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Report of the Working Group on Northeast Atlantic Pelagic Ecosystem Surveys (WGNAPES)

17-20 August 2010

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ICES International Council for the Exploration of the Sea

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Executive Summary

This report was prepared by the Working Group on Northeast Atlantic Pelagic Ecosystem Surveys (WGNAPES) which met in Hamburg, Germany from 17–20 August 2010. Fifteen participants from 8 nations attended the meeting chaired by Ciaran O'Donnell (Ireland). Participants analysed and discussed the results of the acoustic, hydrographic, plankton and fish sampling components of two international ICES coordinated surveys in 2010:

International Blue whiting spawning stock survey. A five vessel acoustic survey covering the main blue whiting spawning grounds to the west of Ireland and the UK. Participating vessels included: the Dutch RV "Tridens", the Irish RV "Celtic Explorer", the Russian RV "Fridtjof Nansen", the Faroese RV "Magnus Heinason" and the Norwegian RV "G.O. Sars".

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 2010 with the participation of the Danish RV "Dana", the Norwegian RV "G.O. Sars", the Icelandic RV "Árni Fridriksson", the Faroese RV "Magnus Heinason" and the Russian RV "Fridtjof Nansen".

The report includes survey results about the distribution and the biomass estimate of spawning blue whiting in March-April west of Ireland and Scotland, 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 2010. The abundance estimates are used in the fish stock assessments 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 2011 are also outlined with descriptions of the relevant protocols, preliminary participants and suggested survey designs.

1 Introduction

1.1 Terms of Reference 2010

The **Working Group on Northeast Atlantic Pelagic Ecosystem Surveys (**WGNAPES) chaired by Ciaran O'Donnell, Ireland, will meet in Hamburg, Germany from 17–20 August 2010 to:

a) critically evaluate the surveys carried out in 2010 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 2010 survey data and provide the following data for the Working Group for Widely Distributed Stocks (WGWIDE):

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 such as mackerel.

c) describe the migration pattern of the Norwegian spring-spawning herring, blue whiting and mackerel stocks in 2010 on the basis of biological and environmental data;

d) Respond to the findings of the Working Group on Redfish Surveys

i) plan and coordinate the surveys on the pelagic resources and the environment in the North-East Atlantic in 2011 including the following:

ii) the international acoustic survey covering the main spawning grounds of blue whiting in March-April 2011.

iii) the international coordinated survey on Norwegian spring-spawning herring, blue whiting and environmental data in May-June 2011.

iv) national investigations on pelagic fish and the environment in June-August 2011.

PGNAPES will report by 1 September 2010 for the attention of SCICOM and ACOM.

1.2 List of participants

Ciaran O'Donnell (Chair)	Ireland
Alexander Krysov	Russia
Matthias Kloppman	Germany
Matthias Schaber	Germany
Karl-Johan Staehr	Denmark
Guðmundur Oskarsson	Iceland
Bram Couperus	Netherlands
Sascha Fässler	Netherlands
Leon Smith	Faroe Islands
Ebba Mortensen	Faroe Islands
Åge Høines	Norway
Melle Webjørn	Norway
Valantine Anthonypillai	Norway

Øyvind Tangen	Norway
Aril Slotte	Norway

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

1.3 Background and general introduction

1.3.1 History of the expert group

Based on an ICES recommendation in 1948, pelagic surveys on herring and blue whiting in the Norwegian Sea were conducted under the flag of ICES from 1950 to the late 1970s. National surveys were continued after this time. After the recovery of Atlanto Scandic Herring stock in the early nineties, fishery was opened again in 1994. It was agreed among the Norwegian Sea countries that the stock should be surveyed under the flag of ICES and that all countries that fished the stock should take part. In 1995 the Planning Group on Surveys on Pelagic Fish (PGSPFN) in the Norwegian Sea saw the light. The first meeting was attended by Norway, Faroes, Iceland and Russia joined from 1997 onwards by representatives from the EU countries (but not in 2002 and 2003). In 2004 the group was renamed to PGNAPES (Planning Group on North-east Atlantic Pelagic Ecosystem Surveys). Because of the similarity in methods and the fact that Blue whiting was also covered in the Norwegian Sea the coordination of that survey was brought under PGNAPES, consisting of the same parties as its predecessor PGSPFN.

1.3.2 Surveys

Since 1995, the Faroes, Iceland, Norway, and Russia, and since 1997 also the EU, jointly coordinate hydro acoustic survey for spring-spawning herring in the Norwegian Sea (Norwegian spring spawners or Atlanto Scandian Herring).

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. Before 2005 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 addition to the coordination of the two international surveys, the data provided by National surveys are taken into account and results are normally briefly presented. This has 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.

The International Blue whiting Spawning stock Survey (IBSS, Section 3.1) is aimed at assessing the spawning-stock biomass of blue whiting during the spawning season in March-April. The International Ecosystem Survey in the Nordic Seas (IESNS, Section 3.2) covers the Norwegian Sea and Barents Sea in late spring (late April-early June) aims at the observation of the pelagic ecosystem in the area, with particular focus on Norwegian Spring-spawning herring, blue whiting, zooplankton and hydrography.

The 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. In addition zooplankton biomass and distribution and hydrography are monitored.

The biomass estimates of herring and blue whiting are important indices for the assessments of the species by the Working Group of Widely Distributed Stocks (WGWIDE).

1.3.3 Main fish species

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 northwest 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 northeast 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 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 blue whiting and 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.

2 Material and methods

The WGNAPES report is predominantly based on results from the two international surveys listed below but also reports results from relevant national surveys within in the area. Technical details of all participating vessels are given in the survey report as annexes to this report.

International Blue whiting spawning stock survey. Five vessels participated, the Dutch RV "Tridens", the Irish RV "Celtic Explorer", the Russian RV "Fridtjof Nansen", the Faroese RV "Magnus Heinason" and the Norwegian RV "G.O. Sars" (Table 1 in Annex 2). The surveyed area (cruise tracks) in March-April 2010 is shown in Figure 1 in Annex 2. All survey methods and results are provided in the combined cruise report (Annex 2).

International ecosystem survey in the Nordic Seas. Five vessels participated, the Danish RV "Dana", the Norwegian RV "G.O. Sars", the Icelandic RV "Árni Fridriksson", the Faroese RV "Magnus Heinason" and the Russian RV "Fridtjof Nansen". The surveyed area (cruise tracks) in May-June 2010 is shown in Annex 3, Figures 1 and 2. Map showing area I to III used in the acoustic estimate of herring and blue whiting is shown in Annex 3, Figure 3. All further details are provided in the combined cruise report (Annex 3).

Other relevant surveys. Details from the ecosystem survey carried out in the Norwegian Sea during July–August 2010 were not available during the compilation of this year's report.

2.1 Hydrography

The hydrographic observations were made using vertical CTD casts. Details of which are presented by survey:

International ecosystem survey in the Nordic Seas are given in Annex 3, Table 1 and Figures 4–9.

International Blue whiting spawning stock survey are given in Annex 2, Table 1 and Figures 10–13.

2.2 Plankton

Sampling stations of plankton and cruise tracks of the participating vessels are shown in Annex 3, Figure 10. In total, 370 plankton stations were conducted during the International ecosystem survey in the North East Atlantic in 2010. All vessels used WP2 nets (180 or 200 μm) to sample plankton according to the standard procedure for the surveys, except the Russian vessel that used Djedy net. The nets were hauled vertically from 200 m, or the bottom, to the surface and all data obtained are presented as g dry weight m^{-2}. Further details about the sampling procedure are given in Annex 3, S3.

2.3 Fish sampling

During the surveys directed trawling was carried out opportunistically to ground-truth acoustic recordings and for representative biological sampling of the populations. In most cases fishing was carried out on fish traces identified on the echosounders. All vessels used a large or medium-sized pelagic trawl for biological sampling as detailed in Annex 3 as a text table and Annex 2 (Table 5).

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 onboard 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 when possibly analysing distribution of deep-sea species in future with the data.

Each trawl catch was sorted and weighed for species composition. Further details about the procedure and intensity regarding the samples are given within the relevant cruise reports (Annex's 2–3).

2.4 Acoustics and biomass estimation

During the surveys, acoustic recordings of fish and plankton were collected continuously and integrated using calibrated echosounder systems with a primary operating frequency of 38 kHz.

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 echo recordings to trawl catches.

The acoustic equipment on the research vessels was calibrated immediately prior or during the surveys against standard calibration spheres. No vessel inter-calibration was performed during either the blue whiting or Atlanto-Scandian herring survey (Annex 2, S3).

Acoustic estimates of herring and blue whiting abundance were obtained by visual scrutiny of the echo recordings using different post-processing systems (Annex 3, S2). To estimate the abundance, the allocated s_A-values were averaged for each of the covered ICES-rectangles (0.5° latitude by 1° longitude for the May survey and by 1° latitude by 2° longitude for the March/April survey), as detailed further in Annex 3 (S2) and Annex 2 (S2).

To estimate the total abundance of fish in the survey area, the fish density (nm^{-1}) per ICES-rectangle was multiplied by the number of square nautical miles contained in each ICES- rectangle. Fish abundances for each ICES-rectangle were then summed for defined survey subareas and for the total survey area. Biomass estimates were calculated by multiplying abundances by the average weight of the fish in each ICES-rectangle and then summing all rectangles within defined survey 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 Hydrography

The 2010 winter NAO index was distinctly negative and lower than the long-term average (1950–2009; and see Figure 3.1.1). Hence, favourable winds supporting a strong Atlantic influence in the waters west of the British Isles were lower than during high NAO years.

Temperatures during the blue whiting spawning stock survey were relatively warm reaching values between < 9°C in the North and approximately 11°C in the southwestern part of the survey area. Temperature values were slightly lower than in 2009 as were the salinity values throughout the area. Due to the early season and to the deep convection occurring in the deeper parts of the area, there was not much stratification in the water column rather than a relatively uniform distribution of temperatures down the water column.

In May, during the Ecosystem Survey in the Nordic Seas, temperatures in the surface ranged between < 1°C northeast of Iceland (< 0°C north of Jan Mayen) and > 8°C in the southern part of the survey area. The polar front was encountered slightly south of 65°N east of Iceland extending eastwards towards the 0° Meridian where it turned almost straight northwards up 70°N. North of 70°N it turned north-eastwards and intersected the boundary of the survey area at about 5°E.

Particularly north and west of the polar front temperatures decreased with depth to values < 0°C while south and east of it the drop in temperature down the water column was not as pronounced. The warmer North Atlantic water formed a broad tongue that stretched far northwards along the Norwegian coast with temperatures up to > 6°C in the surface layers. However, particularly in the surface layers the band of warmer water > 7°C was not as wide as in 2009 but narrower and more confined to areas closer to the Norwegian coast. With increasing depth this core of warm Atlantic water became even more confined to areas closer to the coast in the South and forming only a narrowband of warmer water centred along the 15° meridian in the North.

Surface temperatures of the East Icelandic Current were lower than in the year before. Contrasting to the previous three years, the cold arctic water that characterizes the area off the east coast of Iceland was also observed further south and east down to 65°N and 8 to 10°W.

There were only weak indications of warmer North Atlantic water entering the Barents Sea while temperatures decreased gradually to values < 3°C eastwards. Again, temperatures are still higher than the long-term mean for the area.

Detailed information is given in the respective survey reports (Annexes 2 and 3).

3.2 Plankton

In 2010 zooplankton biomass distribution was shifted eastward compared to 2009 (Figure 3.2.1). Zooplankton biomass was lower in most areas and particularly so in the cold water of the East Icelandic current (Figure 3.2.1). The highest zooplankton biomasses were observed in the eastern Norwegian Sea, close to the coast of Northern Norway. Biomass in the Barents Sea was low.

Total average biomass of zooplankton in May 2010 was slightly higher than in 2009, but still the second lowest biomass measured since 1997 (Table 3.2.1). The reason for the slight increase in biomass was a small increase in the eastern Norwegian Sea. The reduction in biomass continued in the western region, west of 2°W, where the lowest biomass since 1997 was recorded (Table 3.2.1).

3.3 Norwegian Spring-spawning herring

During the ecosystem survey in the Norwegian Sea and Barents Sea in May 2010, the coverage of Norwegian spring-spawning herring was considered adequate and in line with previous years. Herring were recorded throughout the survey area, except for the northeastern part and the Jan Mayen zone (Annex 3), which is the main difference from the survey in 2009. The highest values were recorded in the central Norwegian Sea and at the eastern edge of the cold waters of the East Icelandic Current. Compare to 2009, there were less herring in the western most area presumably causing a slight eastward displacement of the centre of gravity of the acoustic recordings in 2010 as compared to 2009 (Figure 3.3.1), which has been calculated since 1996. As in previous years, the smallest and youngest fish were found in the northeastern area and both size and age increased southwestward. According to the survey, the herring stock is now dominated by 6 year old herring (2004 year class) in number but 8, 7 year old herring (2002 and 2003 year classes) are also numerous. No strong *year class*es were found in the Barents Sea, indicating weak recruitment since 2004. The time-series of abundance (both in numbers and biomass) of Norwegian spring-spawning herring in May is shown in Table 3.3.1. The total biomass of Norwegian spring-spawning herring was estimated to 6.0 million tons which is only around 2/3 of the estimate from 2009 (10.7 million tons) and 2008 (10 million tons).

3.4 Blue Whiting

<u>International blue whiting spawning stock survey (IBSSS)</u>

During the 2010 survey a mismatch in temporal alignment from the pre-agreed survey plan (ICES CM 2009/RMC:06, Section 5.1) led to a 15 daytime-lag between the Russian and other participant vessels. This time-lag was deemed too large to produce a single synoptic survey estimate as in previous years. As a result survey data were presented in a two survey format. Russian survey data are presented as a stand-alone survey estimate and the 'combined' survey is made up of data from Faroes, Netherlands, Norway and Ireland (Annex 2).

A review of the 'combined' survey abundance estimate was carried out during the WGNAPES meeting and is presented here as a continuation of the survey time-series (Tables 3.4.1–3.4.3). It was agreed within the group that the gap in area coverage occurred in an area of concentrated fishing effort and thus contained a high but unquantified biomass. Mean acoustic density for the un-surveyed rectangles within the core spawning area was determined by means of interpolation from surrounding surveyed rectangles following established methods.

Combined survey

The total estimated abundance of blue whiting for the 2010 international combined survey was 3.01 million tonnes, representing an abundance of 19.2x109 individuals. Spawning stock biomass was estimated at 2.9 million tonnes and abundance as 18.6x109 individuals. In comparison to 2009, there was a significant decrease (50%) in the observed stock biomass and a related decrease in stock numbers of 51% (Table 3.4.1).

