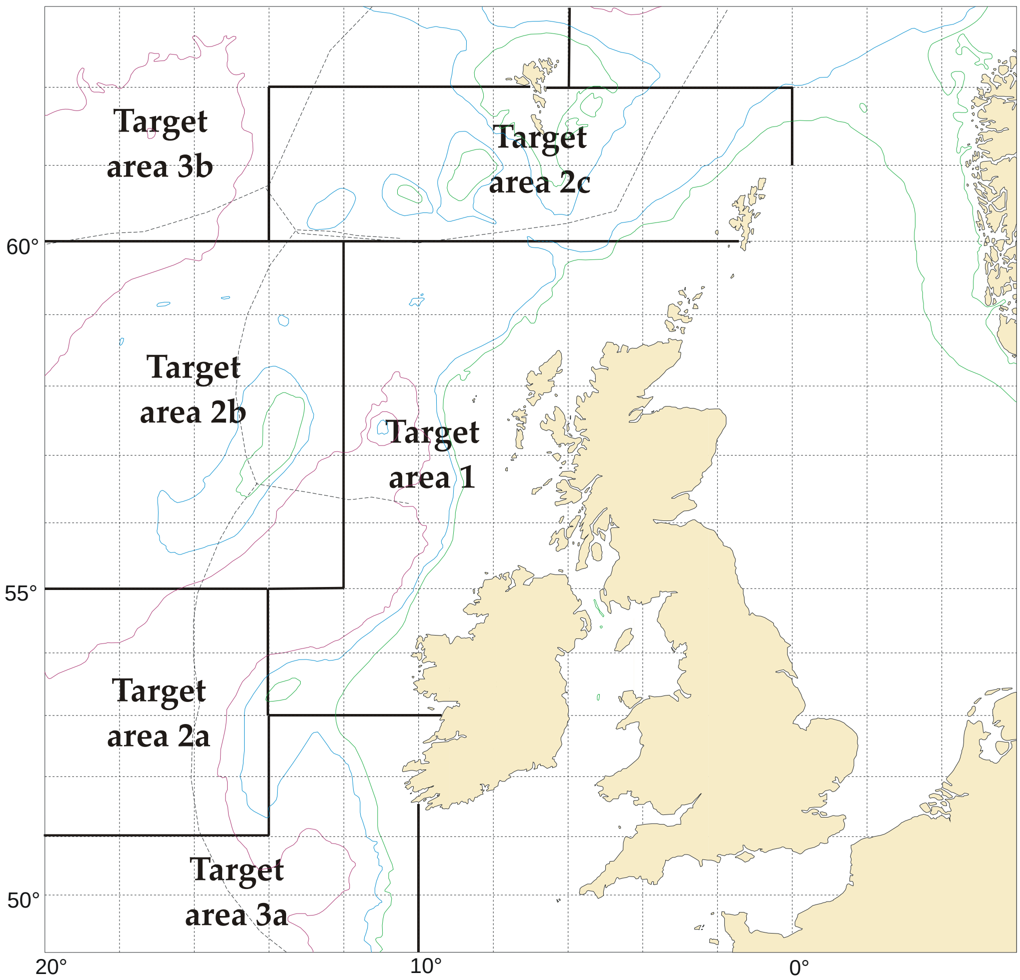


**Figure 5.1.1. Target areas for the International blue whiting spawning stock surveys.**

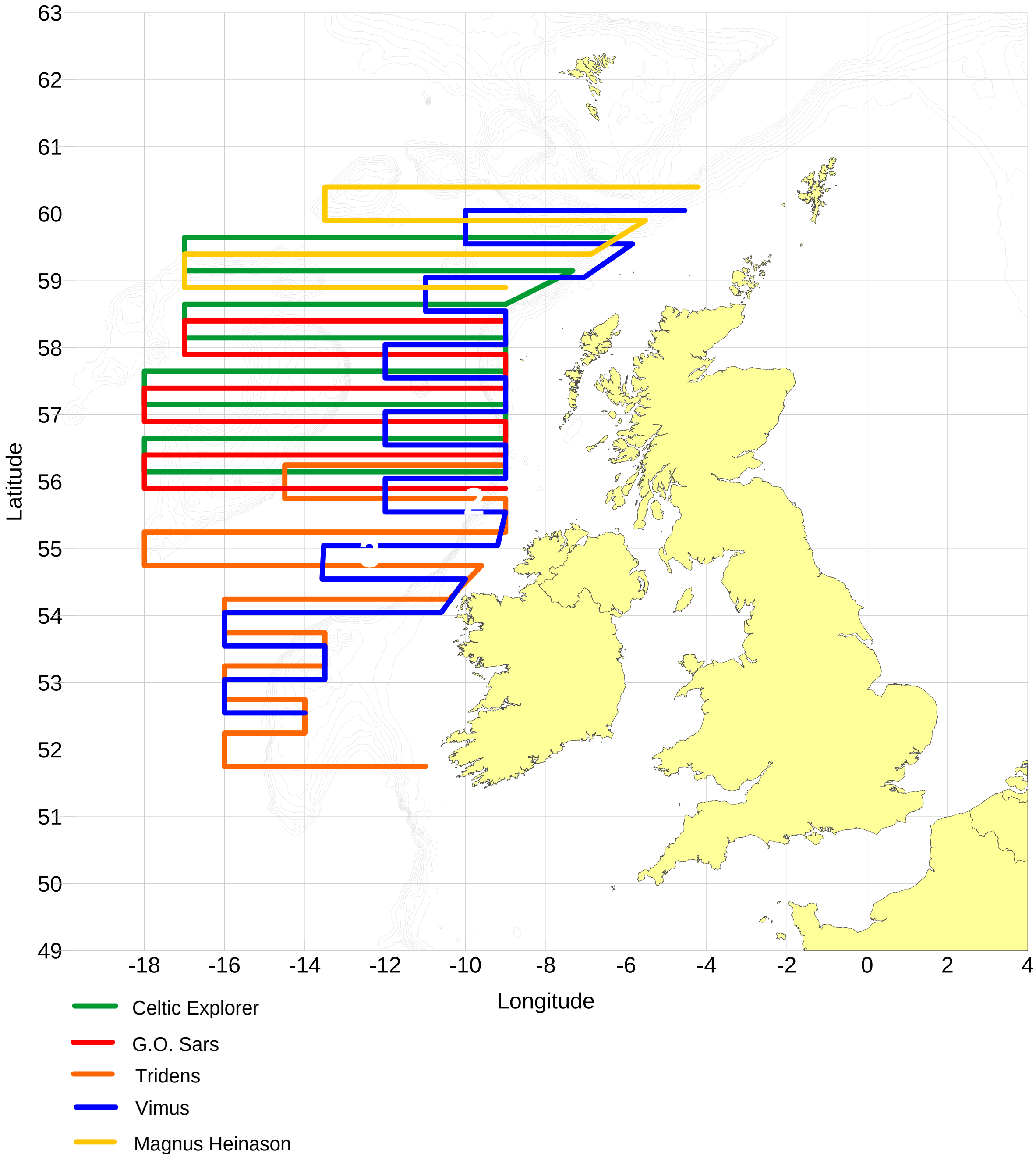


**Figure 5.1.2. Preliminary survey tracks for the 2009 International blue whiting spawning stock survey.**

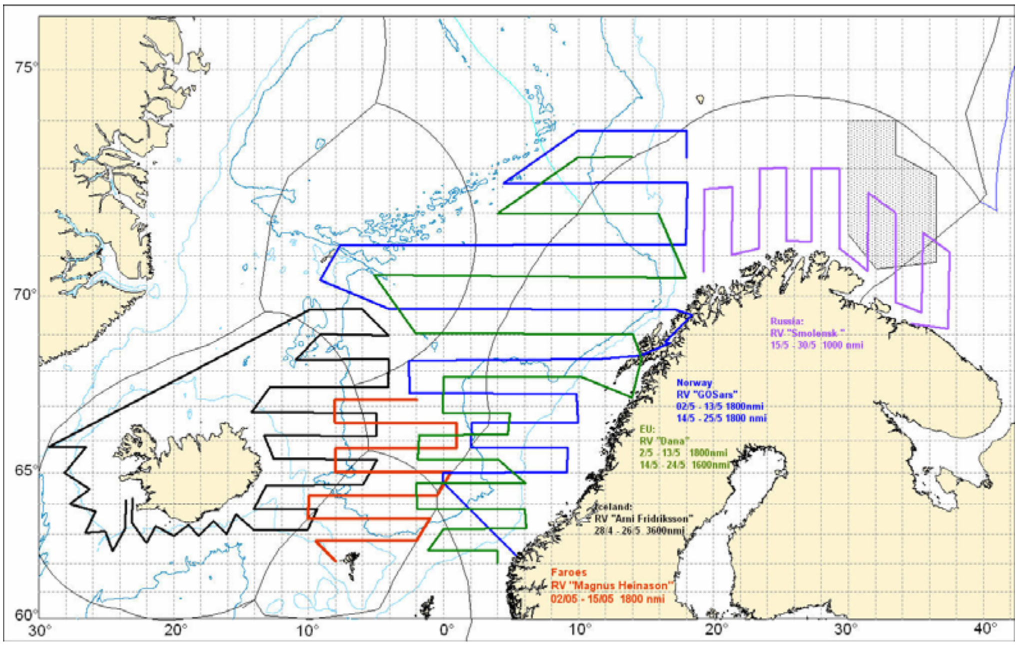


**Figure 5.2.1. Preliminary survey tracks for the 2009 International ecosystem survey in the Nordic Seas.**

# Annex 1: List of participants

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## Annex 2: International blue whiting spawning survey report

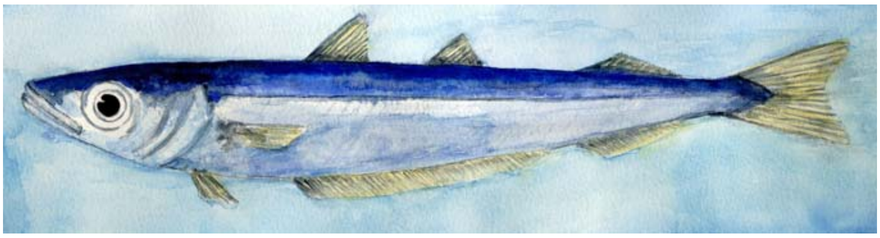
Working Document

# Planning Group on Northeast Atlantic Pelagic Ecosystem Surveys

Hirtshals, Denmark, 19-22 August 2008

# Working Group on Widely Distributed Stocks

ICES, Denmark, 2–11 September 2008



# INTERNATIONAL BLUE WHITING SPAWNING STOCK SURVEY SPRING 2008


Ciaran O'Donnel[1^]

Ciaran O'Donnel[1^*], Eugene Mullins[1], Graham Johnston[1], Eckhard Bethke[8], Get Holst[3], David Wall[9] - RV "Celtic Explorer"

Ivan Oganin[4], Sergey Harlin[4] - RV "Fridtjof Nansen"

Are Salthaug[2*], Valantine Anthonypillai[2*], Jarle Kristiansen[2], [2], Jan de Lange[2], Elna Meland[2] - FV "Gardar"

Jan Arge Jacobsen[5], Leon Smith[5*], Mourits Mohr Joensen[5], Fróði Skúvadal[5] - RV "Magnus Heinason"

Sytse Ybema[6], Thomas Pasterkamp[6], Kees Bakker[6], Joe Freijser[6], Eric Armstrong[7], Mathias Kloppman[8] and Dirk Tijssen[3] - RV "Tridens"

**1 Marine Institute, Galway, Ireland**

**2 Institute of Marine Research, Bergen, Norway**

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**6 Institute for Marine Resources & Ecosystem Studies, IJmuiden, The Netherlands**

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**8 Federal Research Institute for Fisheries, Hamburg**

**9 Irish Whale and Dolphin Group (NGO)**

*** Participated in the after-survey workshop**

**^ Survey coordinator in 2008**

## Introduction

In spring 2008, 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 cooperation allows for wider and more synoptic coverage of the stock and more rational utilization of resources than uncoordinated national surveys. The survey was the fifth 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 (F. Nansen: Oganin *et al*. 2008; Celtic Explorer: O'Donnell *et al*. 2008; M. Heinason: Jacobsen *et al*. 2008; Tridens: Ybema *et al.* 2008).

This report is based on a workshop held after the international survey in Kaliningrad, 23–25 April, 2008 where the data were analysed and the report written. Parts of the document were worked out through correspondence during and after the workshop.

## Material and methods

### Survey planning and Coordination

Coordination of the survey was initiated in the meeting of the Planning Group on Northeast Atlantic Pelagic Ecosystem Surveys (PGNAPES, ICES 2007) 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 |
|---|---|---|
| Fridtjof Nansen | PINRO, Murmansk, Russia | 24/3–14/4 |
| Celtic Explorer | Marine Institute, Ireland | 31/3–15/4 |
| Gardar | Institute of Marine Research, Norway | 29/3–06/4 |
| Magnus Heinason | Faroese Fisheries Laboratory, Faroe Islands | 05/4–16/4 |
| Tridens | Institute for Marine Resources & Ecosystem Studies, the Netherlands | 17/3–02/4 |

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

### Sampling equipment

All vessels employed a single vessel midwater trawl for biological sampling, the salient properties of which are given in Table 5. Acoustic equipment for data collection and processing are also presented in Table 5.The survey and abundance estimate are based on acoustic data collected through scientific echosounders using 38 kHz frequency. Transducers were calibrated with the standard sphere calibration (Foote *et al.* 1987) prior to the survey for all vessels. The Celtic Explorer system was not calibrated due to unfavourable conditions at the selected site at the end of the survey. However, the system was last calibrated in October and will be again calibrated in July. Any irregularities arising will be communicated to the group. Salient acoustic settings are summarized in Table 2.

During the survey, 3 acoustic inter-vessel calibrations were carried out (Appendix 1-3) following the methods described by Simmonds & MacLennan 2007.

Biological sampling

All components of trawl catches were sorted and weighed; fish were identified to species (when possible) and other taxa to higher taxonomic levels. The level of blue whiting sampling of by each vessel is shown in Table 5.

Hydrographic sampling

Hydrographic sampling by way of vertical CTD casts was carried out by each participant vessel (Figure 2 and Table 1) up to a minimum depth of 1,000m in open water. Hydrographic equipment specifications are summarized in Table 5.