Stock distribution

Blue whiting were recorded in all areas surveyed. In total 7,165 (nautical miles) of survey transects were completed during the combined survey relating to an area coverage of 109,000nmi² (Annex 2, Figure 1, Tables 1 and 3).

Combined survey coverage was down by 18% overall, the largest single reduction occurred in the north Porcupine area (42% reduction) caused by the gap in coverage followed by Rockall (30% reduction) and Hebrides (11% reduction). The Faroes/Shetland area saw an increase in coverage of 30% as effort was extended further north in the search for blue whiting registrations. Reduced coverage in Rockall was a conscious decision as a result of the near zero blue whiting registrations encountered by the RV "Celtic Explorer" and RV "G.O. Sars".

The gap in area coverage in the core north Porcupine and south Hebrides areas can be attributed to poor weather encountered by the RV "Tridens" and the mismatch in timing of coverage by the RV F. Nansen. The concept of vessels co-surveying allocated areas within the same time period is to ensure no gaps in coverage occur. The area in question was likely to contain a high blue whiting abundance as indicated by the focus of international fishing effort during the time of surveying.

The highest concentrations of blue whiting were recorded in the Hebrides core area which remains consistent with the results from previous surveys (Annex 2, Figure 8a, Table 3a). Overall the bulk of the stock was centred further south than during the same time in 2009 (Annex 2, Figure 4). Medium and high density registrations extended further into the Rockall Trough between 56–58 degrees of latitude than observed in 2009. To the north and south of this region blue whiting registrations of medium to high density were distributed almost entirely within a narrowband running close the shelf edge often extending no more than 10nmi west of the 250m contour (Annex 2, Figure 8c-d).

In the western and northern extremes of the survey area low density blue whiting registrations dominated. Aggregations observed in western Rockall during the 2009 survey and the associated commercial fishing activity were notably absent in 2010. Spawning blue whiting normally present in western Rockall appear to have been displaced eastwards into the Rockall Trough which may be due to the influence of colder less saline water observed at depth in western Rockall by the RV Celtic Explorer.

Stock composition

Individuals of ages 1 to 13 years were observed during the survey. A comparison of age reading between nations was carried out and the results are presented in Annex 2, Appendix 2. Overall, good agreement in age readings was achieved across nations from the combined survey. The largest variation came from Russian age readings, where smaller individuals were markedly older than those for other nations. This can be in part attributed to a new blue whiting age reader onboard the Russian survey. The 2009 year class (1-year old fish) was notably absent from Russian samples as compared to other nations which reported 1-year old fish from all subareas (Annex 2, Table 4a-b).

The stock within the survey area is dominated by age classes 6, 7 and 8-years, of the 2004, 2003 and 2002 year classes respectively, contributing over 73% of spawning-stock biomass and 66% of the spawning stock abundance (Tables 3.4.2–3.4.3).

Juvenile blue whiting were represented in all subareas in 2010. Maturity analysis of combined survey samples indicate that 10% of 1-year old and 96% of 2-year old fish were mature as compared to Russian estimates of where no 1-year old fish were observed and 1% of 2-year old fish were considered mature (Annex 2, Tables 4a-b).

From combined survey data the Porcupine subareas were found to contain immature blue whiting as in previous years. The largest proportion of 1-year old fish representing 2% (9,500t) of the total biomass and 8% (283 million individuals) of the total abundance was observed in the north Porcupine area. The Hebrides also contained immature representing 0.7% (9,200t) of total biomass and 3% (247 million) of total abundance.

Faroe/Shetland area had a significant contribution of 2-year old fish (2008 year class) representing 24% (59,400t) of the total biomass and 44% (870 million) of total abundance for this area. The positive signal of this prerecruiting year class was not observed in any other subarea in the same proportion (Annex 2, Figure 10).

Overall immature blue whiting from the combined estimate represented 1% (23,400t) of the total biomass and 4% (615 million) of the total abundance recorded during the survey.

International ecosystem survey in the Nordic Sea

The total biomass of blue whiting registered during the May 2010 survey was 0.26 million tons (Annex 3), which is very low (the corresponding estimates from 2006, 2007, 2008 and 2009 were 6.2, 2.4, 1.1 and 0.9 mill. tons, respectively). The stock estimate in number for 2009 is 1.7 billion, which is only about 30% of the 2009 estimate. With exception of two year olds the reduction in estimate is seen in all ages. The small amount of two year olds seen in this year's survey was found around the Faroes.

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 (Annex 3) have been used as an indicator of the abundance of blue whiting in the Norwegian Sea because the spatial coverage in this are provides a coherent time-series with adequate spatial coverage – this estimate is used as an abundance index in the WGWIDE. The age-disaggregated total stock estimate in the "standard area" is presented in Annex 3, showing that the part of the stock in this index area is dominated by 6 year old blue whiting. Time series from the "standard survey area" is presented in Annex 3.

Blue whiting were observed mostly in connection with the continental slope in south and east and very little were found in the open sea (Annex 3). The mean length of blue whiting is shown in Annex 3. It should be noted that the spatial survey design was not intended to cover the whole blue whiting stock during this period.

Joint surveys in the Nordic Sea

The data from the joint survey in the Nordic sea were not available during the compilation of this report.

3.5 Mackerel

Mackerel distribution from the IBSS survey

Mackerel abundance during the 2010 survey was considerably lower than observed during the 2009 survey and was comparable to background levels observed in previous surveys (2004–2008). Mackerel were encountered along the shelf slope west of the

Hebrides and further south as schools of medium to high density. In general, mackerel distributions during the blue whiting spawning stock survey are sporadic.

Mackerel distribution from the International ecosystem survey in the Nordic Seas (IESNS) survey

In later years an increasing amount of mackerel has been observed in the Norwegian Sea during the combined survey in May targeting herring and blue whiting. The edge of the distribution has also been found progressively further north and west. In 2008 during the Faroese survey, mackerel was found in the southeastern part of the investigated area, and all the way up to 64°N in 2009 but 63°N in 2010 (Figure 15). Like in 2009, the 2005 year class dominated in the total catches of the combined survey.

Mackerel egg sampling

During the 2009 International Ecosystem Survey in the Nordic Seas (IESNS) spawning mackerel had been found for the first time in larger numbers west of Norway up to 68°N. This raised the concern of WGMEGS about being able to cover the whole extent of the much enlarged mackerel spawning area. In order to support the effort of WGMEGS during the 2010 survey, WGNAPES was asked to recommend sampling of additional plankton stations for a rough estimate of the magnitude of mackerel spawning activity outside the MEGS area.

Altogether 36 plankton samples taken during the Norwegian and EU participation in the IESNS with RVs "G.O. Sars" and "Dana", some of them taken additionally to the originally planned stations, were analysed for fish eggs. The covered area was between 62° and 67°N and between 0° E/W and the Norwegian coast. Only 1 mackerel egg was found in those samples. The egg was of stage 1a. These findings suggest that mackerel spawning off the Norwegian coast form only a minor and negligible part of the total spawning stock. Most of the eggs were those of the pearlside *Maurolicus muelleri*.

Mackerel distribution from the joint Nordic Sea mackerel survey in July–August

The data from the joint survey in the Nordic Sea were not available during the compilation of this report.

4 Discussion

4.1 Hydrography

West of the British Isles, the water characteristics are chiefly influenced by three major components: the Subpolar Gyre that may carry cool Subarctic water into the area, the North Atlantic Current (NAC) and by the advection Eastern North Atlantic Water (ENAW) that both may carry warmer and saline waters. Ultimately, the Subpolar Gyre dominates the influence of the two latter in the area. When the gyre is large, more cold Subarctic water is advected to the area in the Rockall Bank vicinity while the NAC and the ENAW is shifted eastwards towards the shelf edge. Under weak Subpolar Gyre situations the major northward branch of the NAC runs west of Rockall Bank while more warm and saline ENAW is advected to the area between the British Isles and Rockall Bank (Hatun *et al.*, 2009). This situation might again have been responsible for the relatively warm and saline waters encountered west of the British Isles during the 2010 blue whiting spawning stock survey. The long-term trends for the area also indicate that temperatures and salinity were steadily rising in the area after the exceptionally cold period the ended in the mid 90s (Holliday *et al.*, 2009) indicating at a stronger influence of warm ENAW since then in the area. However, the observed slight decline in both, temperature and salinity values seem to corroborate indications that this trend might possibly be reversing currently since salinity anomaly is declining, although temperatures are still anomalously high, but slightly declining only since 2007 (Holliday *et al.*, 2009).

The hydrographid situation in the Norwegian Sea was broadly much the same as observed in 2009 with some cooling in the surface layer that can at least partly be explained with the low air temperatures during the strong winter of 2009/10.

In the Norwegian Sea, where the herring stock is grazing the two main features of the circulation 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 saline 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 Faroese 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.

After two years with strong westerlies (high winter NAO index) during 2007 and 2008, with an increased influence of Arctic water in the southern Norwegian Sea, the strength of the westerlies in winter 2010 was low. However, the increased Arctic influence in the western areas of the Norwegian Sea is still observed in 2010. After several 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 had been observed over the last several years. This is due to a lower 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 2010 is close to and in some areas less than the 1995–2010 average. In the central and eastern parts, however, the Atlantic water is still warmer than the 1995–2010 average, about 0–1°C dependent on the area and depths. The main reason for this is that the inflowing Atlantic water is still warmer and more saline than normal, and in particular the Atlantic water that flows northward through the Faroe-Shetland Channel is observed to be considerable warmer and saltier than normal.

4.2 Plankton

Recent years decrease in zooplankton biomass is dramatic in the sense that biomass in the cold water has decreased by 80% since 2003; while in the warmer water biomass has decreased by 55% since 2002. The reason for this drop in biomass is not obvious to us. The unusually high biomass of pelagic fish feeding on zooplankton has been suggested to be one of the main causes for the reduction in zooplankton biomass (ICES, 2008). However, carnivorous zooplankton and not pelagic fish are the main predators of zooplankton in the Norwegian Sea (Skjoldal *et al.,* 2004), and we do not have good data on the development of the carnivorous zooplankton stocks. A fairly strong relationship between NAO and zooplankton biomass was observed, particularly during the late 1990s (ICES, 2006). However, this relationship seems to be less pronounced now. During 2008 and 2009 the western part of the Norwegian Sea cooled due to input of more Arctic water. The eastern Norwegian Sea has become warmer mainly due to input of warmer Atlantic water. In 2010 the southeastern Norwegian Sea cooled a bit (probably surface cooling during the cold winter this year). The Arctic water masses in the west spread further eastward compared to 2009. The warming of the Atlantic water masses do not seem to be in favour of increased zooplankton production in the Norwegian Sea. The cooling of the eastern Norwegian Sea was followed by increased biomass in 2010. Summing up, the reason for the reduction in zooplankton biomass is not clear to us and more research to reveal this is recommended.

4.3 Norwegian spring-spawning herring

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 mainly concentrate on the situation in the feeding areas in the period May-July.

Similarly to the previous six years, it was decided not to draw up a suggested herring migration pattern for 2010 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 and westerly distribution than in

2003. There was, however, a slight eastward shift of the center of gravity of the distribution in 2010 compared to 2009.

In May the herring were migrating westward into the Norwegian Sea to start feeding and main concentrations were found in the central part of this area, mostly consisting of the 2004 year class while the 2002 year class was observed in much smaller number than in previous years. The amount of herring measured in the survey was actually less than expected and anticipated from the stock assessment in 2009 (ICES 2009/ACOM:12) and the surveys in recent years (ICES 2009/RMC:06). For example, the past estimates of the 2002 year class indicate that it is very strong but the current estimate give a less optimistic estimates of its size and show a reduction of 61% (Figure 4.3.1 and Table 3.3.1). The estimate for the 2004 year class is closer to what was expected (42% reduction) and support the view from last year that this year class is strong and comparable to the 1998 and 1999 year classes. Overall, the 2003 year class appeared now to be at similar size as the 2002 year class that has been considered large in recent years. If this is related to problems and inaccuracy in ageing is uncertain but there are no indications of it currently but it should be examined.

During the last several years, a temperature reduction has been observed in the western part, which continued this year, while a temperature increase has been observed in the eastern part of the Norwegian Sea. This could explain the slight eastward displacement of the centre of gravity of the herring distribution observed in May 2010, beside the fact that the feeding migration is still ongoing during the survey period. Additionally, the plankton situation in the Norwegian Sea was again this year at a very low level, particularly in the western area.

4.4 Blue whiting

The seventh international blue whiting spawning stock survey shows a significant decrease in stock biomass (50%) and a related decrease in stock numbers (51%) as compared to the 2009 survey. Total stock abundance was revised during the WGNAPES meeting by interpolating surrounding mean acoustic values into unsurveyed rectangles. The exercised revised the total-stock biomass upwards by 19% (580,000t) and stock abundance by 15% ($2.8x10^9$ individuals). The revised estimate is considered robust by the group and it is recommended that this estimate is accepted by WGWIDE. The international survey in the Nordic seas in May also observed the strong decrease in the stock found during the spawning stock survey.

The Russian estimate for the spawning stock survey is greater than the revised estimate, however, due to large discrepancies in age reading and timing it was agreed that this estimate should not be put forward. Acoustic estimates determined using Russian acoustic values and age length keys derived from the combined survey data provided an estimate which is comparable to the revised estimate presented here.

The stock within the survey area is dominated by age classes 6, 7 and 8-years, of the 2004, 2003 and 2002 year classes respectively, contributing over 73% of spawning-stock biomass and 66% of the spawning stock abundance. Mean length (30 cm) and weight (147.8 g) are the highest on record in the international survey time-series indicating the continued reliance of the stock on larger older age classes coupled with continued poor recruitment.

The contribution of immature fish to the total biomass remains small. However, a small but positive signal of 2-year old fish was observed in the Faroe/Shetland area and is a somewhat encouraging sign in a period of prolonged poor recruitment. This positive signal was also observed during the international survey in the Nordic seas in May. Maturity analysis indicated that peak spawning in 2010 was later than in previous years due to the proportion of spent fish observed. In 2009 peak spawning was considered earlier as a much larger proportion of the stock surveyed was spent. Survey timing remains fixed with little variation between years.

The combined effort of the international blue whiting spawning stock survey was carried out over 28 days as compared to 29 days in 2009. The time-lag between combined vessels and the F. Nansen resulted in data from co-surveyed rectangles being non-admissible. The success of the International survey rests on cooperation from all survey vessels to survey as planned within agreed time and allocated areas. Had all vessels covered areas as agreed within the allocated time frame it would be possible to produce a single synoptic survey estimate with a high degree of precision and without the need for interpolation.

4.5 Mackerel

The data from the joint survey in the Nordic Sea were not available during the compilation of this report.

5 Planning

5.1 Planned acoustic survey of the NE Atlantic blue whiting spawning grounds in 2011

Five vessels are scheduled to participate in the 2011 spawning stock survey including the Faroe Islands, the Netherlands (EU-coordinated), Ireland (EU-coordinated) Norway and Russia.

Survey timing and design were discussed in detail during the meeting. The group decided that in 2011 the survey area would be divided in two components (north and south) covering core spawning subareas with the dividing line occurring at 55.30ºN. This revised survey methodology would see each participant vessel covering their allocated area twice in opposing directions. The aim of this modified design is to analyse the potential effects of migration by means of survey replication. Overall this would provide a two survey biomass estimate for the combined area while maintaining the integrity of the survey index.

It was decided that the "Tridens" and "C. Explorer" would co-survey the southern subarea and the "F. Nansen" and "G.O. Sars" would cover the northern subarea. Survey extension in terms of coverage (52–61ºN) would be maintained ensure containment of the stock and survey timing would also remain fixed as in previous years.

Vessels should use the reciprocal cruise track on the secondary coverage, repeating CTD stations in the original positions. This will allow for temporal changes to be monitored between surveys. Biological sampling should be carried out following methods normally applied to sampling acoustic registrations, again to provide detailed information on the progress of spawning between replicates.

Individual vessels would maintain a transect spacing of 40nmi. Coverage in the western extreme in southwest of Rockall, will work on an annual rotation between survey vessels. This will be decided at the next WGNAPES meeting in 2012. In 2011 the C. Explorer volunteered to cover southwest Rockall.

Within respective north–south area components surveying would be carried out as follows:

Ship	Primary Coverage	Secondary Coverage	Area Component	Supplementary
Celtic Explorer	North - South	South - North	Porcupine N & S	SW Rockall (2011)
Tridens	South - North	North - South	Porcupine N & S	
G.O. Sars	South - North	North - South	Hebrides	
F. Nansen	North - South	South - North	Hebrides	
Magnus Heinason	North - South	South - North	Faroes/Shetland	

Individual vessel dates are listed below:

Ship	Nation	Vessel time (days)	Active survey time (days)	Preliminary survey dates
Celtic Explorer	EU (Ireland)	21	18	25/3–14/4
G.O. Sars (TBC)	Norway	15	12	21/3–5/4
Magnus Heinason	The Faroes	14	11	30/3–14/4
Tridens	EU (Netherlands)	21	14	22/3–12/4
F. Nansen	Russia	30	21	22/3-13/4

Preliminary cruise tracks for the 2011 survey are presented in Figure 5.1.1.

As newly nominated survey coordinator in 2011 onwards the Netherlands has been tasked with coordinating contact between participants prior to and during the survey. Detailed cruise lines for each ship will be circulated by the coordinator to the group as soon as final vessel availability and dates has been communicated (end of January 2011).

As the survey is planned with inter-vessel cooperation in mind it is vitally important that participants stick to the planned transect positioning to ensure that survey effort is evenly allocated and the situation observed in 2010 is not repeated.

Survey participants should treat primary and secondary coverage as independent surveys in terms of data handling and submissions to the WGNAPES database. This can be done using a new cruise code for each replicate. It is important to clearly separate survey data prior to submission to facilitate the timely production of the combined survey estimates. Participants are also required to use the logbook system for recording course changes, CTD stations and fishing operations. An example format will be circulated to participants shortly after the WGNAPES 2011 meeting.

The survey will be carried according to survey procedures described in the "Manual for Acoustic Surveys on Norwegian Spring-spawning Herring in the Norwegian Sea and Acoustic Surveys on Blue whiting in the Eastern Atlantic" (PGNAPES report 2008).

5.2 Planned International ecosystem survey in the Nordic Seas, spring/summer 2011

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 2011.

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 2011 are given in Figure 5.2.1.

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 2011. Final dates and vessels shall be communicated to the coordinator no later than 15 January 2011. 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 2011.

It is proposed that the Danish vessel starts its survey at 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 at the beginning of May (the date(s) and name(s) of vessel(s) will be decided by mid November 2009) by conducting the Svinøy hydrographic section. After this the area north of 66°N will be surveyed by the Norwegian and EU 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.

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", Version 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 2010 survey intercalibration will be attempted carried out between the Faroes, Danish and Norwegian vessels. No intercalibration has taken place since the 2005 survey. It is recommended, that serious effort should be put into intercalibrations at the 2011 survey, as it failed in 2010. Furthermore the proposed intercalibration should be taken into consideration when detailed cruise tracks for participating vessels are planned by the survey coordinator. Fishing should 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
G.O. Sars	Norway	30	28	1/5 – 30/5
Fridjof Nansen	Russia	21	21	15/5 – 05/6
Dana	Denmark (EU)	30	23	28/4 – 28/5
Magnus Heinason	Faroes	14	12	4/5 – 18/5
Arni Fridriksson	Iceland	26	23	28/4 – 24/5

Final dates will be decided by the end of 2010.

6 Survey protocol and standardization

The survey manual relating to WGNAPES coordinated surveys will be reviewed and updated at the 2011 WGNAPES meeting to reflect developments in survey methodology. The review will also take into consideration updates in software and roles and responsibilities for designated survey coordinators as well as the standardization of newly established surveys, namely the ecosystem trawl/acoustic surveys targeting mackerel in the Norwegian Sea.

Methods currently employed during WGNAPES coordinated surveys are highlighted below. Detailed methods employed during specific surveys are available within individual cruise reports as shown in Annex's 2–4 of this report.

6.1 Biological sampling procedure

Presently participating countries collect either scales or otoliths for age reading. This raised the question whether the results are different and whether one should choose for one of the two methods in order to standardize the survey procedures.

A working paper on the exchange of scales and otoliths between Norway, Faroe Islands, Iceland and Denmark presented at WGWIDE in 2008 (Anon., 2008) examining the age readings of 159 spring-spawning herring (of which 30 specimens were 6 years or older) showed that the age readings of both otoliths and scales were very similar. There was no significant difference. Another working paper (Couperus, 2008) was presented at PGNAPES in 2008. Here otoliths and scales of 92 herring van the EU participation in the May survey of 2008 were read by an experienced scale reader in Denmark and an experienced otoliths reader in the Netherlands. There was no indication that there is any difference in performance between age reading from scales and otoliths, although it was noted that the sample was limited and the specimens were not older than 7 years.

Taking into account these results the EU survey on board FRV Dana will switch from scales to otoliths in 2010. An important consideration also being that scales easily come off and get lost during processing of the catch and sometimes it is difficult to find suitable specimens for age reading.

6.2 Trawling

Last year it was noted that for some participants in the surveys on Atlanto-Scandian herring in the Norwegian Sea problems occurred in catching larger schools. The EU vessel FRV Dana has switched from the Foto trawl to the bigger Miljonair trawl, resulting in bigger catches. However it is still not possible to fish for larger schools on depth because the winches are not powerful enough. Hence, biological samples are usually collected at night at the surface. In some cases not being able to fish at depth for big schools leads to scrutiny issues. Generally the rule is applied that if large schools are impossible to catch at depth, it is most probably blue whiting.

6.3 PGNAPES exchange format

The database will be changed, to incorporate fluorescens data from the CTD hauls. A new column will be added in the Hydrography table. The updated exchange format will be distributed to the group's members.

7 PGNAPES database

Internet database

A PGNAPES Internet database (Oracle 10g Express platform) was established at Faroe Marine Research Institute before the post-cruise meeting in IJmuiden, April 2007.

Now more than 3 years have gone. Ten international surveys have been uploaded (50 national cruises), the first ones with difficulties, but as the group has conformed to new data formats and routines, the submission and upload of data now is completed within a week after the cruise completion.

To have data in place before the meetings is important for the group's achievements, as no time is used to collect and organize data during the meetings.

Data from the International Blue Whiting Spawning Stock Survey

Data from all participating countries, very satisfactory, where received and uploaded to the database, before the planned post cruise meeting in Bergen. This is the same experience as last year, where the submission of data from the April Blue Whiting survey was flawless. The post cruise meeting was cancelled due to volcanic ash from Eyjafjallajøkull, and all data were extracted from the database, and processed by the participators locally.

Data from International Ecosystem Surveys in the Nordic Seas

Were received and uploaded to the database before the WGNAPES meeting in Hamburg. Though especially labour intensive sample data, such as age readings and processing plankton samples at the start of the holidays, delayed the data considerably.

NO, IS and FO have initiated a July survey targeting Mackerel in the Nordic Seas. Data from this survey has been uploaded in the database as well.

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. A copy of ASFIS codes obtained from the FAO webpage has been uploaded to the WGNAPES sharepoint, for the group members' convenience.

The species list includes the TSN's (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 the participating countries introduce "new" species.

Assessment calculation application

As is, the assessment calculation is made by the Norwegian part of the group, using the BEAM application, using data from the PGNAPES database. A raw assessment calculation is also made by the Faroese part of the group, allocating the mean length and weight from all trawl stations to the whole area.

Comparing the results from BEAM and the raw assessment calculation, gives the group a good indication of the quality of calculations.

To have an assessment application available for the whole group is essential to ensure the quality of the work. IMR, Norway is developing a new BEAM application. The application, due in December 2010, will be able to perform assessment calculations on top of tables in PGNAPES table format.

Future Effort

It was agreed at the meeting to incorporate fluorescens data in the hydrography table. A new column will be introduced.

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	CRUISE	LOG	CATCH	BIO	HYDR	ACOUSTIC	ACOUSTICVAL	PL
DK	2008	308	193	71	2379	48625	559	850	54
DK	2009	200904	124	113	3416	3360	554	554	40
DK	2010	201003	167	39	455	4263	645	263	46
FO	2006	624	36	58	1598	1359	260	4196	
FO	2007	724	27	42	1948	729	337	5222	
FO	2007	732	76	29	1109	2994	359	4925	31
FO	2008	816	51	32	1199	1890	1249	16954	13
FO	2008	824	77	43	2656	2619	1670	19172	27
FO	2009	920	67	44	1521	2229	1359	22664	
FO	2009	932	90	30	1234	3239	1404	7037	23
FO	2010	1010	65	30	1358	1980	1219	18054	27
FO	2010	1014	77	30	1417	3708	1589	12067	23
FO	2010	1051	99	83	4165	1297			30
IE	2006	403	45	15	2961	545	516	2637	
IE	2007	BWAS07	45	72	2700	534	2445	12368	
IE	2008	BWAS08	70	48	2250	2647	2002	11048	
IE	2009	BWAS09	65	84	2850	1323	2800	12219	
IE	2010	BWAS10	69	35	1350	3304	2345	6163	
IS	2007	A08-2007	130	39	9873	336	4005	26405	68
IS	2007	B08-2007	50						50
IS	2008	A6-2008	137	27	5386	43240	4271	43923	98
IS	2008	B8-2008	20						20
IS	2009	A6-2009	190	29	6671	4624	3834	9266	97
IS	2010	A10-2010	205	255	6365	14420	4615	7322	
IS	2010	A7-2010	217	48	4006	5608	4031	9966	144
NL	2006	BWHTS2006	41	10	400	14778	1363	1363	
NL	2007	BWHTS2007	27	8	420	7958	897	8760	
NL	2008	BWHTS2008	35	19	982	9988	1419	14569	
NL	2009	BWHTS2009	36	9	3749	1898	1853	1057	

COUNTRY	YEAR	CRUISE	LOG	CATCH	BIO	HYDR	ACOUSTIC	ACOUSTICVAL	PL
NL	2010	BWHTS2010	30	67	250	400	1294	204	
NO	2006	2006104	131	53	2576	57741	3515	7582	
NO	2007	2007106	274	409	8871	5749	4478	111484	
NO	2007	2007845	30	36	656	1580	1491	19460	
NO	2008	2008103	118	39	551	3735	686	24537	24
NO	2008	2008809	65	29	842	10335	1399	1657	
NO	2008	2008834	107	117	2712	2319	2235	43796	29
NO	2009	2009206	217	119	2265	5278	664	2556	59
NO	2009	2009833	59	29	1351	528	323	511	
NO	2010	2010104	48	32	617	2238	1753	2271	
NO	2010	2010107	179	93	1903	5802	3150	7803	61
RU	2006	2006048	102	30	371	699	2512	2512	
RU	2007	2007046	21	10	377	190	919	919	
RU	2008	2008067	105	18	1393	909	2461	2461	
RU	2008	2008068	186	64	669	602	456	2844	64
RU	2009	2009072	99	21	1377	939	2081	2207	
RU	2009	2009073	142	70	960	648	354	378	61
RU	2010	2010077	86	19	1264	788	1849	2234	
RU	2010	201078	239	68	2449	2771	569	620	96

The table shows number of records in logbook, catch, biology, hydrography, acoustic, acoustic values and plankton tables' per nation, year, vessel and cruise by 19 August 2010.

8 Agreement and Recommendations

Agreements:

- The location of the next post-cruise meeting of the International Blue whiting spawning stock survey will be in ICES Copenhagen, Denmark and will take place from the 27–29 April, 2011.
- Netherlands was nominated by the group as the new IBSSS coordinator for 2011 onwards.
- The next PGNAPES meeting will take place in Kaliningrad, Russia from the 16–19 August, 2011.
- The group agrees the adoption of the 'Log book' system for all WGNAPES coordinated survey to lessen the workload of those producing abundance estimates for the group at IMR. An example and instruction document will be circulated within the group prior to the next round of surveys.
- During the 2011 IBSSS, national participants agreed to partition data into a two survey format for ease of data handling during the analysis process.
- The group agrees that during the 2011 WGNAPES meeting the acoustic survey manual is reviewed and updated to include new developments in survey methods, sampling gear, post-processing software and biological sampling.

Recommendations:

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

General recommendations

- The group recommends the development of a standardized set of survey methods for mackerel trawl/acoustic surveys currently undertaken in the Norwegian Sea in July. Methods should be developed within the group and in association with WGIPS. The group also recommends input from WGWIDE in this process. These methods should then be included into the revised survey manual.
- The group welcomed the presence of Michael St John (EURO Basin project) during the 2010 meeting. The group recommends the development of links between the survey data collected within WGNAPES group and the project. Someone from the project will attend the 2011 meeting to present historic modelled hydrographic data (1960–2004) for common survey regions in the NE Atlantic.
- The group recommends the continued development of the deep-sea species photo guide (initiated at the PGNAPES meeting in 2008). Members are requested to bring new material to the WGNAPES meeting in 2011 so that the guide can be further developed.
- In light of the large discrepancies in maturity reported for both blue whiting and herring during the May survey, group members are encouraged to participate in the upcoming maturity workshop (WKMSHS) in spring 2011.