#### Acoustic data processing

Acoustic scrutiny was mostly based on trawl information and subjective categorization. Post-processing software and procedures differed among the vessels. On Fridtjof Nansen, the FAMAS post-processing software was used as the primary post-processing tool for acoustic data. Data were partitioned into the following categories, blue whiting, 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 4.2) post-processing software for the previous day's work. Data was partitioned into the following categories; plankton (<120 m depth layer), mesopelagic species, blue whiting and plankton and mesopelagic species. Partitioning of data into the above categories was carried out by an experienced scientist.

On Gardar, 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 and characteristics of the recordings.

On Magnus Heinason, acoustic data were scrutinised every 24 hrs on board using Sonar data's Echoview (V 4.3) 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 4.30) 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.

#### Acoustic data analysis

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 subareas (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 200m.

To obtain an estimate of length distribution within each stratum, all length samples within that stratum were used. If the focal stratum was not sampled representatively, additional 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 ($\rho$) the following relationship was used:

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

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

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

## Results

### Inter-calibration results

In total three inter-vessel calibrations were performed. Results from the inter-calibration between RV "Celtic Explorer" and RV "Fridtjof Nansen" (acoustic only) and the RV "Celtic Explorer" and RV "Magnus Heinason" are summarized in Appendices 1 and 2 respectively. The results of the inter-calibration between RV "Tridens" and FV "Gardar" are summarized in Appendix 3.

The acoustic inter-calibration between the RV "C. Explorer" and the RV "F. Nansen" was carried out in an area with no blue whiting. As a result the exercise was carried out on a low density mesopelagic layer over a single 15 nautical mile transect, with the F. Nansen acting as lead vessel. The results show similar agreement considering the conditions and acoustic logs intervals show good agreement. No comparative tow was carried out due to the absence of targets. A synchronized CTD cast was carried out with 0.4nmi spatial distance between vessels to a maximum depth of 1000m. Analysis of results indicate that profiles show the difference between recorded temperatures was close to zero and for salinity within the whole profile did not exceed 0.005 psu.

The acoustic inter-calibration between the RV "C. Explorer" and the RV "M. Heinason" was second exercise carried out (first was in 2007) in an area with high density registrations of blue whiting. The exercise was performed over a single 15 nautical mile transect, with the M. Heinason acting as lead vessel. Data analysis we focused on acoustic densities allocated to blue whiting. Acoustic recordings show variable agreement, with M. Heinason obtaining larger values during the first part of the track, but better agreement in the second half of the track. This may be accounted for to a degree by spatial heterogeneity of schools as vessels were 0.5nmi apart (Figure 2). Data from the comparative trawl exercise showed vessels had a similar overall catchability. Celtic Explorer (mean length: 27.7 cm, range 24-36cm) and Magnus Heinason (mean length: 28cm, range 23.5-36cm). For the same trawling period the C. Explorer recorded a higher catch (250Kg compared to 150Kg). In 2007, the Celtic Explorer showed a tendency to capture larger individuals during the same exercise.

Between the RV "Tridens" and FV "Gardar" an intercalibration was carried out following the standard procedure described by Simmonds & McLennan 2007. The target was an average dense blue whiting layer. Acoustic recordings showed good relative agreement but Gardar showed slightly higher values on average. Blue whiting caught by Tridens had a slightly different length frequency distribution (mean length of 27.6 cm +/- 2.19) compared to blue whiting caught by Gardar (mean length 28.9 cm +/- 2.24).

### Distribution of blue whiting

Blue whiting were recorded all areas surveyed relating to a combined coverage of 127 thousand square nautical miles (Figures 4–6). The highest concentrations were recorded in the area between the Hebrides, Rockall and Faroe Banks and are consistent with the results from previous surveys. Schools with the greatest recorded density were observed by the Magnus Heinason to the north of the Rosemary Bank in the Hebrides subarea (Figure 7) but overall less variability in school density was detected this year compared to 2007.

In comparison to 2007, the biomass was comparatively distributed, with the exception of the southern subareas (Porcupine Bank) where a significant reduction in distribution was observed. Over 50% of the total-stock biomass was recorded in the Hebrides subarea, as observed in 2006 and 2007. With the exception of the southern and western extremes of the survey area, the 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 significant discrepancies occur, which can be attributed to spatial and temporal heterogeneity in the abundance of blue whiting and temporal heterogeneity in coverage by the different vessels.

### Stock size

The estimated total abundance of blue whiting for the 2008 international survey was 8 million tonnes, representing an abundance of $68 \times 10^9$ individuals (Table 3). The spawning stock was estimated at 7.9 million tonnes and $67 \times 10^9$ individuals. In comparison to the results in 2007, there is a significant decrease (30%) in the observed stock biomass and a related decrease in stock numbers whereas the survey area was not more than 6% lower than the previous year (see table below).

| | | 2004 | 2005 | 2006 | 2007 | 2008 | Change from 2007 (%) |
|---|---|---|---|---|---|---|---|
| Biomass (mill. t) | Total | 11.4 | 8.0 | 10.4 | 11.2 | 8.0 | –29 |
| | Mature | 10.9 | 7.6 | 10.3 | 11.1 | 7.9 | –29 |
| Numbers ($10^9$) | Total | 137 | 90 | 108 | 104 | 68 | –35 |
| | Mature | 128 | 83 | 105 | 102 | 67 | –35 |
| Survey area ($nm^2$) | | 149 000 | 172 000 | 170 000 | 135 000 | 127 000 | –6 |

The reduction in survey area occurred mainly in the peripheral areas which have had low acoustic densities of blue whiting in previous years. However, coverage in the periphery remains an important component of the survey as a whole. The shift in survey effort allowed for a more focused allocation of individual vessel effort into core areas of known abundance.

Biomass observed for all subareas was significantly reduced when compared to 2007. This reduction was most pronounced in the southern areas of the north and south Porcupine bank. The Hebrides subarea showed the lowest overall reduction across areas but still accounted for 22% decrease from 2007 observations.

| Sub-area | | Biomass (million tonnes) 2007 | 2007 % of total | 2008 | 2008 % of total | Change (%) |
|---|---|---|---|---|---|---|
| I | S. Porcupine Bank | 0.75 | 7 | 0.1 | 1 | -88 |
| II | N. Porcupine Bank | 1.8 | 16 | 1.2 | 15 | -33 |
| III | Hebrides | 5.3 | 47 | 4.13 | 52 | -22 |
| IV | Faroes/Shetland | 1.1 | 10 | 0.74 | 9 | -33 |
| V | Rockall | 2.3 | 20 | 1.8 | 23 | -21 |

### Stock composition

Individuals of ages 1 to 14 years were observed during the survey. Stock in the survey area is dominated by age classes 5 and 4 years, of the 2003 and 2004 year classes respectively, contributing 51% of spawning-stock biomass (Table 4, Figure 8).

Over 50% of the total spawning-stock biomass was recorded in the Hebrides subarea, as observed in 2006 and 2007. In general the age structure of stock in this area resembled that of the total survey area, with the exception of having a smaller proportion of older fish. (Figure 9).

Immature individuals were observed in all subareas. Nonetheless, the total proportion of immature fish follows a similar pattern to that observed in 2007 and represents less than 1.5% of the total-stock biomass. The proportion of juvenile fish was highest in the Hebrides subarea. Compared to 2007, a larger proportion of immature individuals were observed in Faroes/Shetland subarea (Table 3). A significant proportion 2 year old fish were found to be immature as compared to previous years. Maturity analysis indicates almost 50% of 2 year old fish were immature in the Hebrides as compared only 20% in the Faroes/Shetland subarea, relating to 35% overall. The length-at-age of 2 year olds was smaller than in previous years indicating a reduced growth rate for this particular age class (Figure 9).

### Hydrography

A combined total of 162 CTD casts were undertaken over the course of the survey. However, at this time the group was only able to produce vertical plots of temperature and salinity due to the absence of a physical oceanographer again at this year's post-cruise meeting. Horizontal plots of temperature and salinity at depths of 10m, 50m, 100 and 200m as derived from vertical CTD casts are displayed in Figures 10-13 respectively.

## Concluding remarks

### Main results

- The fifth international blue whiting spawning stock survey shows a significant decrease in stock biomass (29%) and a related decrease in stock numbers (34%) in comparison to the previous year's survey. The biomass estimate is comparable to the 2005 estimate. However, abundance in 2005 was bolstered by a series of strong year classes, namely the 2000 year class. In 2008, the same signals of prerecruits are not visible from the 2008 survey.
- The stock in the survey area is dominated age classes 5 and 4 years, of the 2003 and 2004 year classes respectively, which together account for 51% of spawning-stock biomass.
- Mean age (5.1 years), length (28.5 cm) and weight (117 g) are the highest on record in the international survey time-series.
- The survey area was reduced by almost 6% from 2007. Most of the reduction came from peripheral areas with low density in 2007, namely in the western extremes. Nonetheless, estimates for the peripheral areas would have been expected to be of a similar magnitude had the same coverage been achieved.
- Most of the decrease in the stock estimate in 2008 comes from the southern subareas (the Porcupine Bank) this is in contrast to the situation observed in 2007, where an increase was noted from the 2006 estimate. Many factors could potentially cause this difference. The most likely are: (1) a true reduction in abundance in these areas and (2) between-year variation in how well the survey cruise tracks "hit" fish concentrations (i.e. how well the survey captures the true spatial distribution).
- Increased proportion of immature 2 year olds (2006 year class) was observed from maturity analysis of 2008 data.
- The spawning-stock biomass appears to be maintained largely by growth of individuals in the spawning stock and to a lesser extent recruitment to the spawning stock.

### 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 temporal concentration of survey effort into a 4 week window was completed as planned to reduce the effects of double counting to a minimum. Temporal progression was consistent by participating vessels within core areas.
- Variability in the stock estimate from southern areas between 2007 and 2008 would suggest a possible mismatch in timing of peak spawning or spatial coverage due to highly localized aggregations. Temporal coverage in southern areas has remained constant throughout the time-series.

#### Recommendations

- Coordinated survey timing- was greatly improved this year as compared to previous years with the entire survey programme being undertaken within 4 weeks, as compared to 6 weeks in 2007. All members agreed that the temporal progression of the 2007 survey was too long and so positive action was taken to amend this situation. It is recommended this concentrated survey effort will be continued into 2009
- Since temporal and spatial distribution of blue whiting in the Porcupine area is highly variable, survey design needs to be more adaptive utilizing information from the commercial fleet to fine tune the effort allocation in this area prior to the survey.
- Preliminary survey tracks will be formulated at the PGNAPES 2008 meeting for surveys carried out in 2009. It is a requirement that all participants in the 2009 survey programme adhere to this pre-agreed allocation of survey effort
- Dedicated subgroup should be maintained within PGNAPES meeting to address issues arising from the survey programme in 2008
- Again for the second time we have had no dedicated hydrographer present at the post cruise meeting to review the oceanographic data. This is an untenable situation that needs to be addressed at PGNAPES 2008 and before the 2009 survey programme
- Continue and maintain established at sea communications with data summaries, fleet activity and survey findings during the survey. Discussion is to take place in the PGNAPES meeting on a standard information exchange format.
- A photographic species ID guide for all surveys will be circulated in draft form for review will be circulated at the PGNAPES 2008.
- Echoview Template. Leon Smith has updated Template (V9) 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 2009 survey it is recommended the templates are combined
- Intercalibration methods to be reviewed and the manual updated to include R-scripts and compatible data formats
- A member from each participant country should be present at the post cruise meeting to present the survey data and ensure the timely production of the combined cruise report
- Discussions are to take place in the PGNAPES sub meeting on how to use the Oracle database to streamline data extraction into "Beam" for the combined estimate

- Discussions are to take place in the PGNAPES meeting on how to use hydrographical data within this group.
- Discussions are to take place in the PGNAPES meeting mismatch between planned and executed survey tracks.
- Location of 2009 post cruise meeting will be in Galway, dates to be confirmed.

#### Achievements

- Good coverage of core distribution and outlying areas
- Much improved temporal progression of combined survey effort
- Improved coordination of survey effort both temporally and spatially
- All vessels undertook acoustic inter-vessel calibrations.

Timely delivery of data in the PGNAPES format

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## Tables and Figures

**Table 1. Survey effort by vessel. March-April 2008.**

| Vessel | Effective survey period | Length of cruise track (nm) * | Trawl stations | CTD stations | Aged fish | Length-measured fish |
|---|---|---|---|---|---|---|
| Fridtjof Nansen | 24/3–14/4 | 2461 | 18 | 62 | 1393 | 4801 |
| Celtic Explorer | 31/3–15/4 | 2480 | 15 | 28 | 750 | 2500 |
| Gardar | 29/3–06/4 | 1503 | 8 | 26 | 234 | 762 |
| Magnus Heinason | 04/4–16/4 | 1316 | 8 | 30 | 309 | 1031 |
| Tridens | 19/3–02/4 | 1413 | 19 | 15 | 950 | 951 |

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

**Table 2: Acoustic instruments and settings for the primary frequency. March-April 2008.**

| | Fridtjof Nansen | Celtic Explorer* | Gardar | Magnus Heinason | Tridens |
|---|---|---|---|---|---|
| Echo sounder | Simrad ES60 | Simrad EK 60 | Simrad EK 60 | Simrad EK 500 | Simrad EK 60 |
| Frequency (kHz) | 38, 120 | 38, 18, 120, 200 | 38 | 38 | 38 |
| Primary transducer | ES38B | ES 38B | ES 38B | ES38B | ES 38B |
| Transducer installation | Hull | Drop keel | Hull | Hull | Towed body |
| Transducer depth (m) | 4.5 | 8.7 | 9 | 3 | 7 |
| Upper integration limit (m) | 10 | 15 | 15 | 7 | 12 |
| Absorption coeff. (dB/km) | 10.1 | 9.9 | 9.8 | 10 | 9.7 |
| Pulse length (ms) | 1.024 | 1.024 | 1.024 | Medium | 1.024 |
| Band width (kHz) | 2.425 | 2.425 | 2.425 | Wide | 2.43 |
| Transmitter power (W) | 2000 | 2000 | 2000 | 2000 | 2000 |
| Angle sensitivity (dB) | 21.9 | 21.9 | 21.9 | 21.9 | 21.9 |

| | | | | | |
|---|---|---|---|---|---|
| 2-way beam angle (dB) | -20.73 | -20.6 | -20.6 | -20.9 | -20.6 |
| Sv Transducer gain (dB) | | | | 27.22 | 25.11 |
| Ts Transducer gain (dB) | 25.57 | 25.55 | 26.5 | 27.35 | |
| sA correction (dB) | -0.61 | -0.65 | -0.65 | | -0.67 |
| 3 dB beam width (dg) | | | | | |
| alongship: | 6.99 | 6.39 | 7.10 | 7.02 | 6.99 |
| athw. ship: | 6.99 | 6.67 | 7.10 | 6.86 | 6.96 |
| Maximum range (m) | 750 | 1000 | 900 | 750 | 750 |
| Post processing software | FAMAS | Sonardata Echoview | LSSS | Sonardata Echoview | Sonardata Echoview |

*** Indicates calibration results from October 2007.**

**Table 3. Assessment factors of blue whiting. March-April 2008.**

| Sub-area | | | Numbers ($10^9$) | | | Biomass ($10^6$ tonnes) | | | Mean weight | Mean length | Density |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | n.mile² | Mature | Total | %mature | Mature | Total | %mature | g | cm | ton/n.mile² |
| I | S. Porcupine Bank | 9986 | 0.75 | 0.77 | 97 | 0.1 | 0.1 | 97 | 120 | 28.7 | 9 |
| II | N. Porcupine Bank | 22128 | 10.3 | 10.3 | 100 | 1.2 | 1.2 | 100 | 116 | 28.7 | 54 |
| III | Hebrides | 33237 | 36 | 36.6 | 99 | 4.1 | 4.1 | 100 | 113 | 28.3 | 124 |
| IV | Faroes/Shetland | 14426 | 5.2 | 5.85 | 89 | 0.7 | 0.74 | 96 | 126 | 27.6 | 51 |
| V | Rockall | 47043 | 14.4 | 14.4 | 100 | 1.8 | 1.8 | 100 | 125 | 29.2 | 38 |
| Tot. | | 126821 | 66.7 | 67.9 | 98.1 | 7.9 | 8.0 | 99 | 117 | 28.5 | 63 |

**Table 4. Stock estimate of blue whiting, March-April 2008.**

| | Age in years (year class) | | | | | | | | | | Numbers | Biomass | Mean | Prop. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Length | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10+ | | | weight | mature* |
| (cm) | 2007 | 2006 | 2005 | 2004 | 2003 | 2002 | 2001 | 2000 | 1999 | 1998 | ($10^6$) | ($10^6$ kg) | (g) | (%) |
| 16.0 – 17.0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 21 | 0 |
| 17.0 – 18.0 | 38 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 38 | 1.1 | 29.4 | 0 |
| 18.0 – 19.0 | 126 | 61 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 187 | 6.3 | 33.9 | 28 |
| 19.0 – 20.0 | 265 | 246 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 511 | 18.4 | 36 | 10 |
| 20.0 – 21.0 | 246 | 189 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 435 | 18.4 | 42.4 | 33 |
| 21.0 – 22.0 | 216 | 341 | 10 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 570 | 27.4 | 48.2 | 55 |
| 22.0 – 23.0 | 21 | 156 | 186 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 362 | 22.1 | 60.9 | 72 |
| 23.0 – 24.0 | 42 | 243 | 43 | 106 | 0 | 0 | 0 | 0 | 0 | 0 | 434 | 29.4 | 67.7 | 97 |
| 24.0 – 25.0 | 0 | 260 | 401 | 365 | 10 | 53 | 0 | 0 | 0 | 0 | 1088 | 81.5 | 74.9 | 96 |
| 25.0 – 26.0 | 0 | 176 | 1047 | 1796 | 428 | 86 | 0 | 0 | 0 | 0 | 3531 | 297.3 | 84.2 | 100 |
| 26.0 – 27.0 | 0 | 0 | 1448 | 5414 | 1893 | 267 | 103 | 0 | 0 | 0 | 9125 | 834.1 | 91.4 | 100 |
| 27.0 – 28.0 | 0 | 0 | 918 | 5205 | 5167 | 1972 | 376 | 70 | 0 | 0 | 13709 | 1387 | 101.2 | 100 |
| 28.0 – 29.0 | 0 | 0 | 282 | 3640 | 5670 | 2654 | 794 | 291 | 19 | 0 | 13350 | 1484.5 | 111.2 | 100 |
| 29.0 – 30.0 | 0 | 0 | 94 | 776 | 4224 | 2822 | 1183 | 394 | 14 | 37 | 9545 | 1173.8 | 123 | 100 |
| 30.0 – 31.0 | 0 | 0 | 14 | 244 | 1589 | 1565 | 1353 | 377 | 72 | 220 | 5434 | 753.3 | 138.6 | 100 |
| 31.0 – 32.0 | 0 | 0 | 0 | 137 | 735 | 989 | 885 | 380 | 87 | 157 | 3370 | 523.1 | 155.3 | 100 |
| 32.0 – 33.0 | 0 | 0 | 0 | 0 | 243 | 638 | 521 | 665 | 46 | 66 | 2179 | 377.7 | 173.3 | 100 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 33.0 – 34.0 | 0 | 0 | 0 | 74 | 185 | 358 | 364 | 378 | 92 | 110 | 1561 | 295.8 | 189.5 | 100 |
| 34.0 – 35.0 | 0 | 0 | 0 | 57 | 0 | 156 | 278 | 289 | 89 | 3 | 872 | 184.5 | 211.5 | 100 |
| 35.0 – 36.0 | 0 | 0 | 0 | 0 | 0 | 17 | 318 | 87 | 128 | 127 | 677 | 155.9 | 230.2 | 100 |
| 36.0 – 37.0 | 0 | 0 | 0 | 0 | 0 | 57 | 96 | 71 | 82 | 47 | 353 | 89.6 | 254.2 | 100 |
| 37.0 – 38.0 | 0 | 0 | 0 | 0 | 0 | 25 | 35 | 15 | 37 | 79 | 191 | 48.3 | 252.9 | 100 |
| 38.0 – 39.0 | 0 | 0 | 0 | 0 | 0 | 37 | 49 | 55 | 6 | 15 | 162 | 54.1 | 333 | 100 |
| 39.0 – 40.0 | 0 | 0 | 0 | 0 | 0 | 14 | 27 | 21 | 65 | 7 | 134 | 44.4 | 331.5 | 100 |
| 40.0 – 41.0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 0 | 54 | 2 | 65 | 24.6 | 381.6 | 100 |
| 41.0 – 42.0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 38 | 63 | 24.8 | 395.5 | 100 |
| TSN ($10^6$) | 956 | 1672 | 4443 | 17814 | 20144 | 11710 | 6418 | 3093 | 791 | 908 | 67948 | | | |
| TSB ($10^6$ kg) | 40.1 | 98.1 | 409.4 | 1785.6 | 2273 | 1501.1 | 975.8 | 521.1 | 177.8 | 175.6 | 7957.5 | | | |
| Mean length (cm) | 20.2 | 22.3 | 26.3 | 27.3 | 28.6 | 29.6 | 31 | 31.9 | 34.7 | 33.4 | 28.5 | | | |
| Mean weight (g) | 41.9 | 58.7 | 92.2 | 100.2 | 112.8 | 128.2 | 152 | 168.4 | 225.1 | 192.9 | 117.1 | | | |
| Condition (g/dm$^3$) | 5.1 | 5.3 | 5.1 | 4.9 | 4.8 | 4.9 | 5.1 | 5.2 | 5.4 | 5.2 | 5.1 | | | |
| % mature* | 23 | 64 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 98.1 | | | |
| % of SSB | 0 | 1 | 5 | 23 | 29 | 19 | 12 | 7 | 2 | 2 | | | | |

*** Percentage of mature individuals per age or length class**

**Table 5. Country and vessel specific details, March-April 2008.**

| | Fridtjof Nansen | Celtic Explorer | Gardar* | Magnus Heinason | Tridens |
|---|---|---|---|---|---|
| *Trawl dimensions* | | | | | |
| Circumference (m) | 716 | 768 | 2400 | 640 | 1120 |
| Vertical opening (m) | 50 | 50 | 140 | 40 | 30-70 |
| Mesh size in codend (mm) | 16 | 20 | 40 | 40 | ±20 |
| Typical towing speed (kn) | 2.7-3.3 | 3.5-4.0 | 3.5-4.0 | 3.0-4.0 | 3.5-4.0 |
| | | | | | |
| *Biological sampling* | | | | | |
| Length Only | | | | | 200 |
| Lenth/Weight | 200 | 100 | 70 | 100 | |
| Length/Weight/Sex/Maturity | 100 | 50 | 30 | 100 | 50 |
| | | | | | |
| *Hydrographic sampling* | | | | | |
| CTD Unit | SBE911 | SBE911 | SBE911 | SBE911 | SBE911 |
| Standard sampling depth | 1000 | 1000 | 1000 | 1000 | 1000 |
| | | | | | |

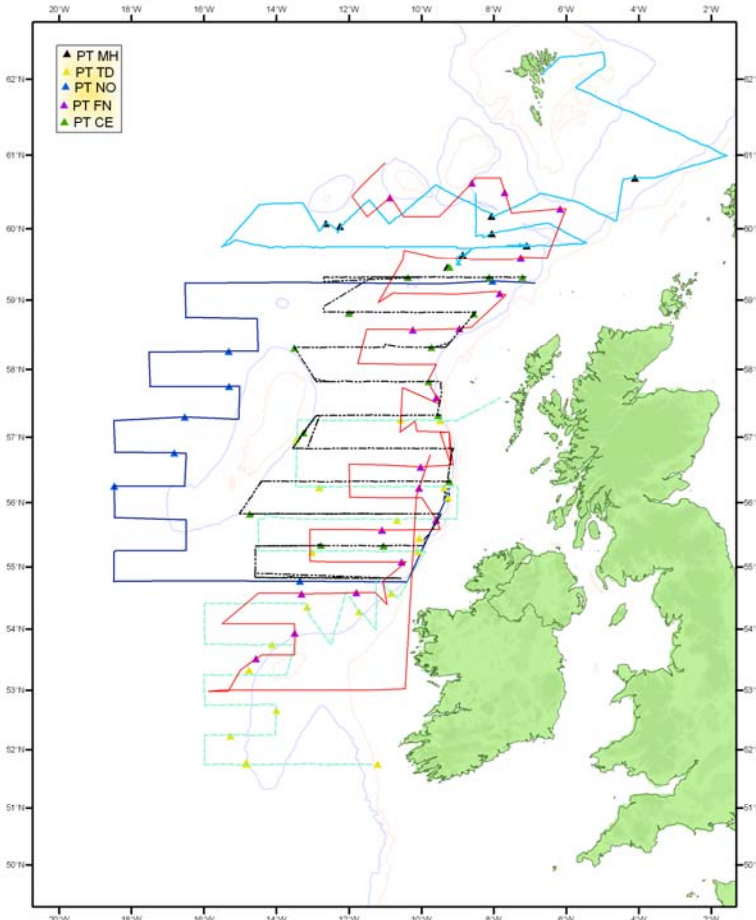



**Figure 1. Combined vessel cruise tracks and trawl stations. CE: Celtic Explorer; MH: Magnus Heinason; TD: Tridens; FN: Fridtjof Nansen: NO: Gardar. March-April 2008.**

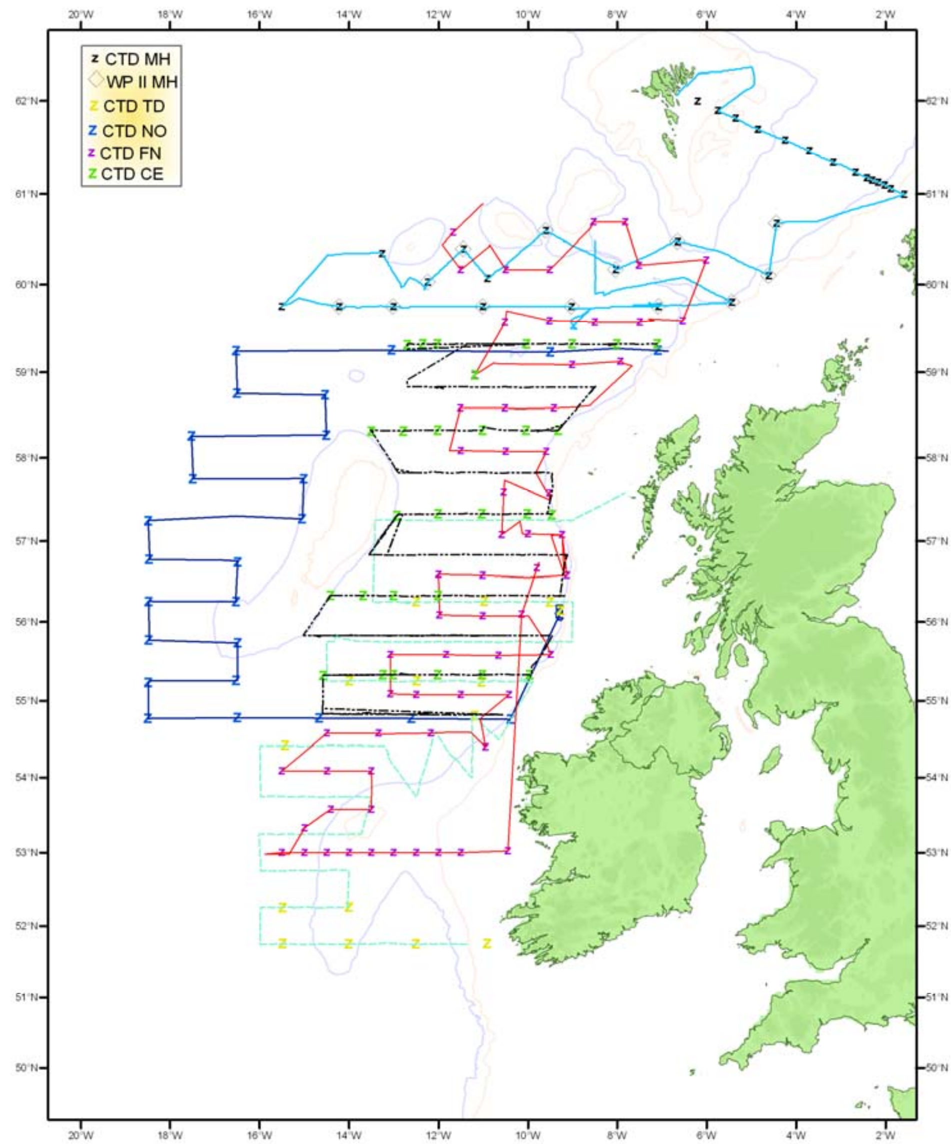



**Figure 2. Combined CTD stations overlaid onto vessel cruise tracks. CE: Celtic Explorer; MH: Magnus Heinason; TD: Tridens; FN: Fridtjof Nansen: NO: Gardar. March-April 2008.**