Survey recommendations:

- Participants are strongly encouraged to adhere to pre-agreed survey plans. Should circumstances change prior to the survey they that will adversely affect the success of the survey then this should be communicated to the group through the survey coordinator as soon as possible.

- All participants are recommended to circulate the final cruise dates among the group, through the respective survey coordinator, by no later than the end of January 2011.
- All nations are recommended to adopt the 7-stage blue whiting maturity scale during coordinated surveys.
- The group stresses the importance that all participants in the IBSSS execute their survey without interruption. Experience from the past years has shown the main components of the stock move very fast, making it very likely that an interruption may have a large affect on the stock estimation. Participants should therefore avoid breaks in continuity wherever possible.

Achievements:

- Data was uploaded in good time before the meetings. The PGNAPES database really stood up to test this year. It was impossible to attend the post-cruise meeting due to Eyjafjallajøkul, and the data were processed and the report compiled over the Internet, though in a considerably slower pace. The Internet database was central in this achievement.
- Good agreement achieved in age determination between countries during the 'combined' stock survey.
- Good communications between IBSS survey vessels was achieved in 2010.
- For the IBSS survey all data were delivered to the PGNAPES database 1 week prior to the post cruise meeting. This allowed for the timely delivery of the survey estimate and report.

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10 Tables and Figures

Table 1.3.1. Organisational frame of the coordinated herring investigations in the Norwegian Sea, 1995–2009.

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 (ICES CM 2008\RMC:05)
2009	Faroe Islands, Iceland, Norway, Russia, EU	3	Hirtshals (ICES CM 2008\RMC:05+ correspondence	Torshavn (this report)

Table 3.2.1. Average zooplankton biomass [g dry weight m-2] at the international ecosystem surveys in the Nordic Seas carried out in April-June for the period 1997–2010. 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	2009	2010	Mean
Total area	8.2	13.4	10.6	14.2	11.6	13.1	12.4	9.2	9.2	8.9	8	7.1	3.9	4.3	9.6
Region W of 2°W	9.1	13.4	13.5	15.7	11.4	13.7	14.6	9.2	10.7	12.6	10.3	7.1	4.4	2.9	10.6
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	7.1	3.3	5.9	8.4

Table 3.3.1. 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 1997–2010.

Survey year/Age	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008*	2008**	2009	2010
0	0	0	0	0	0	0	0	0	0	0	0	0		0	
1	0	24	0	0	0	0	32,073	0	0	3,688	2,058	0	43	202	7,805
2	0	1,404	215	157	1,540	677	8,115	13,735	1,293	35,020	4,122	1,193	381	906	2,330
3	1,169	367	2,191	1,353	8,312	6,343	6,561	1,543	19,679	5,604	15,437	587	199	2,980	1,286
4	3,599	1,099	322	2,783	1,430	9,619	9,985	5,227	1,353	15,894	7,783	8,332	279	2,754	3,329
5	18,867	4,410	965	92	1,463	1,418	9,961	12,571	1,765	1,035	20,292	8,270	5	14,292	2,156
6	13,546	16,378	3,067	384	179	779	1,499	10,710	6,205	1,810	1,261	16,345		9,487	8,282
7	2,473	10,160	11,763	1,302	204	375	732	1,075	5,371	6,336	1,992	1,381		11,629	4,146
8	1,771	2,059	6,077	7,194	3,215	847	146	580	651	7,372	6,781	1,920		1,472	4,519
9	178	804	853	5,344	5,433	1,941	228	76	388	558	5,581	3,958		1,253	319
10	77	183	258	1,689	1,220	2,500	1,865	313	139	651	647	2,500		2,587	513
11	288	0	5	271	94	1,423	2,359	367	262	171	486	416		1,357	804
12	415	0	14	0	178	61	1,769	1,294	526	344	371	242		267	331
13	60	112	0	114	0	78	0	1,120	1,003	807	403	159		183	45
14	2,472	0	158	0	0	28	287	10	364	792	1,047	217		60	17
15+	0	415	128	1,135	85	26	45	88	115	324	953	408		258	25
Number in '000	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	49,687	35,907
Biomass in '000 tons	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	10,700	6,026
*Norwegian Sea															
**Barents Sea (western limit 30ºE)															

Table 3.4.1. Total stock biomass and spawning-stock biomass time-series from the International blue whiting spawning stock survey, 2004–2010.

		2004	2005	2006	2007	2008	2009	2010	Change from 2009 (%)
Biomass	Total	11.4	8	10.4	11.2	8	6.07	3.01	-50%
(mill. t)	Mature	10.9	7.6	10.3	11.1	7.9	6.03	2.98	-51%
Numbers	Total	137	90	108	104	68	46.7	19.2	-59%
(10^9)	Mature	128	83	105	102	67	45.8	18.6	-59%
Survey area (nm^2)		149,000	172,000	170,000	135,000	127,000	133,900	109,320	-18%

Table 3.4.2. Age disaggregated estimate of total stock numbers and biomass from the International blue whiting spawning stock survey, 2004–2010.

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		129,863
2005	3631	4320	18774	25579	26660	8298	2016	728	323	2	4	90,335
2006	3162	5540	32201	38942	16608	7972	2459	791	293	7		107,975
2007	1723	2654	16343	32851	24794	13952	7282	2509	951	420	235	103,714
2008	956	1672	4443	17814	20144	11710	6418	3093	791	908		67,948
2009	2747	3384	3147	6617	16067	15764	8970	4685	2891	514		46,705
2010	621	1291	627	931	2426	5258	4838	2608	467	63	67	19,197

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		11,105
2005	99	217	1377	2194	2546	1046	320	128	76	0.5	0.7	8,004
2006	87	329	2598	3603	1896	1104	495	206	73	3		10,394
2007	68	181	1415	3285	2793	1732	1006	393	167	153		11,193
2008	40	98	409	1786	2273	1501	976	521	178	176		7,958
2009	29	95	103	518	1711	1856	1026	436	170	127		6,070
2010	23	91	64	130	394	883	840	466	99	11	15	3,015

Table 3.4.3. Age disaggregated estimate of total stock numbers and biomass for International blue whiting spawning stock survey in 2010.

Length (cm)	Age/Year class 1	2	3	4	5	6	7	8	9	10	11	12	13	TSN Number (Millions)	TSB Biomass ('000s t)	Mn Wt (g)
13.0 - 14.0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	15
14.0 - 15.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.
15.0 - 16.0	12	0	0	0	0	0	0	0	0	0	0	0	0	12	0.2	19.5
16.0 - 17.0	28	0	0	0	0	0	0	0	0	0	0	0	0	28	0.7	23.4
17.0 - 18.0	60	7	0	0	0	0	0	0	0	0	0	0	0	67	1.9	27.6
18.0 - 19.0	216	0	0	0	0	0	0	0	0	0	0	0	0	216	7	32.6
19.0 - 20.0	179	43	9	0	0	0	0	0	0	0	0	0	0	231	8.9	38.7
20.0 - 21.0	77	128	26	0	0	0	0	0	0	0	0	0	0	230	11	47.8
21.0 - 22.0	30	274	37	0	0	0	0	0	0	0	0	0	0	341	20	58.6
22.0 - 23.0	13	270	86	0	0	0	0	0	0	0	0	0	0	368	24.8	67.4
23.0 - 24.0	6	261	44	0	0	0	0	0	0	0	0	0	0	311	23.8	76.5
24.0 - 25.0	0	112	22	0	0	0	0	0	0	0	0	0	0	134	11.7	87
25.0 - 26.0	0	153	70	14	0	0	0	0	0	0	0	0	0	237	22.1	93.4
26.0 - 27.0	0	28	100	43	28	0	0	0	0	0	0	0	0	199	21.2	106.1
27.0 - 28.0	0	0	85	222	102	85	34	0	0	0	0	0	0	529	65.8	124.4
28.0 - 29.0	0	14	82	218	246	410	218	55	14	0	0	0	0	1256	170.2	135.5
29.0 - 30.0	0	0	66	299	565	881	1013	266	0	33	17	0	0	3140	463.6	147.6
30.0 - 31.0	0	0	0	77	505	1577	1210	444	92	15	15	0	0	3935	631.9	160.6
31.0 - 32.0	0	0	0	58	510	1063	1048	597	15	0	15	0	0	3305	570.7	172.7
32.0 - 33.0	0	0	0	0	297	699	681	768	52	0	0	0	0	2498	468.3	187.5
33.0 - 34.0	0	0	0	0	138	415	246	369	123	0	0	0	0	1293	262.4	203
34.0 - 35.0	0	0	0	0	15	30	90	90	60	15	0	0	0	299	70.1	234.7
35.0 - 36.0	0	0	0	0	19	58	58	19	58	0	0	0	0	213	53.7	252
36.0 - 37.0	0	0	0	0	0	0	188	0	0	0	0	0	0	188	52	276.3
37.0 - 38.0	0	0	0	0	0	0	36	0	54	0	18	0	0	108	32.9	304.3
38.0 - 39.0	0	0	0	0	0	40	0	0	0	0	0	0	0	40	12.8	319.5
39.0 - 40.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.
40.0 - 41.0	0	0	0	0	0	0	14	0	0	0	0	0	0	14	4.9	340
41.0 - 42.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.
42.0 - 43.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.
43.0 - 44.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.
44.0 - 45.0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	1.8	555
TSN (Mils)	621	1291	627	931	2426	5258	4838	2608	467	63	64	0	3	19198	.	.
TSB ('000s t)	23.3	91.1	63.5	129.5	393.8	882.7	840	466	99	10.9	12.9	0	1.8	.	3014.5	.
Mn L (cm)	19.1	22.8	25.6	28.8	30.6	31	31.3	31.8	33.4	30.9	32.4	.	44.5	.	.	30.0
Mn Wt (g)	37.4	70.6	101.3	139.2	162.3	167.9	173.6	178.7	211.8	171.2						
% Mature	10	96	100	100	100	100	100	100	100	100	100	100	100			
% of SSB	10	96	100	100	100	100	100	100	100	100	100	100	100			

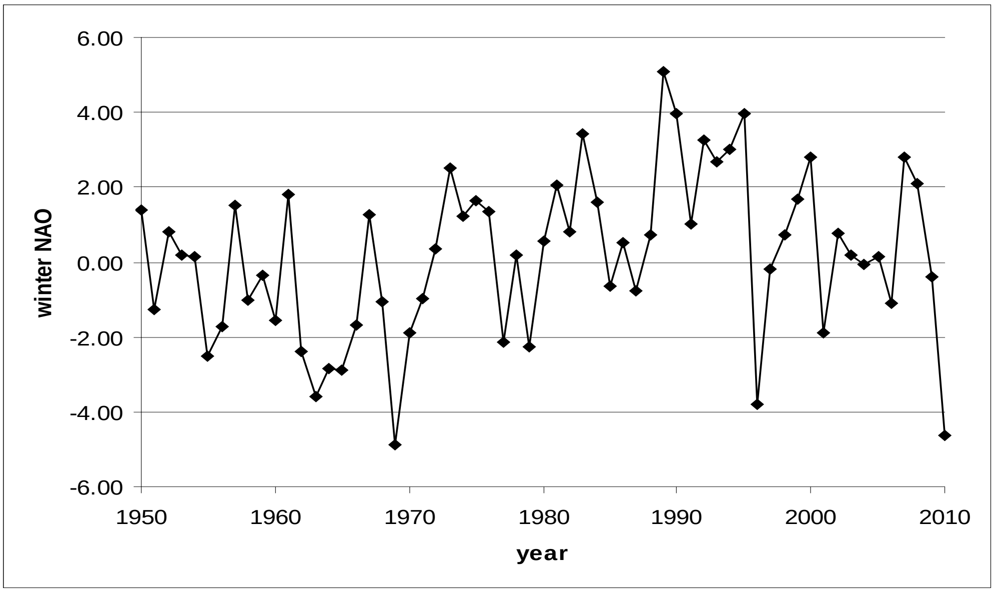

Figure 3.1.1. The winter NAO index between 1950 and 2009. Data from Hurrel 2010.

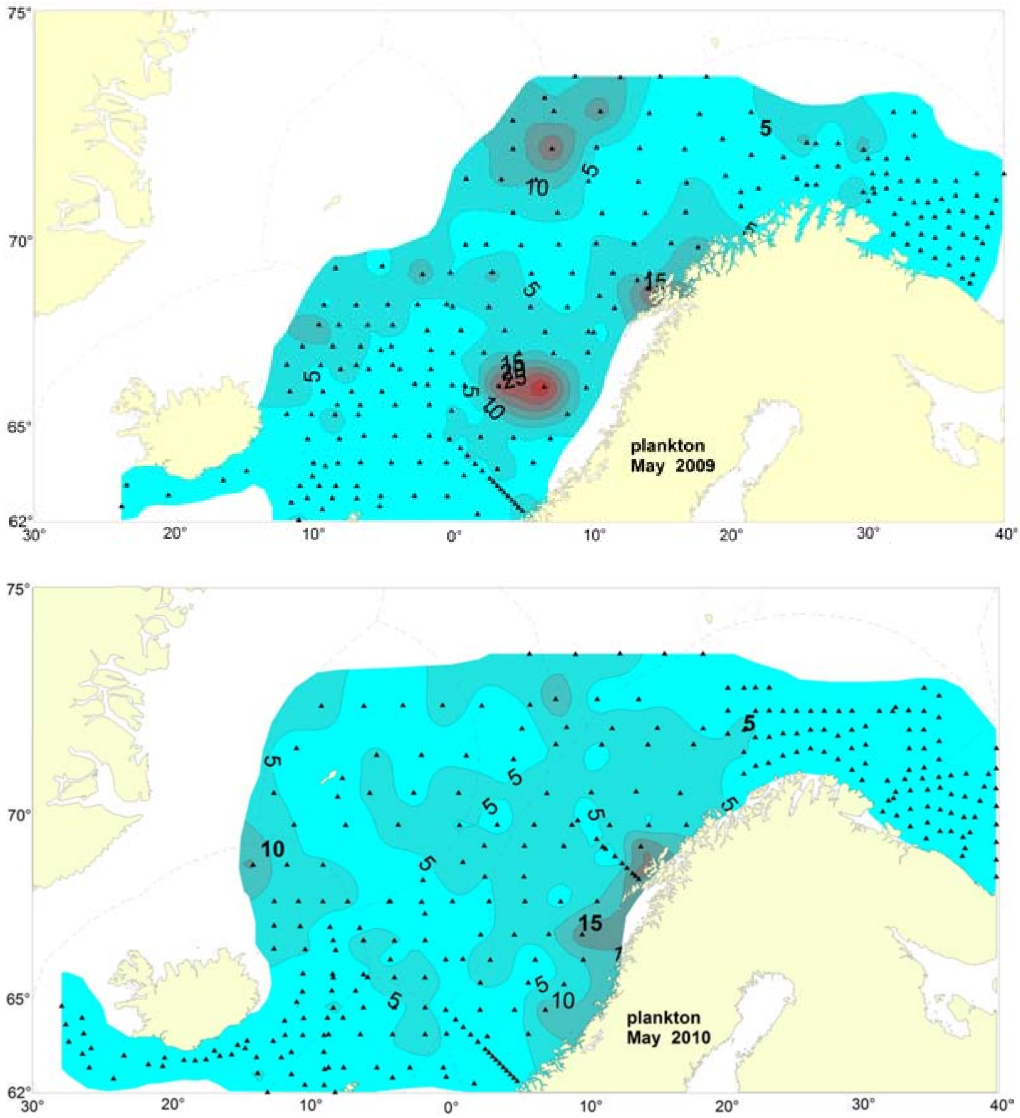

Figure 3.2.1. Zooplankton biomass (g dw m^{-2}; 200–0 m) in May 2009 and 2010.