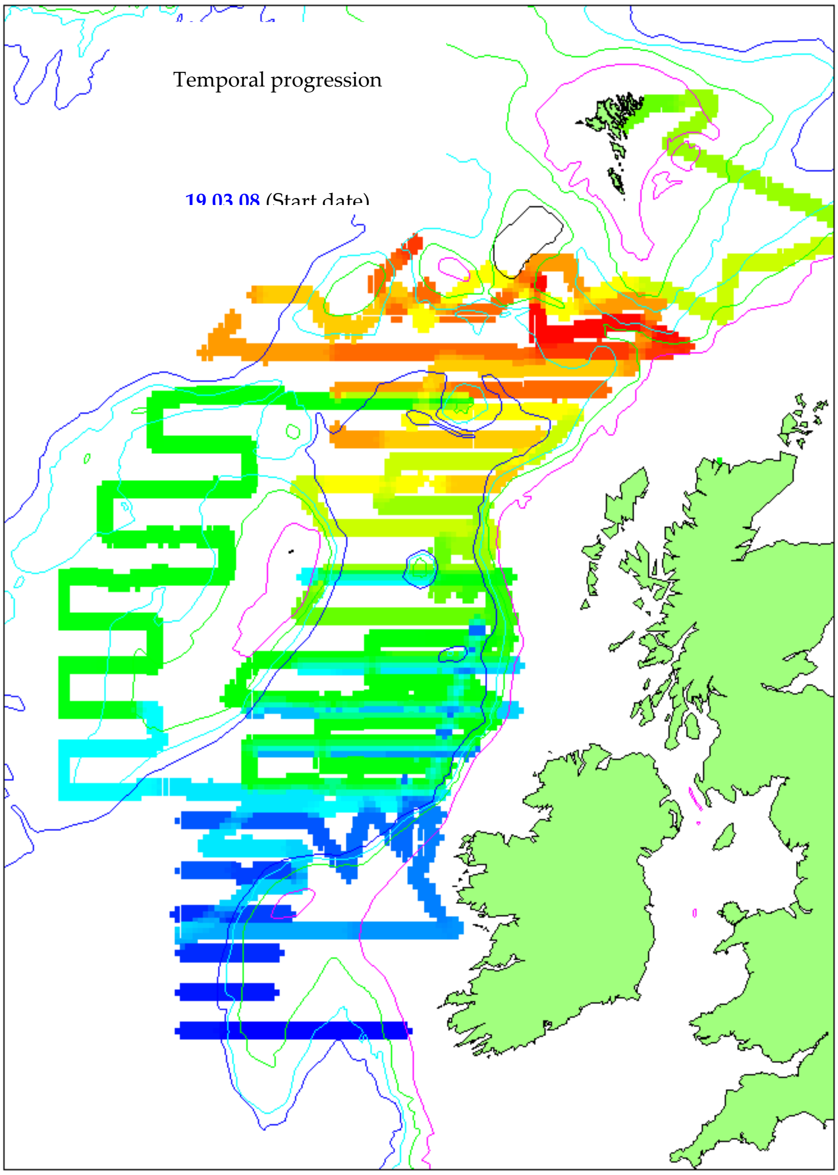



**Figure 3. Temporal progression of the combined survey, 19 March–15 April 2008**

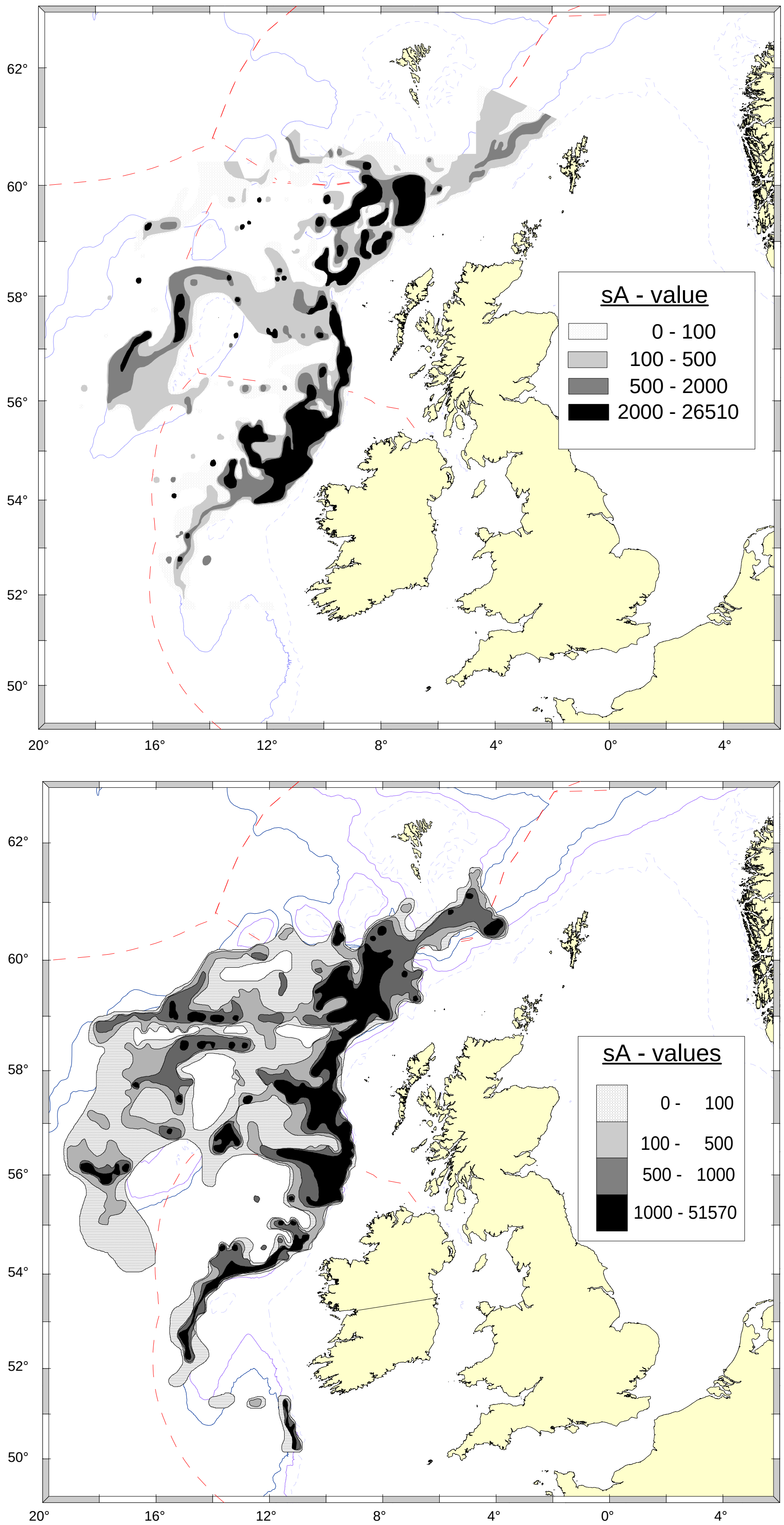



**Figure 4. Schematics maps of combined blue whiting acoustic density ($s_A$, $m^2/nm^2$) in March-April 2007 (lower panel) and 2008 (upper panel).**

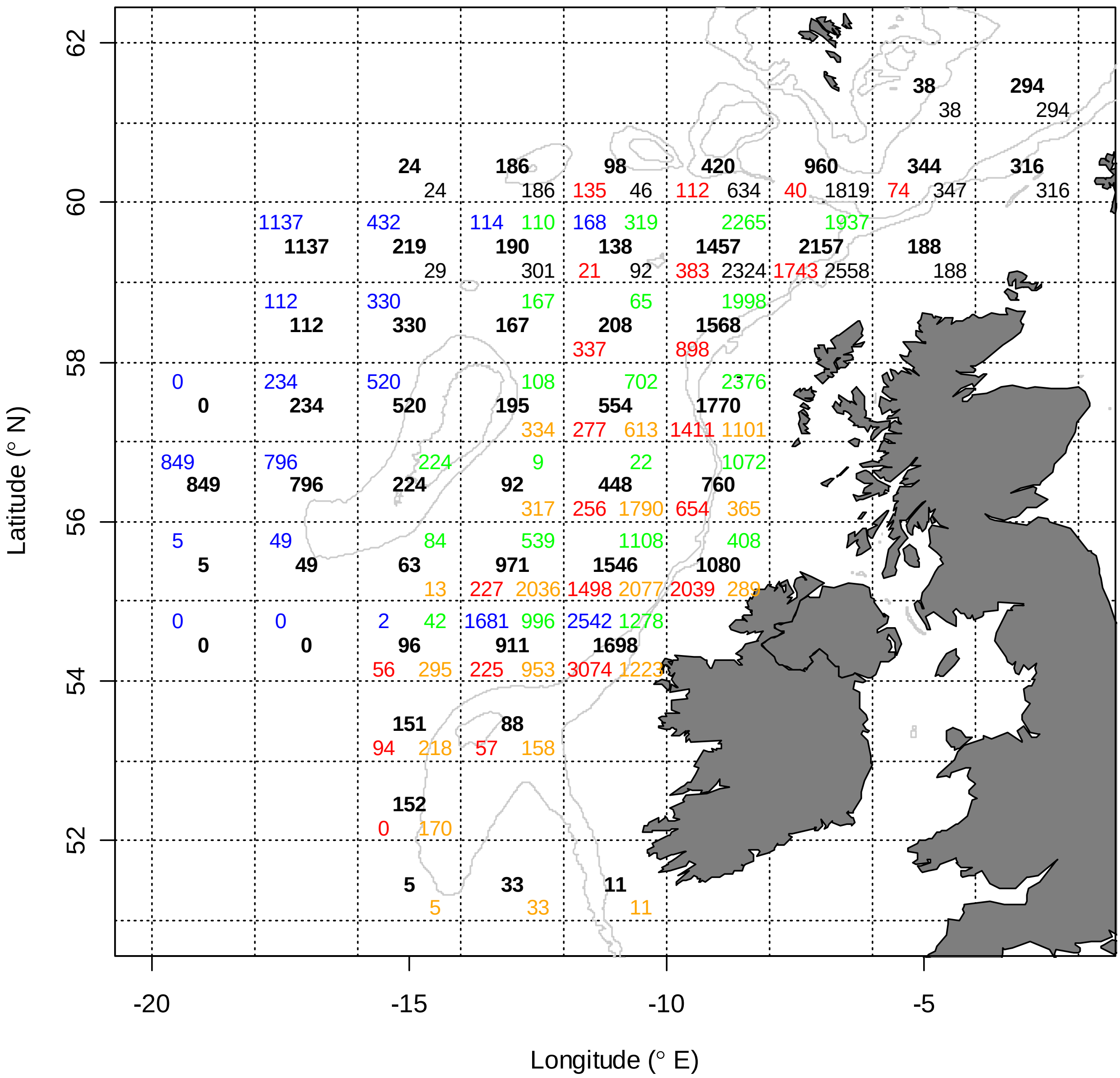



**Figure 5. Mean blue whiting acoustic density ($s_A$, m²/nm²) for all vessels combined and for each individual vessel: Celtic Explorer: green, Magnus Heinason: grey, Netherlands: orange, Fridtjof Nansen: red, Gardar: blue. Combined totals are displayed in the middle of the square in bold black.**March-April 2008