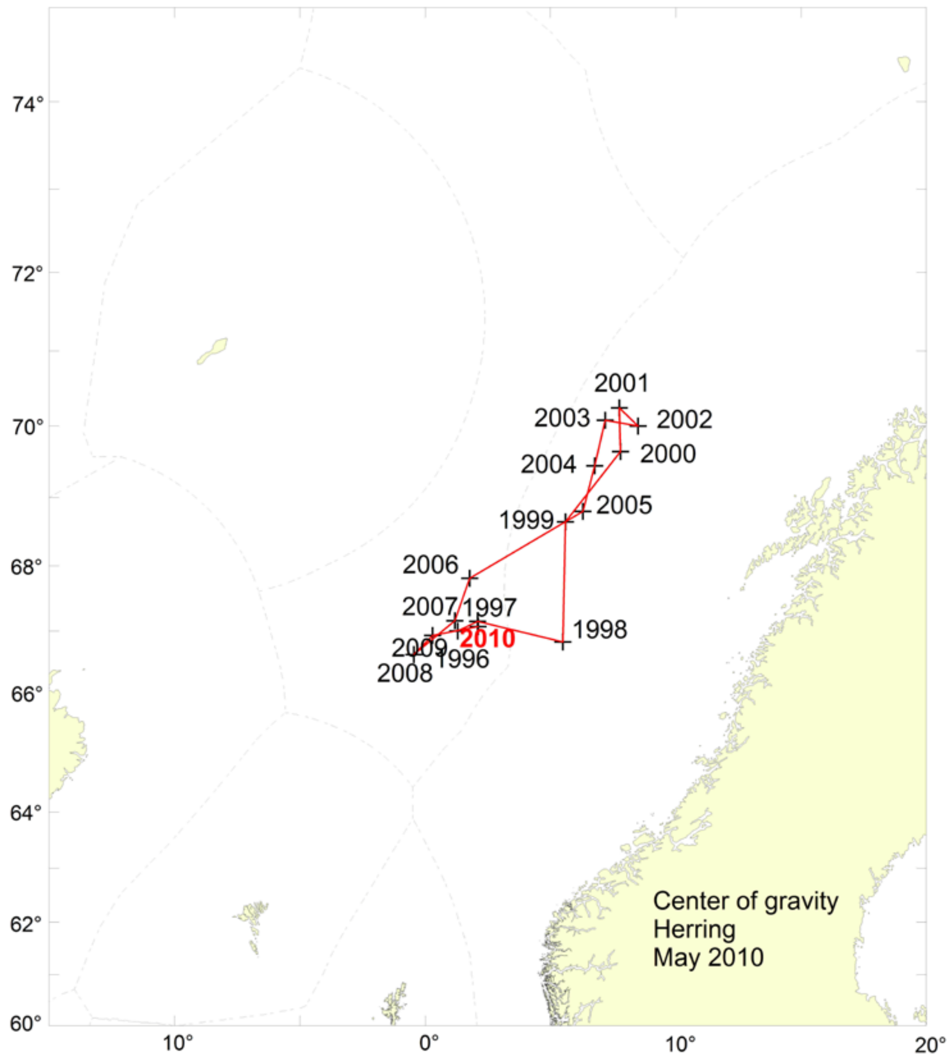

Figure 3.3.1. Centre of gravity of herring during the period 1996–2010 derived from acoustic. Acoustic data from area II and III only, i.e. west of 20°E.

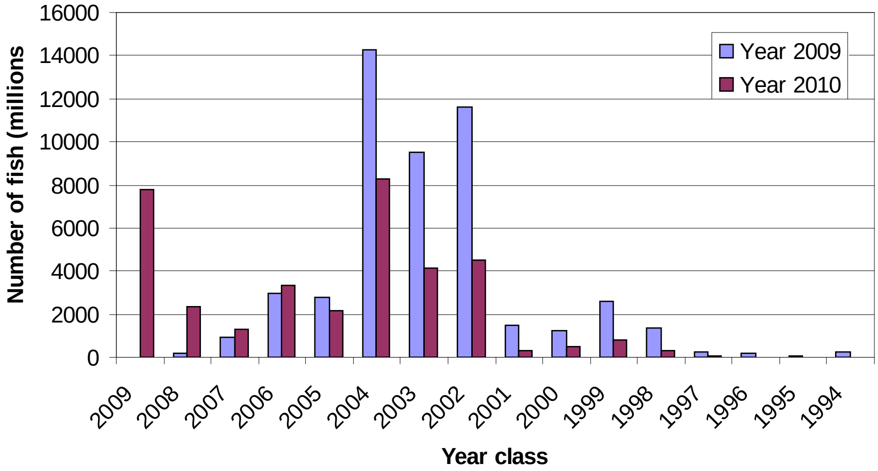

Figure 4.3.1. A comparison of the results of the acoustic measurements of NSSH in May 2009 and May 2010 in the Nordic seas for the different year classes.

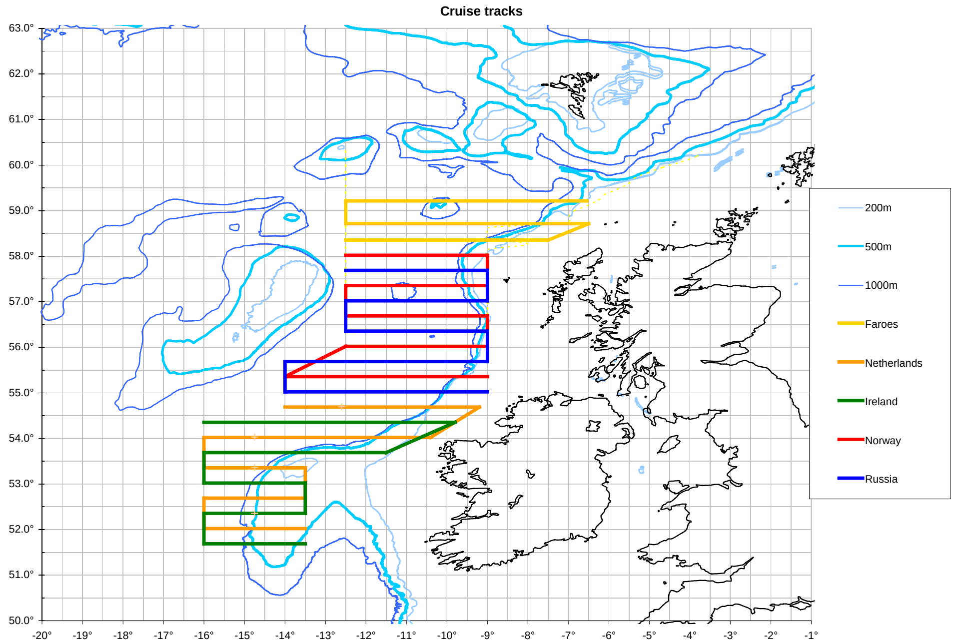

Figure 5.1.1. Preliminary survey tracks for the 2011 International blue whiting spawning stock.

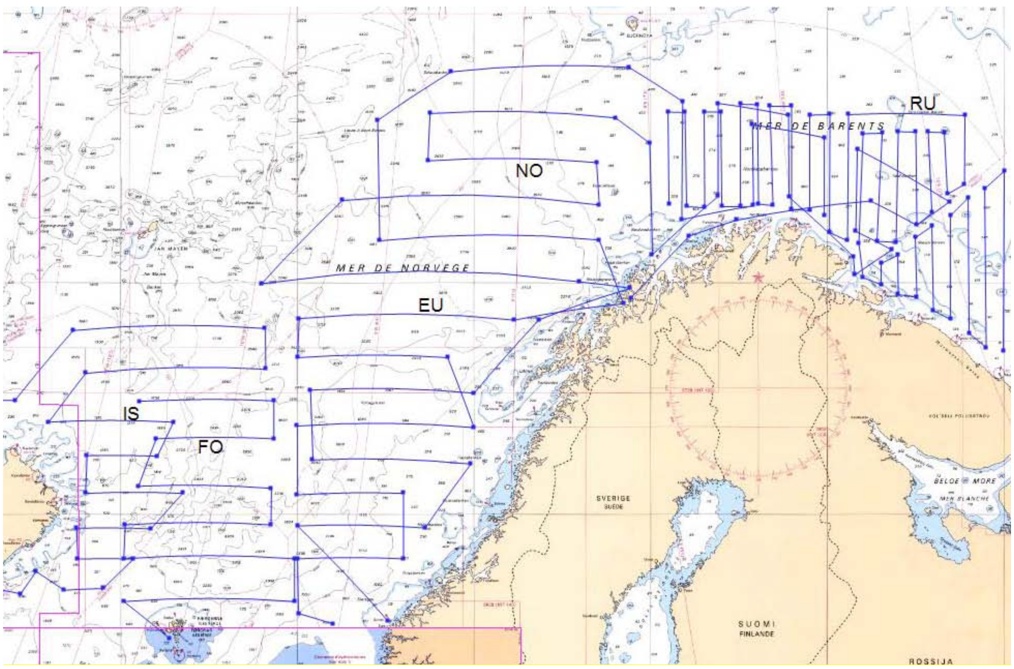

Figure 5.2.1. Preliminary survey tracks for the 2011 International ecosystem survey in the Nordic Seas.

Annex 1: List of participants

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Annex 2: International blue whiting spawning survey report

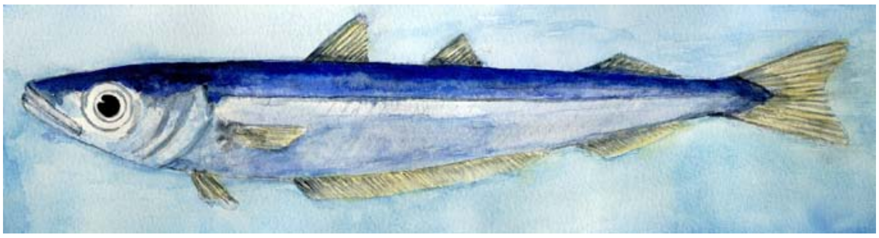
Working Document

Working Group on Northeast Atlantic Pelagic Ecosystem Surveys

Hamburg, Germany, 17–20 August 2010

Working Group on Widely distributed Stocks

Vigo, Spain, 28–03 September 2010



INTERNATIONAL BLUE WHITING SPAWNING STOCK SURVEY SPRING 2010

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Introduction

In spring 2010, five research vessels representing the Faroe Islands, Ireland, the Netherlands, Norway and Russia surveyed the blue whiting spawning grounds to the west of the UK and Ireland. 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 seventh coordinated international blue whiting spawning stock survey since 2004. 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*: Rybakov *et al.*, 2010; *C. Explorer*: O'Donnell *et al.*, 2010; *M. Heinason*: Jacobsen *et al.*, 2010; *Tridens*: Couperus *et al.*, 2010)

This report is based on correspondence undertaken after the International survey by all participants and during the post cruise meeting held in Bergen from May 3–4 with participation from Ireland and Norway.

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, 2009) and continued by correspondence until the start of the survey. Participating vessels together with their effective survey periods are listed below:

Vessel	Institute	Survey period
Fridtjof Nansen	PINRO, Murmansk, Russia	5/4–17/4
Celtic Explorer	Marine Institute, Ireland	19/3–7/4
G.O. Sars	Institute of Marine Research, Bergen, Norway	21/3–03/4
Magnus Henson	Faroe Marine Research Institute, Faroe Islands	02/4–14/4
Tridens	Institute for Marine Resources & Ecosystem Studies (IMARES), the Netherlands	19/3–9/4

Cruise tracks 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). Regular communication between vessels was maintained during the survey (via e-mail, InmarSat C and VHF radio) exchanging blue whiting distribution data, fleet activity and biological information.

<u>*Sampling equipment*</u>

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. All transducers were calibrated with a standard calibration sphere (Foote *et al.*, 1987) prior to the survey. Acoustic settings by vessel are summarized in Table 2.

Acoustic Intercalibration

Inter-vessel acoustic calibrations are carried out when participant vessels are working within the same general area and time and weather conditions allow for an exercise to be carried out. The procedure follows the methods described by Simmonds and MacLennan 2007.

Biological sampling

All components of the catch from the trawl hauls were sorted and weighed; fish and other taxa were identified to species level. The level of blue whiting sampling of by vessel is shown in Table 5.

Hydrographic sampling

Hydrographic sampling by way of vertical CTD cast was carried out by each participant vessel (Figure 2 and Table 1) up to a maximum depth of 1,100m 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 4.8) 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.

On G.O. Sars, 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. 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 trawl data were analysed with a SAS based routine called "BEAM" (Totland and Godø 2001) and used to calculate age and length stratified estimates of total biomass and abundance (numbers of individuals) within the survey area as a whole and within 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 (ρ) the following relationship was used:

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

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

BEAM does not distinguish between mature and immature individuals, and calculations dealing with only mature fish were therefore carried out separately after the final BEAM run separately for each 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

No acoustic inter-calibrations were carried out during the 2010 survey due to time restrictions.

Distribution of blue whiting

During the 2010 survey a mismatch in temporal alignment from the pre-agreed survey plan (Appendix 3.) led to a 15 daytime-lag between participant vessels. This time-lag was deemed too large to produce a single synoptic survey estimate and as a result survey data are presented here in a two survey format. The 'combined' survey is made up of data from Faroes, Netherlands, Norway and Ireland and is presented as a continuation of the current survey index. The 'Russian' survey data are presented as a stand-alone single survey estimate. Both surveys covered core spawning areas along the shelf break and followed good temporal progression respectively.