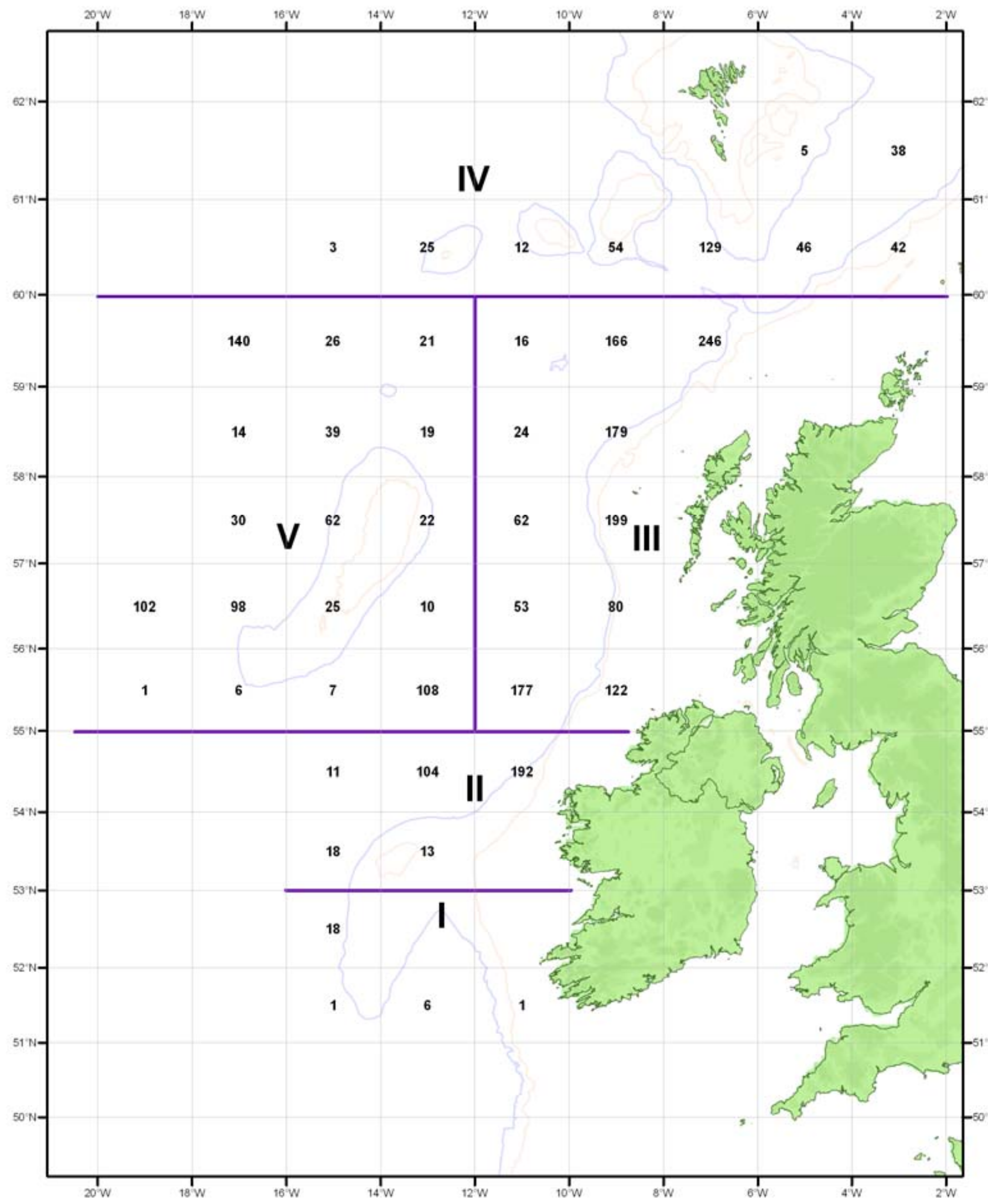



**Figure 6. Blue whiting biomass in 1000 tonnes by subarea as used in the assessment. March-April 2008.**

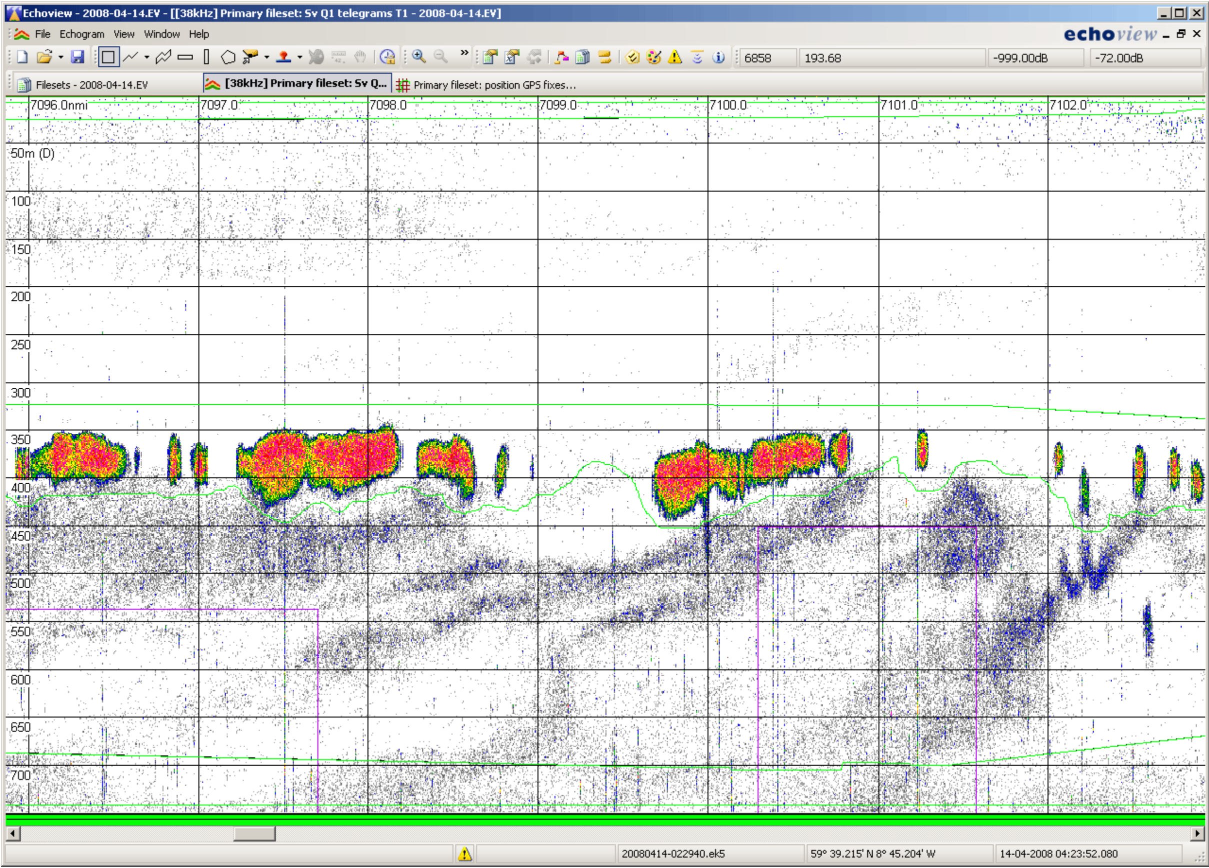
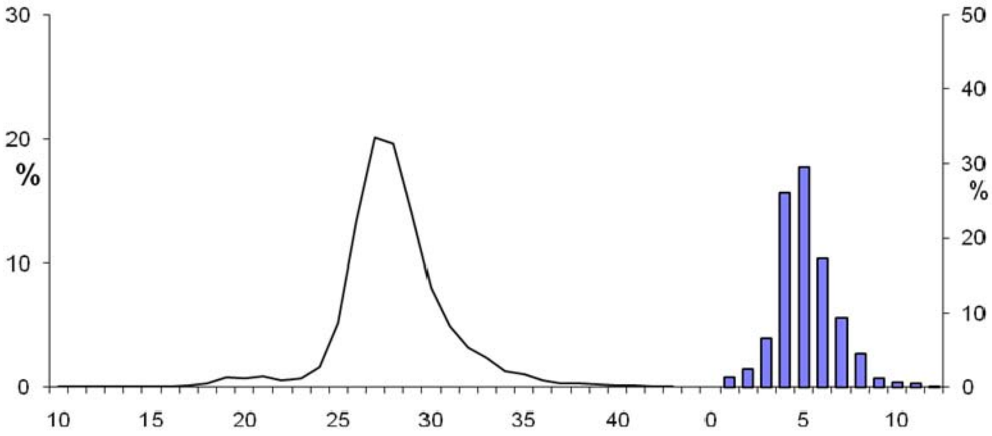
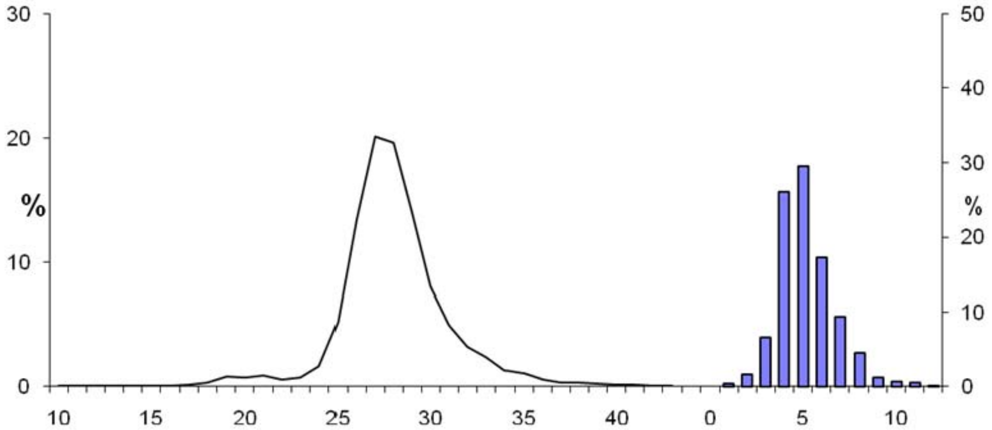



**Figure 7. Typical high density school observed by the RV "Magnus Heinason" to the north of the Rosemary Bank in the Hebrides subarea. March-April 2008.**

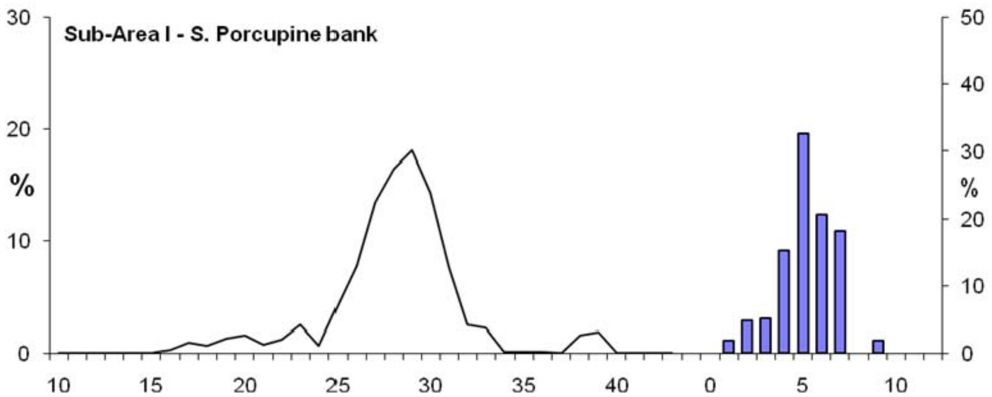


TOTAL STOCK: **8.0 mill. Tonnes, 67 946 mill. Individuals.**



SPAWNING STOCK: **7.9 mill. Tonnes, 66 658 mill. Individuals**

**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. March-April 2008.**



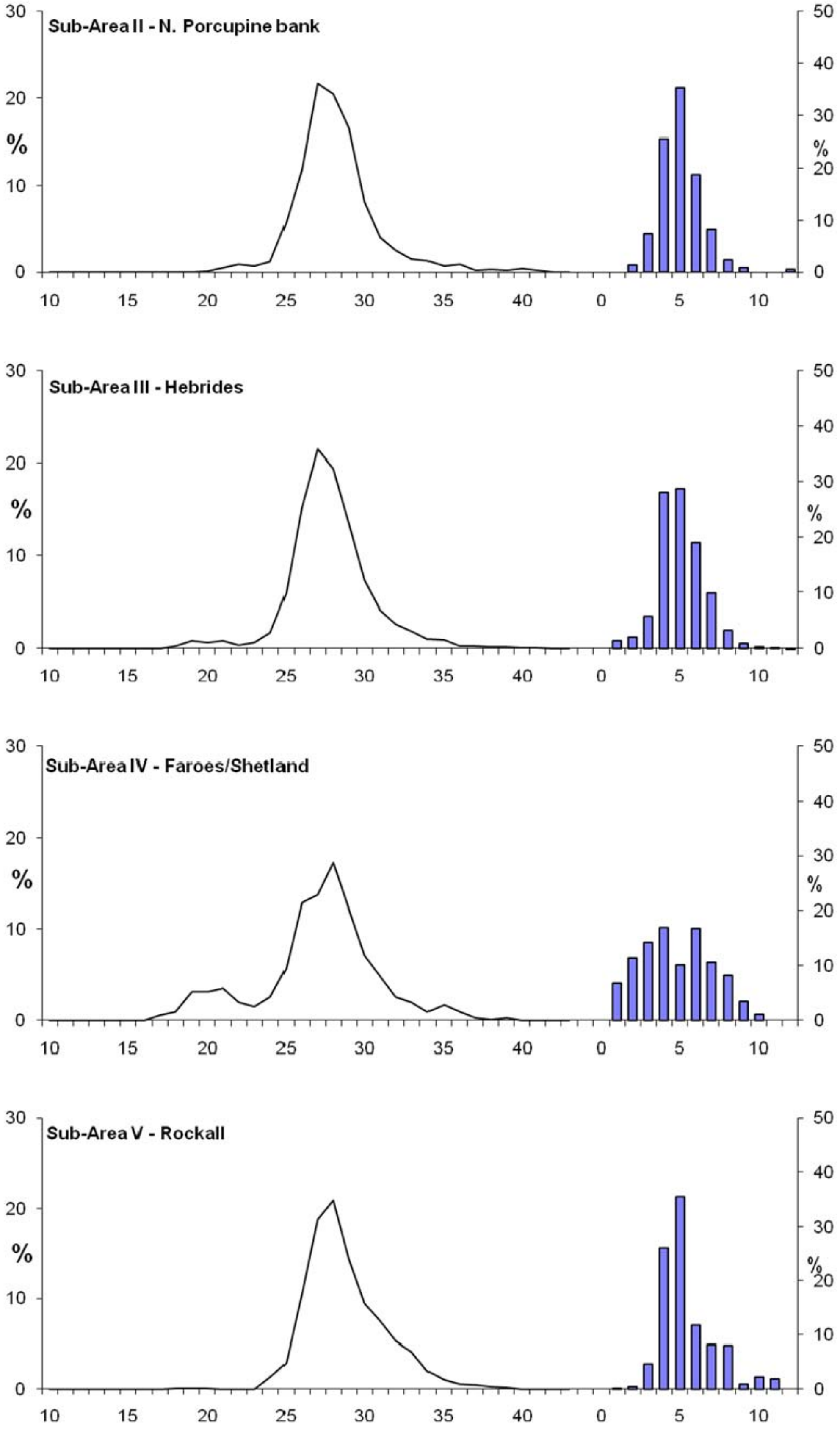



**Figure 9. Length and age distribution (numbers) of blue whiting by subareas (I–V). March-April 2008.**

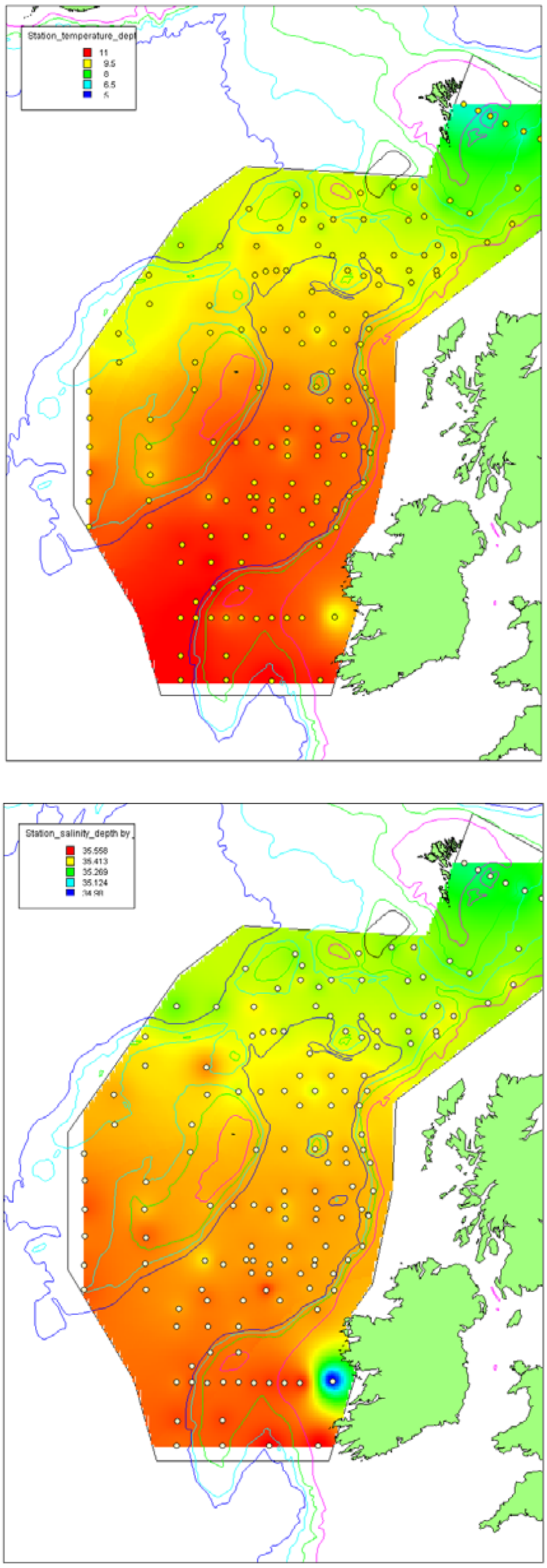



**Figure 10. Horizontal temperature (top panel) and salinity (bottom panel) at 10m subsurface as derived from vertical CTD casts. Yellow circles indicate CTD positions. March-April 2008.**

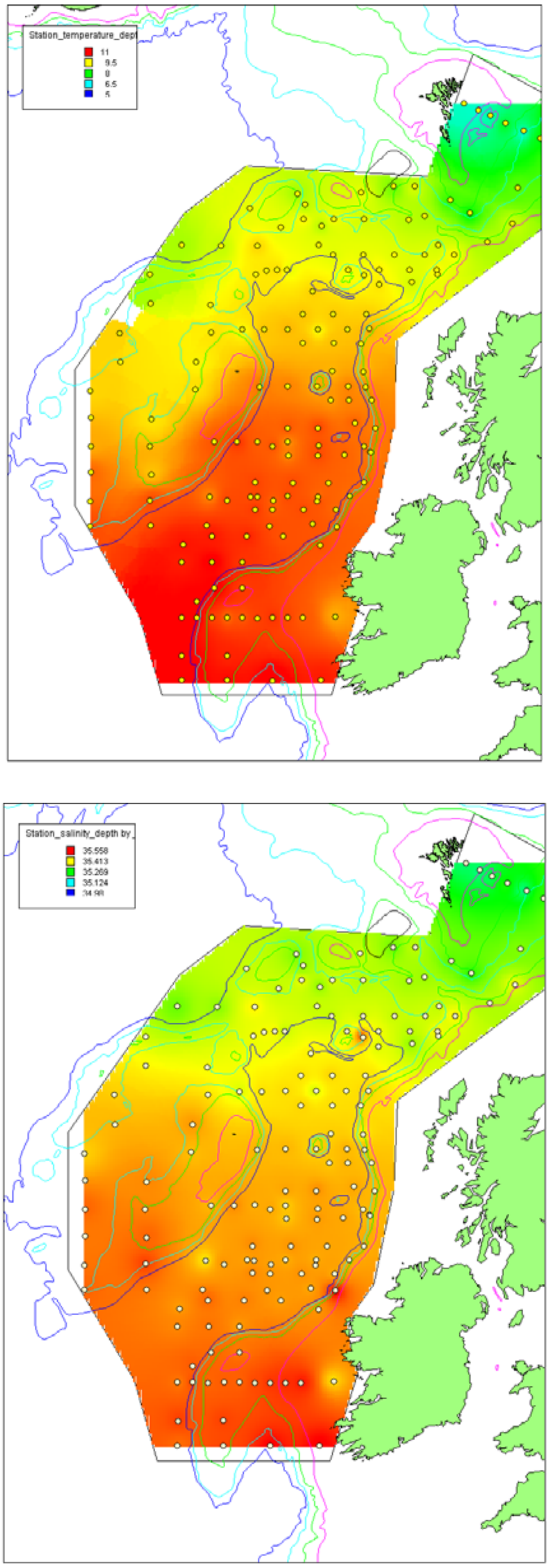



**Figure 11. Horizontal temperature (top panel) and salinity (bottom panel) at 50m as derived from vertical CTD casts. Yellow circles indicate CTD positions. March-April 2008.**

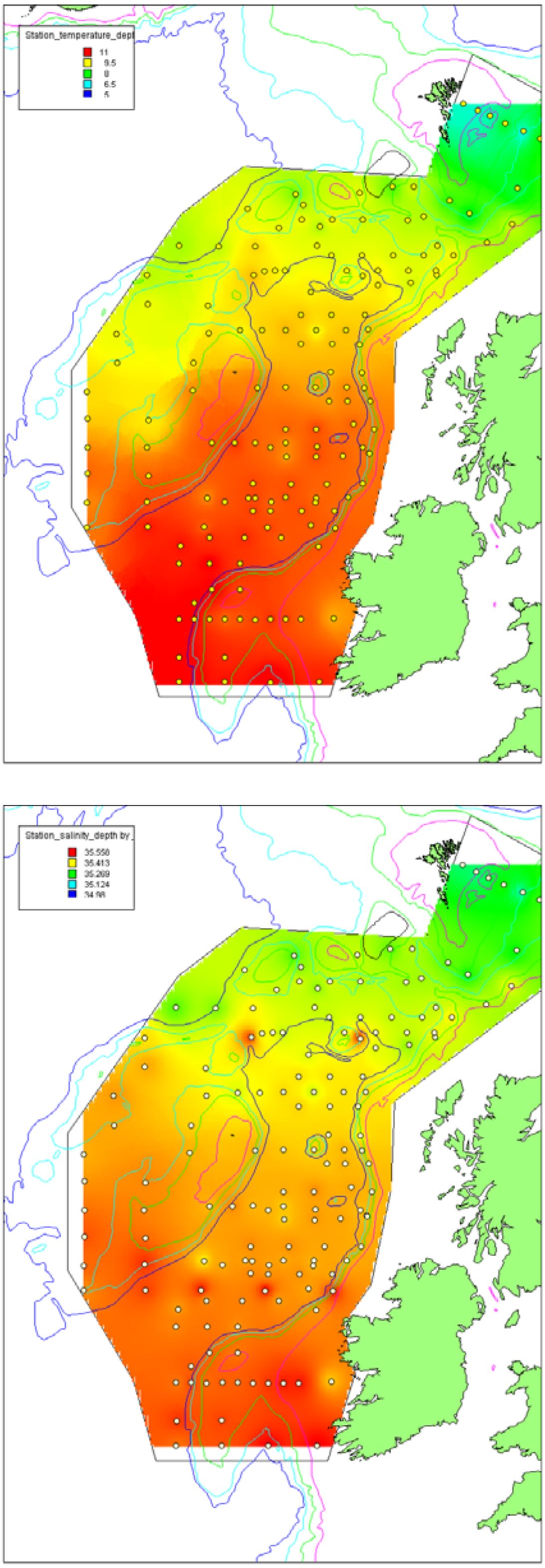



**Figure 12. Horizontal temperature (top panel) and salinity (bottom panel) at 100m as derived from vertical CTD casts. Yellow circles indicate CTD positions. March-April 2008.**

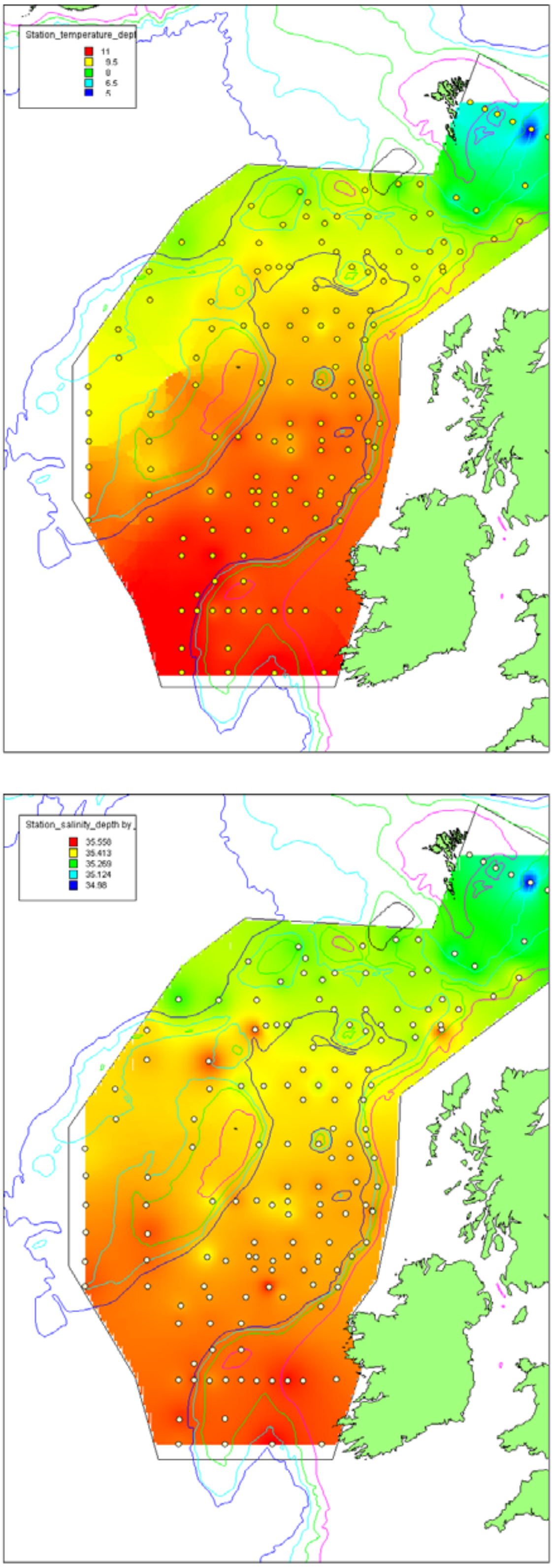



**Figure 13. Horizontal temperature (top panel) and salinity (bottom panel) at 200m as derived from vertical CTD casts. Yellow circles indicate CTD positions. March-April 2008.**

## Appendix 1: Inter-calibration between RV "Celtic Explorer" and RV "Fridtjof Nansen"

Acoustic inter-calibration between RV "Celtic Explorer" and RV "Fridtjof Nansen" was conducted on April 10 to the southwest of the Rosemary Bank. The weather conditions were moderate with winds recorded at 5-20kts from the E and moderate swell of 2.5m from the N. The main acoustic features in the area were lacking with no visible signs of blue whiting schools in the area. As a result it was decided to compare the backscatter from a mesopelagic layer present at approximately 150m.

The exercise was carried out over a single 15nmi transect with the F. Nansen acting as lead vessel cruising at 7kts and beginning at 15:35 at position 59°07'N and 010°45W. The Explorer followed at 0.4nmi and 0.5 degrees to port of the F. Nansen. Transect orientation was aligned to run with the prevailing wind direction to reduce the effects of data drop outs on the hull mounted transducer on board the F. Nansen. The requested ER 60 settings from the F. Nansen were adopted by the Explorer (ping rate 1.2; bottom detection minimum 750, max 790m).

In the data analysis the entire channel data (surface to 750m) for each 1nmi ESDU was analysed as no obvious schools were visible. Figure 1 shows acoustic densities recorded by the two vessels and for each ESDU. Acoustic recordings show a degree of agreement with the exception of the second mile interval. From 4 to 15nmi the recorded data are similar considering the low density of the layer surveyed. Overall, it appears that the C. Explorer is recording slightly higher densities than observed by the F. Nansen. However, this may be attributed by the spatial heterogeneity of the low density mesopleagic layer. .

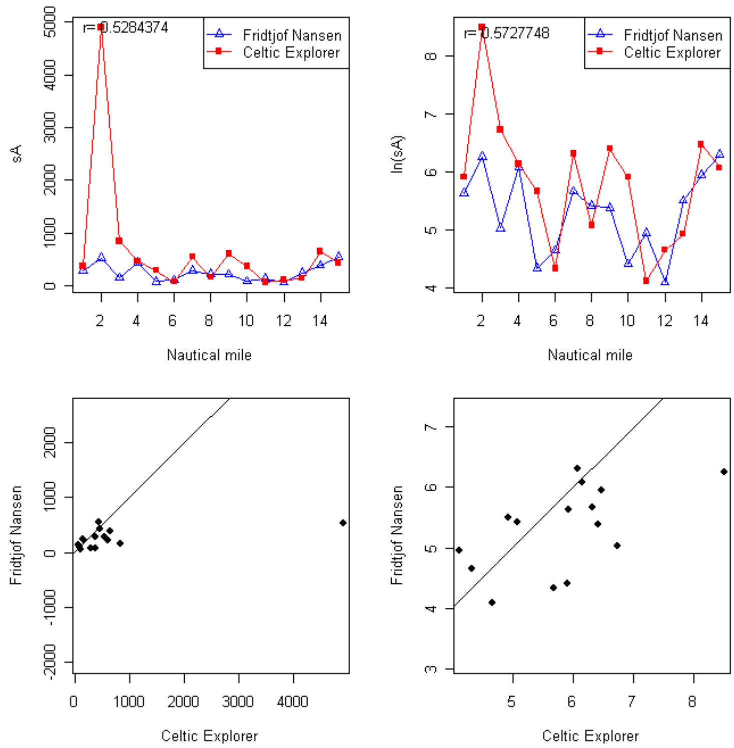



**Figure 1. Comparison of blue whiting acoustic densities recorded by Fridtjof Nansen (open triangles) and Celtic Explorer (squares). The lower panels show the data as scatterplots. The diagonals are drawn as continuous lines.**

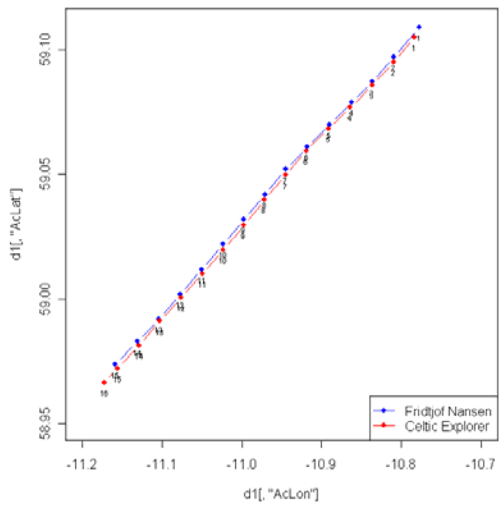



**Figure 2. Intercalibration track followed by the Fridtjof Nansen (blue squares) and Celtic Explorer (red squares).**

At log intervals of 12-14nmi vessels appear to be most aligned and this is reflected in the acoustic observations recorded. Considering the availability of targets during the exercise the exercise was indeed useful and sufficed to say that intercalibration exercises on low density acoustic registrations of mesopelagic layer are not ideal.