Blue whiting were recorded in all areas surveyed. In total 9,015nmi (nautical miles) of survey transects were completed (combined survey 7,165nmi and Russian survey 1,850nmi) relating to an area coverage of 109,000nmi² (square nautical miles) and 40,000nmi² respectively (Figure 1, Tables 1 and 3).

Combined survey coverage was down by 18% overall, the largest single reduction occurred in the north Porcupine area (42% reduction) followed by Rockall (30% reduction) and Hebrides (11% reduction). The Faroes/Shetland area saw an increase in coverage of 30% as effort was extended further north in the search for blue whiting registrations. Reduced coverage in Rockall was a conscious decision as a result of the near zero blue whiting registrations encountered by the RV *Celtic Explorer* and RV *G.O. Sars*.

The gap in area coverage in the north Porcupine and south Hebrides areas can be attributed to poor weather encountered by the RV *Tridens* and the mismatch of timing of coverage by the co-survey vessel the RV *F. Nansen*. The concept of vessels co-surveying allocated areas within the same time period is to ensure no gaps in coverage occur. The area in question was likely to contain a high blue whiting abundance as indicated by the focus of international fishing effort during the time of surveying. None coverage of this area no doubt resulted in an underestimate of abundance in this core area by the combined survey (Figure 1 and 4).

The highest concentrations of blue whiting were recorded in the Hebrides core area which remains consistent with the results from previous surveys (Figure 8a, Table 3a). Overall the bulk of the stock was centred further south than during the same time in 2009 (Figure 4). Medium and high density registrations extended further into the Rockall Trough between 56–58 degrees of latitude than observed in 2009. To the north and south of this region blue whiting registrations of medium to high density were distributed almost entirely within a narrowband running close the shelf edge often extending no more than 10nmi west of the 250m contour (Figure 8c-d).

In the western and northern extremes of the survey area low density blue whiting registrations dominated. Aggregations observed in western Rockall during the 2009 survey and the associated commercial fishing activity were notably absent in 2010. Spawning blue whiting normally present in western Rockall appear to have been displaced eastwards into the Rockall Trough due which may be due to the influence of colder less saline water observed at depth in western Rockall by the RV *Celtic Explorer* (O'Donnell *et al.*, 2010).

Stock size

Combined survey

The estimated total abundance of blue whiting for the 2010 international combined survey was 2.43 million tonnes, representing an abundance of 16.4x10⁹ individuals (Figure 7, Tables 3a and 4a). Spawning stock was estimated at 2.4 million tonnes and 15.8x10⁹ individuals. In comparison to 2009, there is a significant decrease (60%) in the observed stock biomass and a related decrease in stock numbers (65%).

		2004	2005	2006	2007	2008	2009	2010	Change from 2009 (%)
Biomass	Total	11.4	8	10.4	11.2	8	6.07	2.43	-60%
(mill. t)	Mature	10.9	7.6	10.3	11.1	7.9	6.03	2.4	-60%
Numbers	Total	137	90	108	104	68	46.7	16.4	-65%
(10^9)	Mature	128	83	105	102	67	45.8	15.8	-66%
Survey area (nm^2)		149,000	172,000	170,000	135,000	127,000	133,900	109,320	-18%

The Hebrides core area was found to contain 56% of the total biomass observed during the survey and is consistent with the results from previous surveys (50% in 2008, 62% in 2009 relative to total-stock biomass for that year). The north Porcupine and Faroes/Shetland areas ranked second and third highest contributing 20% and 12% to the total respectively. The breakdown of combined survey biomass by subarea is shown below:

		Biomass (million tonnes)				
		2009		2010		
			% of		% of	
	Sub-area		total		total	Change (%)
I	S. Porcupine Bank	0.1	1	0.1	4	0%
II	N. Porcupine Bank	1.2	15	0.5	20	-58%
III	Hebrides	4.13	52	1.4	56	-66%
IV	Faroes/Shetland	0.74	9	0.3	12	-59%
V	Rockall	1.8	23	0.2	8	-89%

Russian survey

The estimated total abundance of blue whiting for the 2010 Russian survey was 3.79 million tonnes, representing an abundance of 27.2x10⁹ individuals (Figure 5, Table 3b and 4b). Spawning stock was estimated at 3.65 million tonnes and 24.7x10⁹ individuals.

Stock composition

Individuals of ages 1 to 13 years were observed during the survey. A comparison of age reading between nations was carried out and the results are presented in Appendix 2. Overall, good agreement in age readings was achieved across nations from the combined survey. The largest variation came from Russian age readings, where smaller individuals were markedly older than those for other nations. The 2009 year class (1-year old fish) was notably absent from Russian samples as compared to other nations which reported 1-year old fish from all subareas (Table 4a-b).

The stock within the survey area is dominated by age classes 6, 7 and 5-years, of the 2004, 2003 and 2005 year classes respectively, contributing over 73% of spawning-stock biomass (Table 4a, Figure 9 and 10).

The Hebrides area remains the most productive in the current survey time-series and has consistently contributed over 50% to the total SSB (Figure 7). The age profiles of all subareas are dominated by the three most prolific age classes within the stock (2003, 2002 and 2004). The Hebrides and Faroe/Shetland subareas contained the oldest age classes observed, up to 13 years (1997 year class).

Juvenile blue whiting were represented in all subareas in 2010. Maturity analysis of combined survey samples indicate that 10% of 1-year old and 96% of 2-year old fish were mature as compared to Russian estimates of where no 1-year old fish were observed and 1% of 2-year old fish were considered mature (Tables 4a-b).

From combined survey data the Porcupine subareas were found to contain immature blue whiting as in previous years. The largest proportion of 1-year old fish representing 2% (9,500t) of the total biomass and 8% (283 million individuals) of the total abundance was observed in the north Porcupine area. The Hebrides also contained immature representing 0.7% (9,200t) of total biomass and 3% (247 million) of total abundance.

Faroe/Shetland area had a significant contribution of 2-year old fish (2008 year class) representing 24% (59,400t) of the total biomass and 44% (870 million) of total abundance for this area. The positive signal of this prerecruiting year class was not observed in any other subarea in the same proportion (Figure 10).

Overall immature blue whiting from the combined estimate represented 1% (23,400t) of the total biomass and 4% (615 million) of the total abundance recorded during the survey.

Hydrography

A combined total of 173 CTD casts were undertaken over the course of the survey. Horizontal plots of temperature and salinity at depths of 10m, 50m, 100 and 200m as derived from vertical CTD casts are displayed in Figures 11–14 respectively.

Concluding remarks

Main results

- The seventh international blue whiting spawning stock survey shows a significant decrease in stock biomass (-60%) and a related decrease in stock numbers (-65%) as compared to the previous year's survey.
- Total stock abundance is not considered fully reflected due to a gap in combined survey coverage between the 55–56ºN. This area was the focus of the bulk of international fishing effort during the survey and may therefore contain a significant yet undetermined contribution to the overall estimate in 2010.
- The stock in the survey area is dominated by 6, 7 and 5-years, of the 2004, 2003 and 2005 year classes respectively. Together these year classes account for 73% of spawning-stock biomass.
- Mean length (29.8 cm) and weight (147.8 g) are the highest on record in the international survey time-series indicating the continued reliance of the stock on larger older individuals.
- The contribution of immature fish to the total biomass remains small. However, a positive signal of 2-year old fish was observed in the Faroe/Shetland area and is an encouraging sign in a period of prolonged poor recruitment.
- Maturity analysis indicated that peak spawning in 2010 was later than in previous years due to the proportion of spent fish observed. In 2009 peak spawning was considered earlier as a much larger proportion of the stock surveyed was spent.
- The combined survey effort was carried out over 28 days as compared to 29 days in 2009. The 2010 survey commenced 3 days later than in 2009 so timing is considered comparable. It was planned during PGNAPES planning meeting in 2009 that the survey should be completed within a 21 day window.
- The F. Nansen began surveying 10 days later than in 2009 and 15 days after the Tridens began in the southern co-surveyed area. This large time-lag continued northwards and as a result data from co-surveyed rectangles was non-admissible to the combined survey estimate.

Interpretation of the results

- Both surveys (Combined and Russian) provide a snapshot of relative abundance within the survey area at the time of surveying. It is not possible to overlay estimates due to the significant time-lag. Had all vessels covered areas as agreed within the allocated time frame it would be possible to produce a single survey estimate with a high degree of precision.
- The 2010 estimate of abundance for the combined survey can be considered robust for those areas covered. Over 76% of the total biomass was observed in subareas surveyed by more than one vessel. However, the gap in coverage has no doubt resulted in an underestimate of the stock.
- The Russian survey appears to have successfully contained the stock within the survey area as a consequence of the more eastward orientation in 2010 and may be a more representative estimate of the stock as a whole.

- Survey timing is fixed annually to coincide with peak spawning of the stock. In 2010 as in 2009 the time of peak spawning varied. However, in both years the stock was contained within the survey area due to the extensive survey area and so estimates of abundance are credible.

Recommendations

- Agreements made by *all* survey participants during the planning phase (WGNAPES) need to be adhered to by *all* participants during the survey to ensure synoptic coverage.
- The results of the blue whiting otiliths exchange program should be made available prior to the WGNAPES meeting in August for discussion at the meeting.

Achievements

- Good at sea communications between participant vessels for the combined survey was achieved and allowed the survey to be adapted to ensure coverage of area of distribution.
- Delivery of survey data in the PGNAPES format to Leon Smith was achieved in a timely fashion.

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Table 1. Survey effort by vessel. March-April 2010.

Vessel	Effective survey period	Length of cruise track (nm)	Trawl stations	CTD stations	Aged fish	Length-measured fish
Fridtjof Nansen	5/4–17/4	1,850	19	55	1078	3,897
Celtic Explorer	20/3–3/4	2,260	13	42	450	1,350
G.O. Sars	21/3–3/4	2,140	12	28	176	600
Magnus Heinason	02/4–14/4	1,490	9	28	463	1,039
Tridens	23/3–4/4	1,275	9	21	450	1,171
Total		9,015	62	174	2,617	8,057

Table 2. Acoustic instruments and settings for the primary frequency. March-April 2010.

	Fridtjof Nansen	Celtic Explorer	G.O. Sars	Magnus Heinason	Tridens
Echo sounder	Simrad EK60	Simrad EK 60	Simrad ER 60	Simrad EK 500	Simrad EK 60
Frequency (kHz)	**38, 120**	**38**, 18, 120, 200	**38**, 18, 70, 120, 200,	**38**	**38**
Primary transducer	ES38B	ES 38B	ES 38B - SK	ES38B	ES 38B
Transducer installation	Hull	Drop keel	Drop keel	Hull	Towed body
Transducer depth (m)	4.5	8.7	8.5	3	7
Upper integration limit (m)	10	15	15	7	12
Absorption coeff. (dB/km)	10	10	9.8	10	9.8
Pulse length (ms)	1.024	1.024	1.024	1.024	1.024
Band width (kHz)	2.425	2.425	2.43	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	-20.8	-20.9	-20.5
Sv Transducer gain (dB)				27.15	25.09
Ts Transducer gain (dB)	25.72	25.71	26.62	27.1	
s_A correction (dB)	-0.63	-0.63	-0.63		-0.63
3 dB beam width (dg)					
alongship:	6.99	6.97	7.09	7	7.09
athw. ship:	7.04	7.01	7.07	6.9	7.02
Maximum range (m)	750	750	750	750	750
Post processing software	FAMAS	Sonardata Echoview	LSSS	Sonardata Echoview	Sonardata Echoview

Table 3. Assessment factors of blue whiting. (Top: Combined survey (Netherlands, Norway, Faroes and Ireland) and bottom: Russian survey). March-April 2010.

a). Combined survey

	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	9,404	0.87	0.88	98.6	0.12	0.13	99.6	141.4	30.3	13.3
II	N. Porcupine Bank	13,741	3.65	3.68	99.1	0.47	0.47	99.7	127.2	29.9	34.1
III	Hebrides	29,744	8.61	8.64	99.7	1.38	1.38	99.9	159.5	30.4	46.3
IV	Faroes/Shetland	19,389	1.96	1.99	98.2	0.24	0.25	99.1	123.7	26.2	12.7
V	Rockall	37,042	1.25	1.25	99.9	0.21	0.21	100.0	170.2	30.4	5.7
Tot.		109,320	16.33	16.4	99.6	2.43	2.43	99.8	147.8	29.8	22.2

b). Russian survey

	Sub-area		Numbers (10^9)			Biomass (10^6 tonnes)			Mean weight	Mean length	Density
		n.mile^2	Mature	Total	%mature	Mature	Total	%mature	g	cm	ton/n.mile^2
I	S. Porcupine Bank	-	-	-	-	-	-	-	-	-	-
II	N. Porcupine Bank	12,208	2.37	2.65	89	0.34	0.36	94	136	29.2	30.6
III	Hebrides	23,844	21.16	23.14	91	3.14	3.24	97	140	29.3	139.6
IV	Faroes/Shetland	4,151	1.18	1.42	83	0.17	0.19	89	132	29.5	51.6
V	Rockall	-	-	-	-	-	-	-	-	-	-
Total		40,203	24.71	27.21	91	3.65	3.79	96	139	29.3	97.3

Table 4a. Combined survey stock estimate of blue whiting, March-April 2010.

Length	Age in years (year class)										Numbers	Biomass	Mean	Prop.
Length	1	2	3	4	5	6	7	8	9	10+			weight	mature*
(cm)	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	(*10-6)	(10^6 kg)	(g)	(%)
13.0 – 14.0	1	0	0	0	0	0	0	0	0	0	1	0	15	0
14.0 – 15.0	0	0	0	0	0	0	0	0	0	0	0	0	.	.
15.0 – 16.0	10	0	0	0	0	0	0	0	0	0	10	0.2	19.6	0
16.0 – 17.0	22	0	0	0	0	0	0	0	0	0	22	1	24	0
17.0 – 18.0	56	5	0	0	0	0	0	0	0	0	61	2	27	0
18.0 – 19.0	204	0	0	0	0	0	0	0	0	0	204	6	31	0
19.0 – 20.0	184	31	4	0	0	0	0	0	0	0	219	8	37	0
20.0 – 21.0	89	115	24	0	0	0	0	0	0	0	228	11	47	0
21.0 – 22.0	44	216	28	0	0	0	0	0	0	0	288	16	57	50
22.0 – 23.0	16	297	92	0	0	0	0	0	0	0	405	27	67	75
23.0 – 24.0	5	284	47	0	0	0	0	0	0	0	336	24	73	100
24.0 – 25.0	0	121	15	0	0	0	0	0	0	0	136	11	82	100
25.0 – 26.0	0	81	123	7	0	0	0	0	0	0	211	17	82	100
26.0 – 27.0	0	17	101	35	28	0	0	0	0	0	181	18	98	100
27.0 – 28.0	0	0	110	190	73	61	25	0	0	0	459	55	120	100
28.0 – 29.0	0	13	60	117	229	425	195	43	5	0	1087	145	134	100
29.0 – 30.0	0	0	57	310	580	732	773	191	0	30	2673	378	141	100
30.0 – 31.0	0	0	0	71	539	1401	952	313	67	16	3359	516	154	100
31.0 – 32.0	0	0	0	35	531	1018	731	434	10	10	2769	458	165	100
32.0 – 33.0	0	0	0	0	319	662	450	566	36	0	2033	359	176	100
33.0 – 34.0	0	0	0	0	152	439	157	233	80	0	1061	204	192	100
34.0 – 35.0	0	0	0	0	18	29	69	78	49	13	256	57	223	100
35.0 – 36.0	0	0	0	0	26	54	48	14	41	0	183	45	245	100
36.0 – 37.0	0	0	0	0	0	0	155	0	0	0	155	40	260	100
37.0 – 38.0	0	0	0	0	0	0	35	0	21	7	63	17	279	100
38.0 – 39.0	0	0	0	0	0	18	5	0	3	1	27	9	311	100
39.0 – 40.0	0	0	0	0	0	0	0	0	0	0	0	0	.	.
40.0 – 41.0	0	0	0	0	0	0	14	0	0	0	14	5	340	100
41.0 – 42.0	0	0	0	0	0	0	0	0	0	0	0	0	.	.
42.0 – 43.0	0	0	0	0	0	0	0	0	0	0	0	0	.	.
43.0 – 44.0	0	0	0	0	0	0	0	0	0	0		0	.	.
44.0 – 45.0	0	0	0	0	0	0	0	0	0	3	3	2	596	100
TSN (10^6)	631	1180	661	765	2495	4839	3609	1872	312	80	16444	2430.4		
TSB (10^6 kg)	22.3	80.8	59.6	102.6	374.2	759.1	616.8	333.2	65.5	16.4	2430.5			
Mean length (cm)	19.2	22.8	25.6	28.9	30.7	31	31.3	31.8	33.3	36.8	29.8			
Mean weight (g)	35.4	68.5	90.3	134.2	149.9	156.8	170.9	177.9	210.2	195	147.8			
% mature*	10	96	100	100	100	100	100	100	100	100				
% of SSB	10	96	100	100	100	100	100	100	100	100				

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

Table 4b. Russian survey stock estimate of blue whiting, March-April 2010.

Length	Age in years (year class)										Numbers	TSB	Mean	Prop
	1	2	3	4	5	6	7	8	9	10+		Biomass	weight	mature
(cm)	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	(*10-6)	(10^6 kg)	(g)	(%)
13.0 - 14.0	0	10	2	0	0	0	0	0	0	0	11.9	0.2	14.5	0
14.0 - 15.0	0	116	12	0	0	0	0	0	0	0	128.3	1.9	14.5	0
15.0 -16.0	0	178	34	0	6	0	0	0	0	0	217.9	3.8	17.7	0
16.0 - 17.0	0	208	14	9	0	0	0	0	0	0	230.2	4.6	20.0	0
17.0 - 18.0	0	288	21	0	0	0	0	0	0	0	309.2	7.5	24.1	0
18.0 - 19.0	0	408	92	0	0	0	0	0	0	0	499.3	15.7	31.4	0
19.0 - 20.0	0	74	225	0	6	0	0	0	0	0	304.7	11.6	37.9	0
20.0 - 21.0	0	19	138	92	0	0	0	0	0	0	249.3	11.1	44.7	0
21.0 - 22.0	0	38	122	0	0	0	0	0	0	0	159.5	8.0	49.9	12
22.0 -23.0	0	7	67	30	0	0	0	0	0	0	104.9	5.9	56.7	15
23.0 -24.0	0	28	75	25	8	4	0	0	0	0	139.1	9.2	65.8	66
24.0 - 25.0	0	13	111	203	27	14	0	0	0	0	367.5	27.0	73.4	71
25.0 - 26.0	0	6	177	291	39	39	0	0	0	0	551.9	46.6	84.4	93
26.0 - 27.0	0	0	94	199	86	0	16	0	0	0	395.0	36.7	92.8	100
27.0 - 28.0	0	0	114	106	131	44	38	50	12	0	495.8	53.2	107.3	100
28.0 - 29.0	0	0	131	382	779	695	217	109	0	0	2313.6	277.1	119.8	98
29.0 - 30.0	0	9	159	388	859	1384	792	210	0	0	3800.6	491.3	129.3	99
30.0 - 31.0	0	0	81	547	1176	2226	1689	584	307	36	6645.3	934.5	140.6	100
31.0 - 32.0	0	0	28	144	579	1089	1053	465	28	27	3413.9	515.5	151.0	99
32.0 - 33.0	0	0	8	200	403	925	873	357	93	0	2860.1	485.4	169.7	100
33.0 - 34.0	0	0	0	76	299	698	889	167	61	0	2188.5	399.6	182.6	100
34.0 - 35.0	0	0	0	2	83	190	261	157	38	0	730.8	146.3	200.1	100
35.0 - 36.0	0	0	0	0	62	23	56	79	87	0	305.9	68.1	222.5	100
36.0 - 37.0	0	0	0	22	20	47	89	0	0	0	177.9	45.0	252.6	100
37.0 - 38.0	0	0	0	64	0	57	64	42	86	35	348.2	96.9	278.2	100
38.0 - 39.0	0	0	0	0	10	10	19	20	0	10	68.4	20.4	298.3	100
39.0 - 40.0	0	0	0	0	19	0	8	58	0	0	85.2	29.1	342.0	100
40.0 - 41.0	0	0	0	0	0	39	48	8	0	0	95.2	33.4	350.8	100
41.0 - 42.0	0	0	0	0	0	0	0	0	0	0	0.0	0.0	-	-
42.0 - 43.0	0	0	0	0	0	0	0	0	0	0	0.0	0.0	-	-
43.0 - 44.0	0	0	0	0	0	0	0	0	0	0	0.0	0.0	-	-
44.0 - 45.0	0	0	0	0	0	0	8	0	0	0	8.3	3.5	424.0	100
TSN (10^6)	0	1401.9	1704.3	2780.7	4591.6	7484.0	6119.0	2304.9	712.2	107.8	27206.4	3788.8		
TSB (10^6 kg)	0	38.8	130.1	345.2	660.2	1122.2	965.9	377.9	127.2	21.3	3788.8			
Mean L (cm)	-	17.2	23.6	28.2	29.9	30.5	31.2	31.4	32.2	65.0	29.33			
Mean W (g)	-	27.7	76.3	124.1	143.8	149.9	157.8	164.0	178.6	364.9	139.3			
% Mature	-	1	52	96	97	100	100	100	100	100				
% of SSB	-	1	52	96	97	100	100	100	100	100				

Table 5. Country and vessel specific details, March-April 2010.

	Fridtjof Nansen	Celtic Explorer	G.O. Sars	Magnus Heinason	Tridens
Trawl dimensions					
Circumference (m)	716	768	600	640	1120
Vertical opening (m)	50	50	30	40	30-70
Mesh size in codend (mm)	16	20	16	40	±20
Typical towing speed (kn)	3.2-4.2	3.5-4.0	3.0-3.5	3.0-4.0	3.5-4.0
Biological sampling					
Length Only	3897				±200
Lenth/Weight		100	70	200	
Length/Weight/Sex/Maturity	1078	50	30	100	50
Hydrographic sampling					
CTD Unit	SBE19plus	SBE911	SBE911	SBE911	SBE911
Standard sampling depth (m)	1000	1000	1000	1000	1000

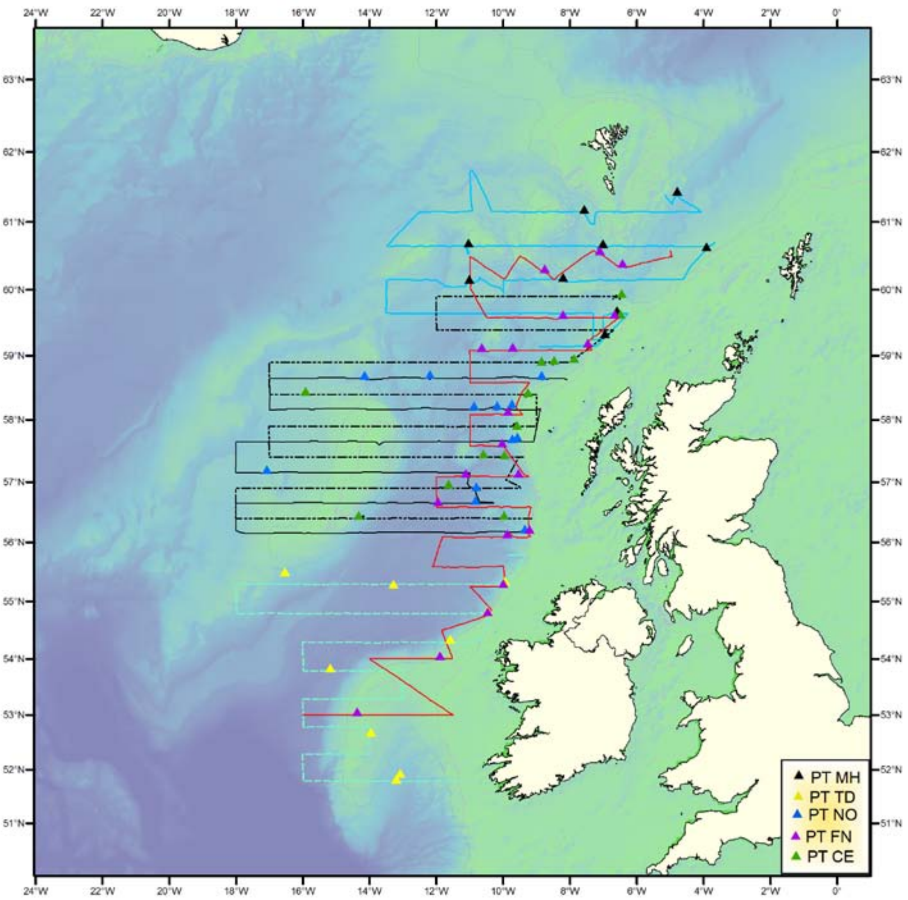


Figure 1. All survey vessel cruise tracks and trawl stations. PT: Indicates pelagic trawl station. CE: Celtic Explorer; MH: Magnus Heinason; TD: Tridens; FN: Fridtjof Nansen: NO: G.O. Sars. March-April 2010.

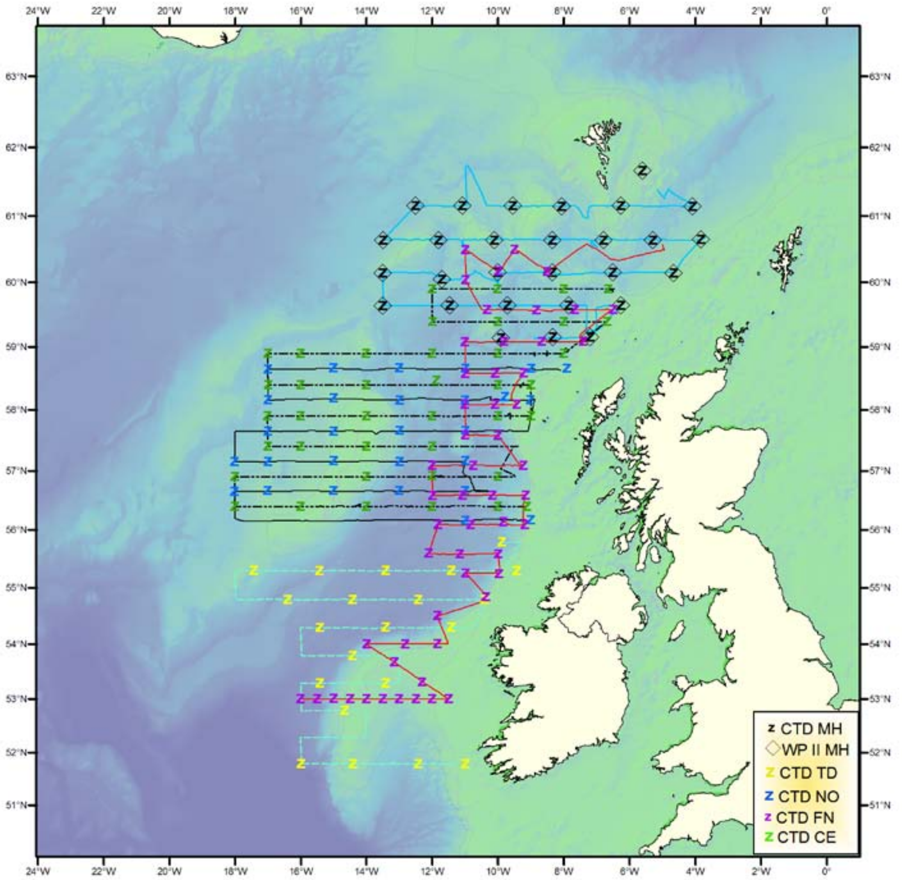


Figure 2. CTD stations overlaid onto vessel cruise tracks for all surveys. WP II: Indicates plankton trawl. CE: Celtic Explorer; MH: Magnus Heinason; TD: Tridens; FN: Fridtjof Nansen: NO: G.O. Sars. March-April 2010.