## Appendix 2: Inter-calibration between RV "Celtic Explorer" and RV "Magnus Heinason"

Acoustic inter-calibration between RV "Celtic Explorer" and RV "Magnus Heinason" was conducted on April 13 at 23:40 to the northeast of the Rosemary Bank at position 59 28.07N and 008 50.84W and took a westward direction over a 15nmi single transect with the M. Heinason acting as the lead vessel cruising at 8.5 knots for 15 nm to position 59 28.04N and 009 20.11W. Weather conditions were moderate with winds of 25 knots from the N and a northerly swell of 3-3.5 m.

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.

Data analysis 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 allocated to blue whiting. The recordings show variable agreement. Recordings by the Celtic Explorer appear more consistent and less variable than those recorded by the M. Heinason for most of the recorded transect. Two distinct areas of interest are visible. First, at 5-9 nm medium density schools are recorded progressing to an area of lower density. The second, from 10-14 nm shows a similar pattern of acoustic density. The recording of the M. Heinason show much greater mile by mile variability with sharp contrasts in recorded values between successive miles. This may be accounted for to a degree by spatial heterogeneity of schools as vessels were 0.5 nm apart (Figure 2).

At the end of the acoustic inter-calibration a comparative trawl exercise was undertaken. Both vessels turned and towed in parallel over the area that acoustic integration was carried out at a distance of about 0.3 nm apart. Celtic Explorer actively towed for 20 minutes at depths of 410–460 m and caught 250 kg of blue whiting. Magnus Henson towed in the same depth for the same time and caught 150 kg of blue whiting.

The blue whiting in the catch of Celtic Explorer were larger in mean length (mean length: 27.7 cm, range 24-36 cm) compared to the blue whiting in the catch of Magnus Heinason (mean length: 28cm, range 23.5-36cm) as shown in Figure 3. The results indicate that both the Celtic Explorer and the Magnus Heinason equally captured similar blue whiting size classes with no bias towards smaller or larger individuals. In 2007, the Celtic Explorer showed a tendency to capture slightly larger individuals during the same exercise. However, this may be some way attributed to the spatial heterogeneity of schools encountered.

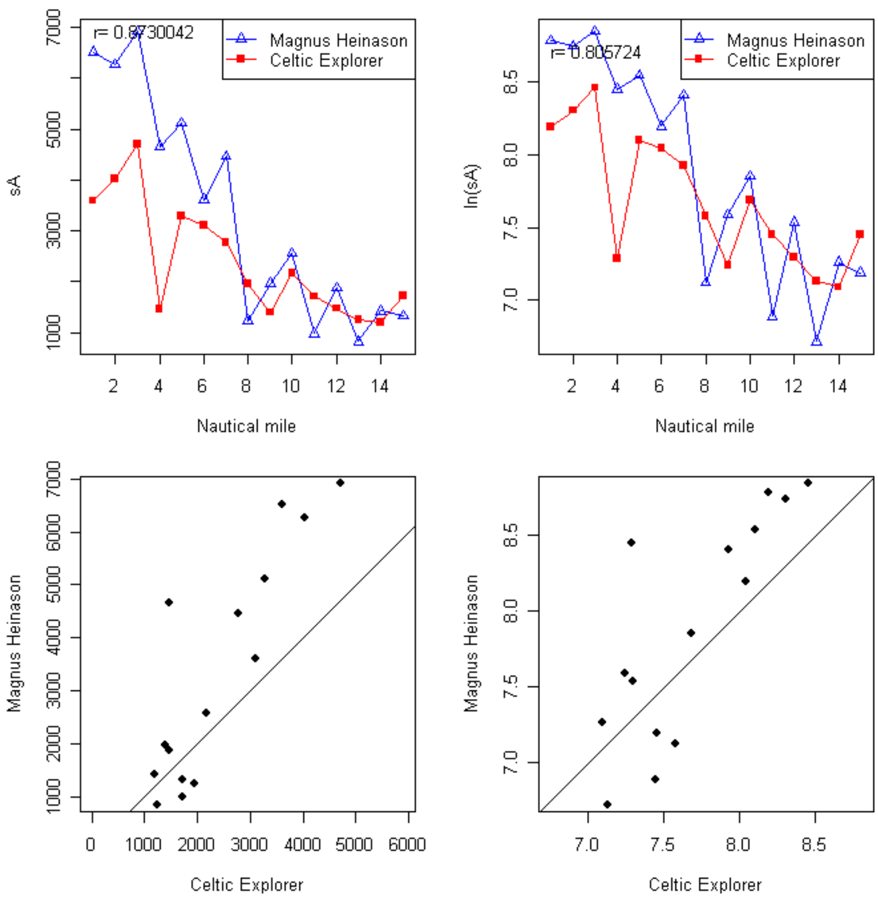



**Figure 1. Comparison of blue whiting acoustic densities recorded by Magnus Heinason (open triangles) and Celtic Explorer (squares). The lower panels give same data as scatterplots. The diagonals are drawn as continuous lines.**

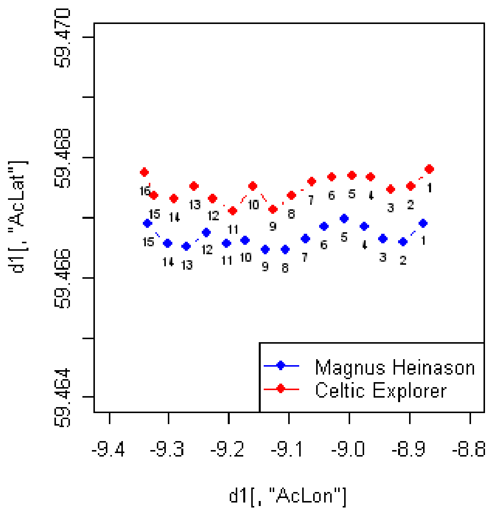



**Figure 2. Intercalibration track followed by the Magnus Heinason (blue diamonds) and Celtic Explorer (red diamonds).**

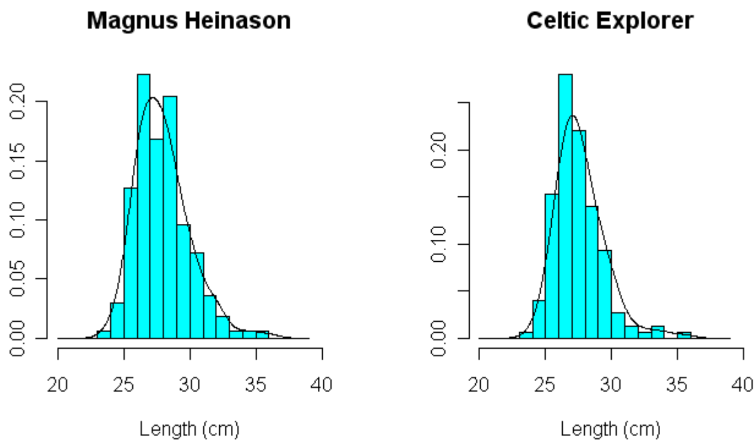



**Figure 3. Length distributions from the trawls hauls by Magnus Heinason and Celtic Explorer. Smoothing is obtained by normal kernel density estimates.**

## Appendix 3: Inter-calibration between RV "Tridens" and FV "Gardar" (Norwegian charter vessel)

An acoustic inter-calibration between RV "Tridens" and FV "Gardar" was conducted on March 29 from about 07.26 to 11.05hrs UTC. The weather was moderate (4m swells from W). The main acoustic features in the area were a layer of blue whiting up to 50m thick, in depths between 400 and 600m and a layer presumed to be plankton and mesopelagic fish in the uppermost 200m. Both layers followed a North/South contour. Inter-vessel calibration was done according to the standard given in Simmonds & McLennan 2007 (Figure 1) where both vessel get the opportunity to take the lead in order to exclude any vessel avoidance differences. The inter-calibration was run over 30 nautical miles between 07:26 -11:05hrs UTC (Figure 1). Vessels cruised at 10 knots on parallel courses, with the distance between the tracks being approximately 0.5 nm.

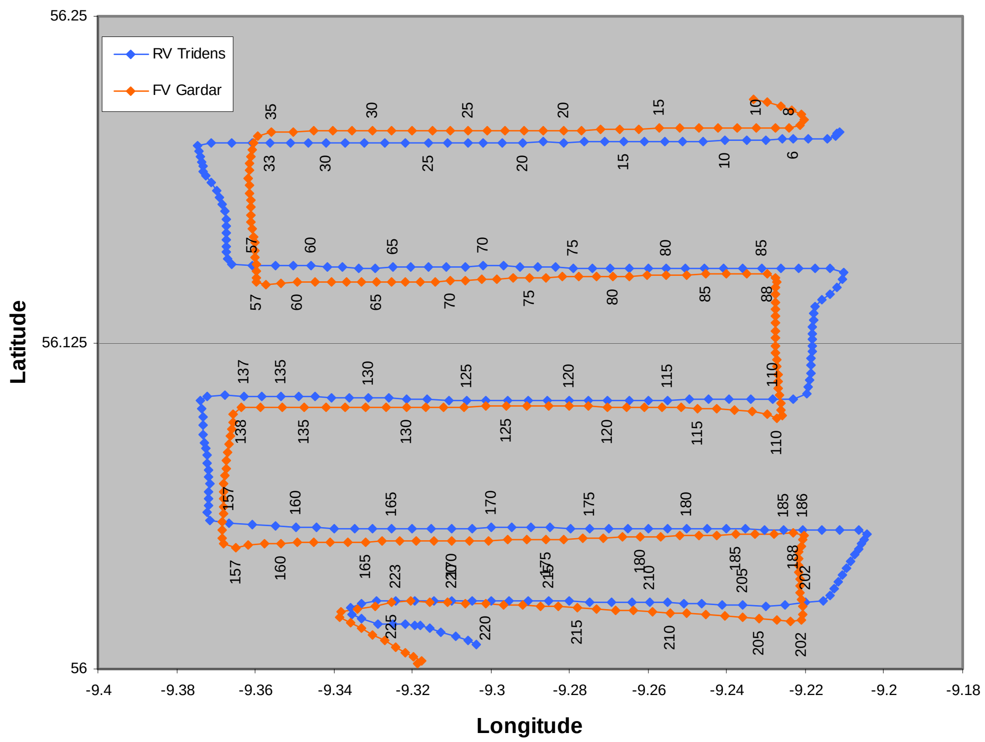



**Figure 1. Cruise tracks of RV "Tridens" and FV "Gardar". Numbers are in minutes from start of intercalibration, showing the temporal difference in tracks.**

### Acoustic comparison

In the data analysis we focused on acoustic densities (aA, m2/nm2) allocated to blue whiting. On both vessels routine procedures were followed for scrutinizing the data. Figure 2 shows acoustic densities recorded by the two vessels, allocated to blue whiting and adjusted for positional differences.

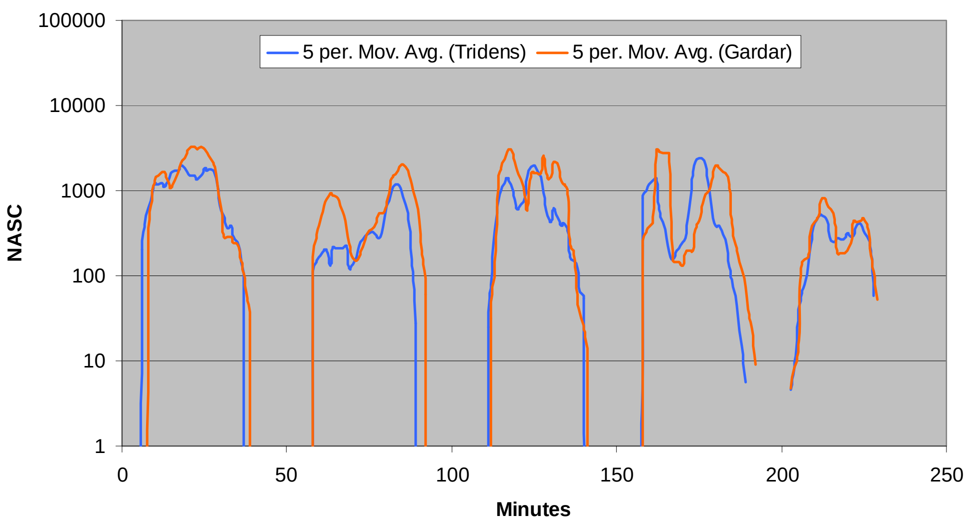



**Figure 2: NASC values exported in I minute intervals and plotted as a 5 minute moving average plotted on a logarithmic scale.**

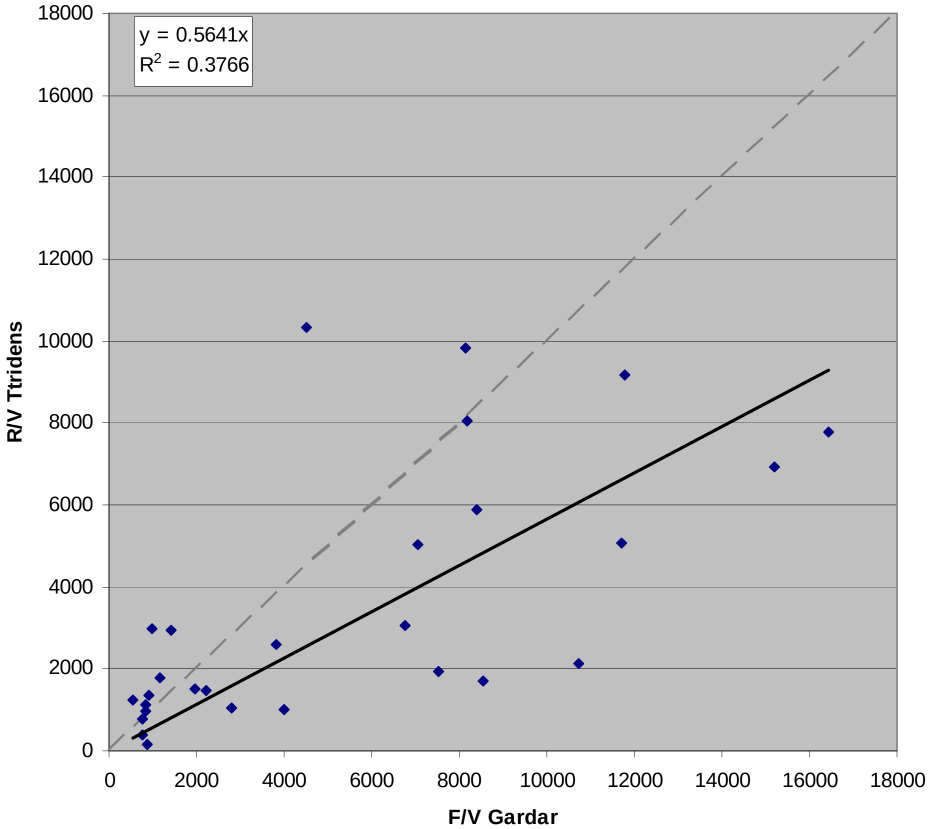



**Figure 3. Comparison of 5 minute NASC values between RV "Tridens" and FV "Gardar".**

### Trawl comparison

After the acoustic inter-calibration, both vessels performed a pelagic trawl of the blue whiting layer, for later comparison. The vessels towed in the same direction at a distance of about 1 nm apart.

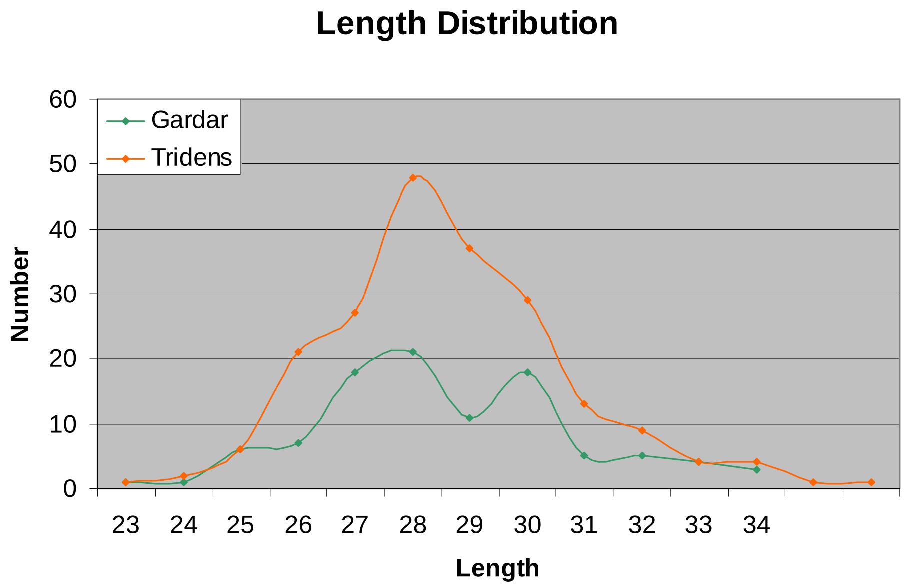



**Figure 4. Blue whiting caught by RV "Tridens" had a mean length of 27.645 cms with a Std Dev. of +/- 2.199 n=203. compared to blue whiting caught by FV "Gardar" with a mean length of 28.875 cms and a Std Dev. of +/- 2.242 n=100.**

### CTD comparison

After the trawl comparison, CTD downcasts were performed on both vessels down to a depth of 1000m.

## Appendix 4: Uncertainty in the acoustic observations and impacts on the stock estimate

**Mikko Heino**

The exercise to estimate uncertainty in acoustic blue whiting observations and the consequences of this uncertainty to stock estimates is repeated using the same procedure as last year (Appendix 3 in Heino *et al*. 2007).

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 it is not attempted to repeat the whole estimation procedure, but instead uncertainty in global mean acoustic density estimate is characterized. 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.

Bootstrapping is used 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, 1000 bootstrap estimates of mean acoustic density, weighted by the stratum areas are calculated. 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 2008 survey as well four earlier international surveys. Mean acoustic density over the survey area is 576 $m^2/nm^2$, with 95% confidence interval being 511…644 $m^2/nm^2$. Relative to the mean, the approximate 95% confidence limits are –11%...+12%, and 50% confidence limits are –4.1%...+3.8%. This is similar level of acoustic uncertainty as observed in 2004–2006, and much less as observed in 2007. This is caused by a few very high density observations in 2007, with three highest values accounting for more than 20% of total cumulative acoustic density. In other years there are no observations that are as influential.

Figure 2 summarizes the results and puts them in the biomass context. The results clearly show that the observed decline in biomass between 2006–2007 and 2008 is more than could be expected from uncertainty arising from spatial heterogeneity. In other words, within the considered domain of uncertainty, the decline is statistically significant.

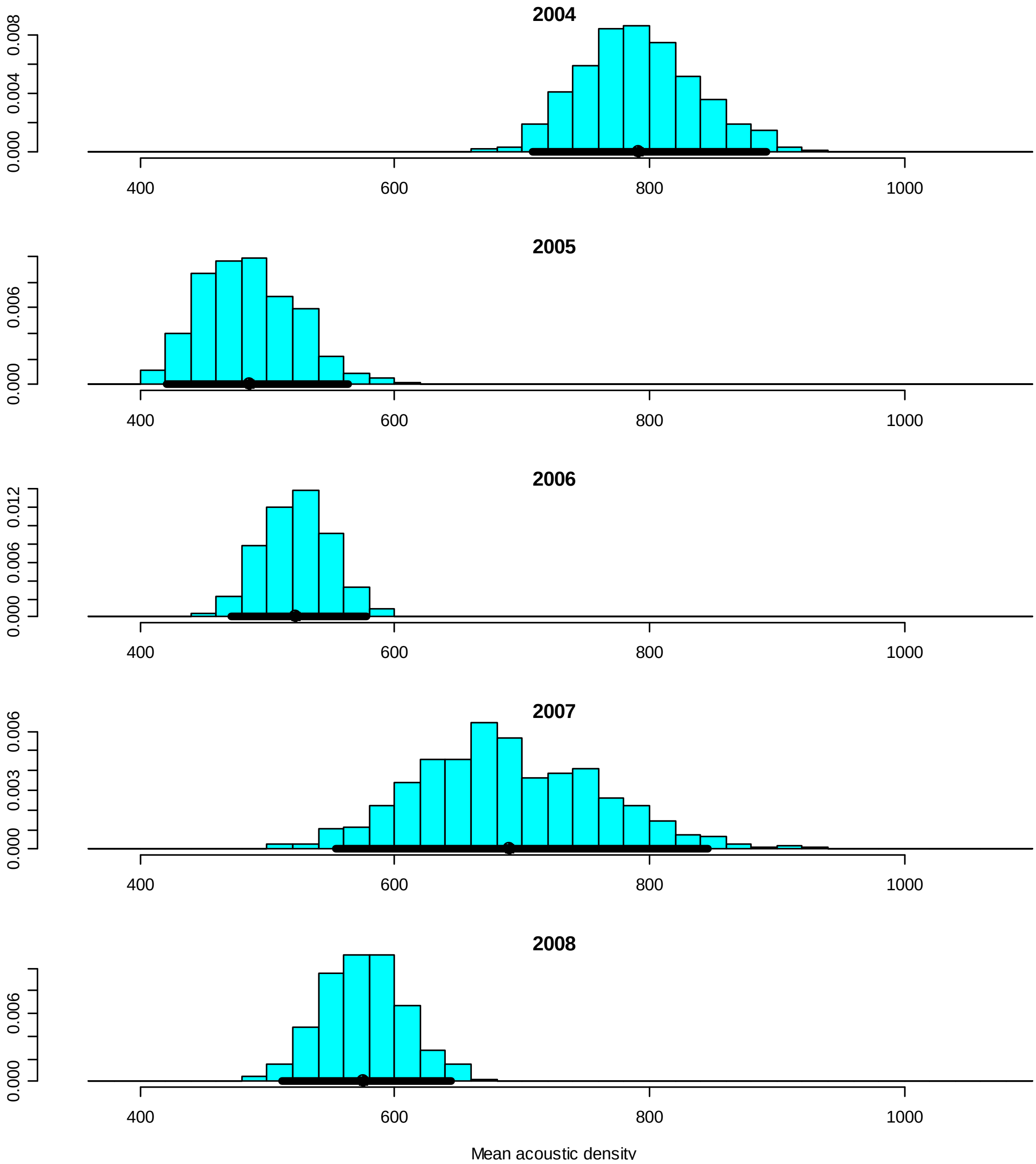



**Figure 1. Distribution of mean acoustic density (in $m^2/nm^2$) based on 1000 bootstrap replicates of acoustic data from blue whiting surveys. Mean acoustic density is indicated with a black dot on the x-axis, while the horizontal bar shows 95% confidence limits.**

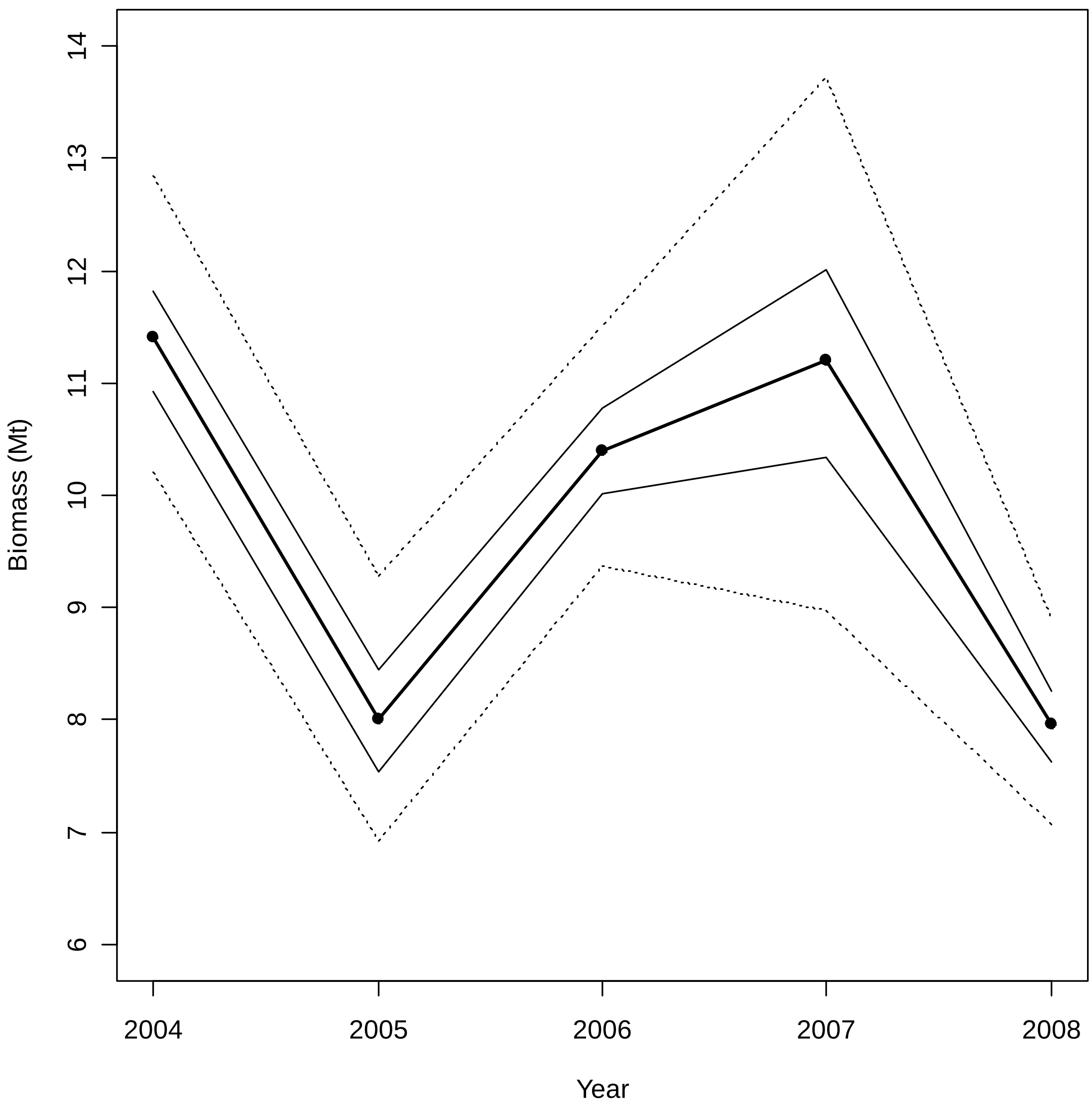



**Figure 2. Approximate 50% and 95% confidence limits for blue whiting biomass estimates. The confidence limits are based on the assumption that confidence limits for annual estimates of mean acoustic density can be translated to confidence limits of biomass estimates by expressing them as relative deviations from the mean values. These confidence limits only account for spatio-temporal variability in acoustic observations.**

## Annex 3: Terms of Reference for the next meeting

**2008/RMC** The **Planning Group on Northeast Atlantic Pelagic Ecosystem Surveys** [PGNAPES] (Chair: Sytse Ybema*, the Netherlands) will meet in Torshavn, Faroe Islands, from 18–21 August 2009 to:

a ) critically evaluate the surveys carried out in 2009 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 2009 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 2009 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 2010 including the following:

i ) the international acoustic survey covering the main spawning grounds of blue whiting in March-April 2010.

ii ) the international coordinated survey on Norwegian spring-spawning herring, blue whiting and environmental data in May-June 2010.

iii ) national investigations on pelagic fish and the environment in June-August 2010.

e ) plan, and as relevant coordinate, surveys in the Northern Norwegian Sea to observe abundance and distribution of pelagic redfish.

f ) Asses the results of the echogram scrutinisation workshop. The dates and location for this workshop have yet to be determined but tit is hoped this will take place early in 2009.

PGNAPES will report by 1 September 2009 for the attention of the Resource Management the Living Resource Committees and ACOM.

**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 interdisciplinary discussion and considerations on ecosystem approach to management of fisheries.<br>**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.<br>**ToR c)** The Planning Group describes the migrations of the stocks and considers possible stock – environment interactions.<br>**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.<br>**ToR e)** There is a need to monitor the pelagic redfish in the Northern Norwegian Sea, where a fishery is rapidly expanding. The task at present for the Planning Group will be to coordinate and quality control surveys in the area where redfish is recorded. In the coming years, the Planning Group should also evaluate the surveys and analyse and report the results. For a survey in 2008, there may be a need for coordination during the spring 2008 through consultations between interested parties.<br>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: | ACOM |
| Linkages to other Committees or Groups: | WGNPBW, WGMHSA and SGBYSAL |
| Linkages to other Organisations: | None |