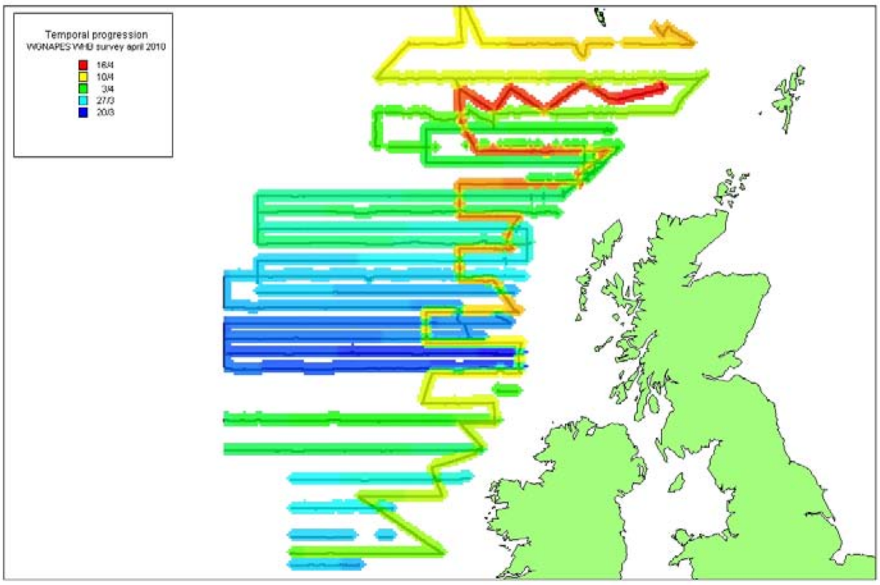
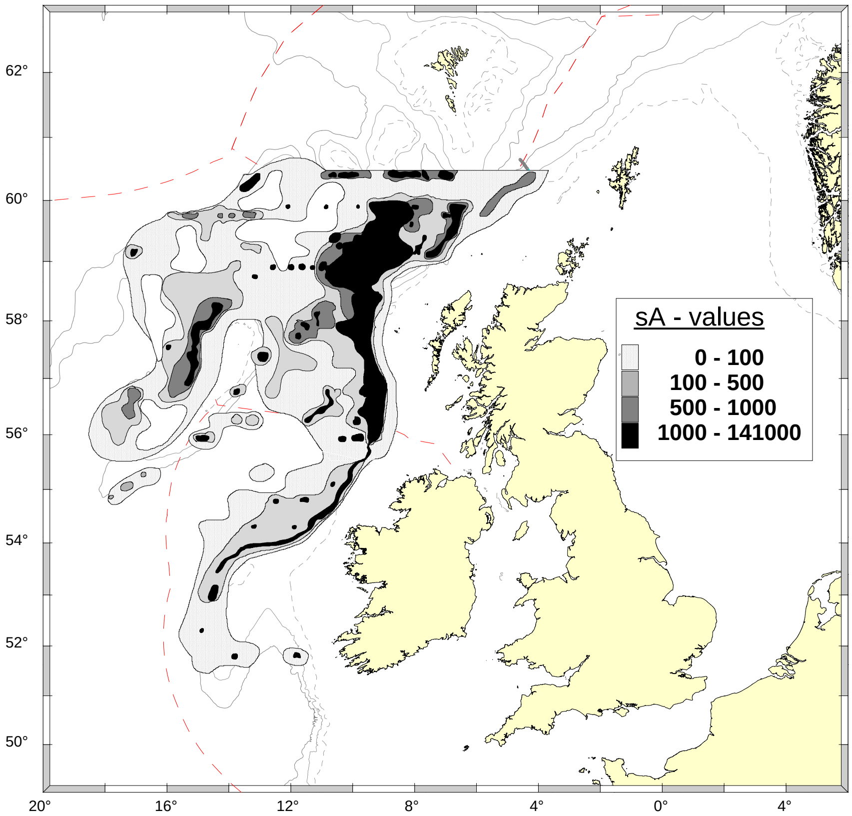


Figure 3. Temporal progression for all surveys, 20 March–16 April 2010.



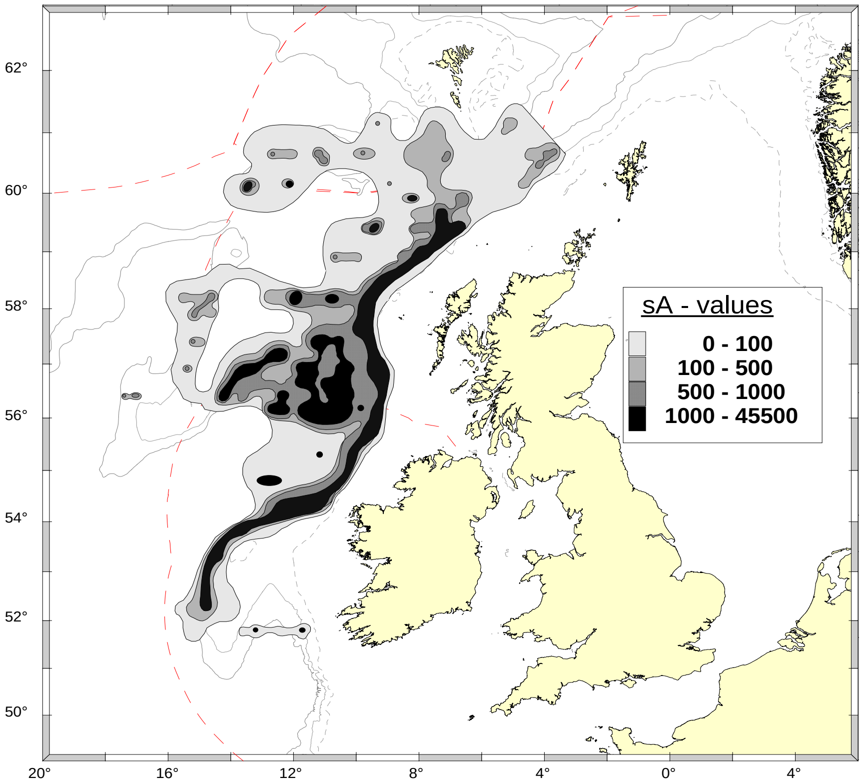


Figure 4. Schematic maps of Combined survey blue whiting acoustic density (s_A, m²/nm²) in March-April 2009 (upper panel) and 2010 (lower panel).

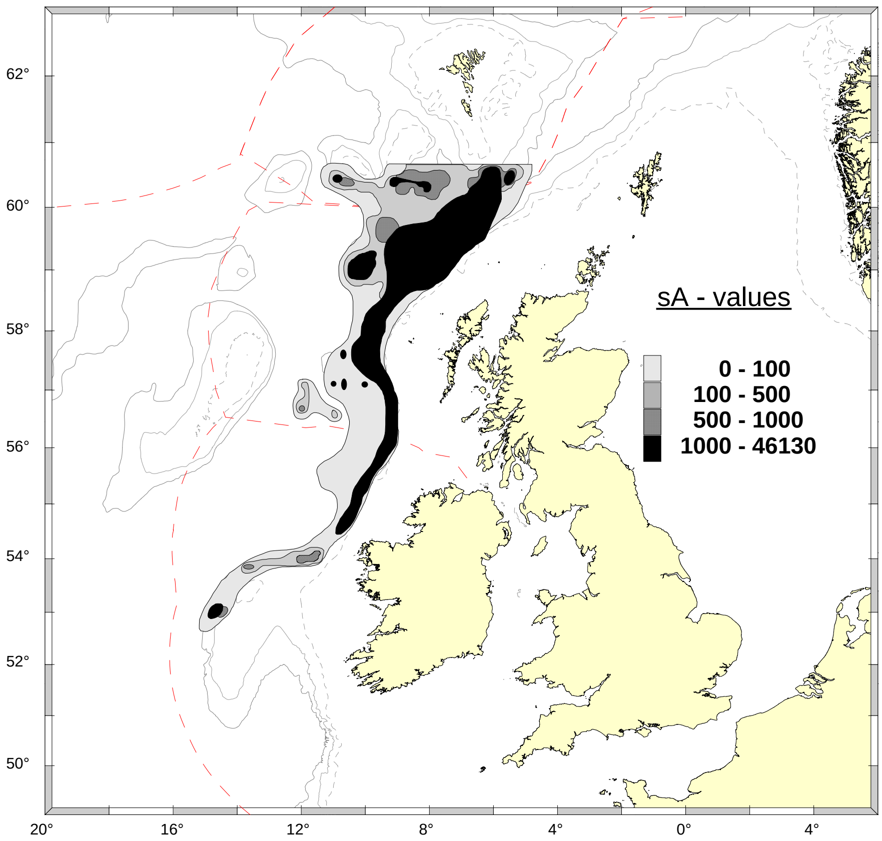


Figure 5. Schematic map of Russian survey blue whiting acoustic density (sA, m2/nm2) in 2010.

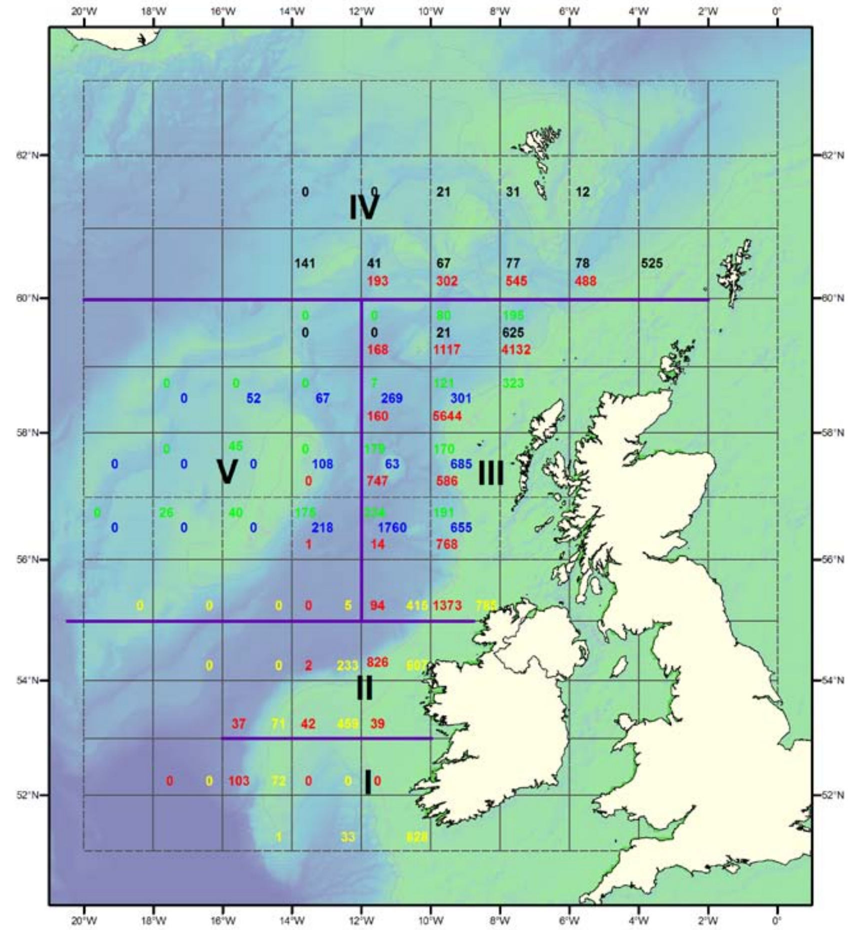


Figure 6. Mean blue whiting acoustic density (s_A, m^2/nm^2) by individual vessel: Celtic Explorer: green, Magnus Heinason: grey, Netherlands: yellow, Fridtjof Nansen: red, G.O. Sars: blue. March-April 2010. Note: A time-lag of 15 days was recorded between the RU survey and the coordinated survey.

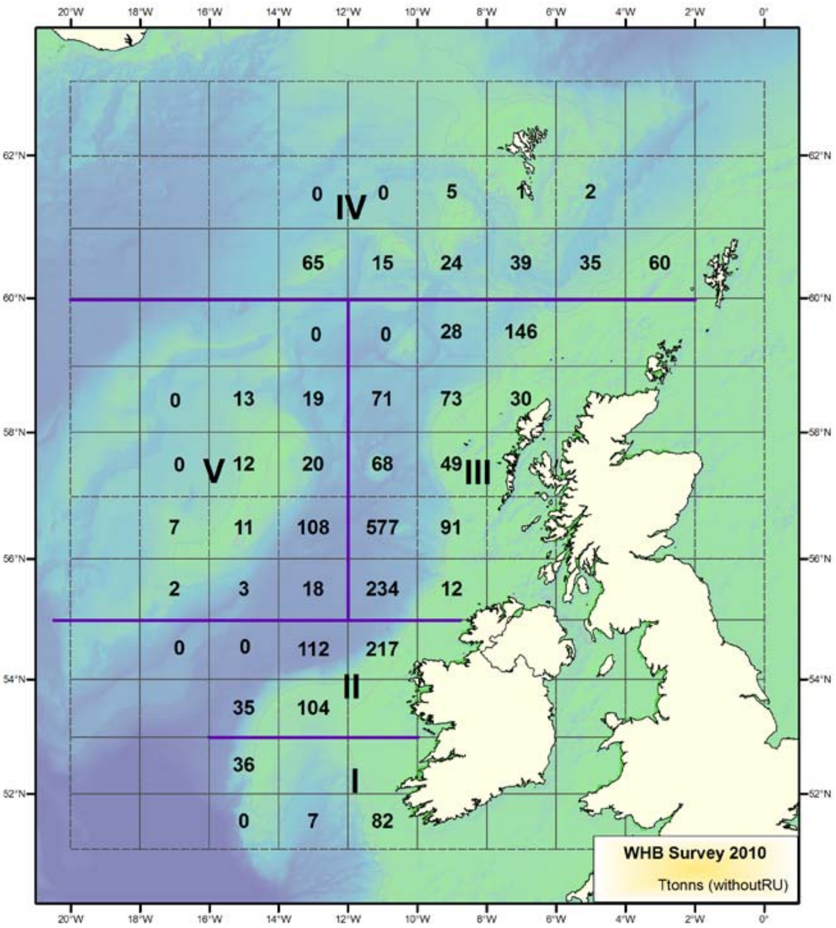
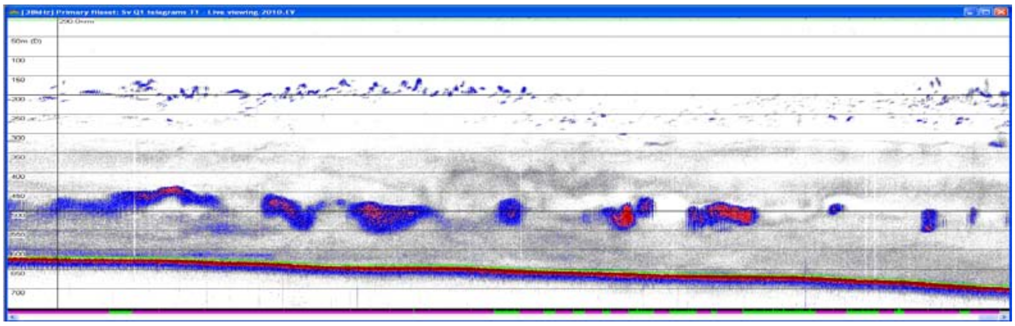
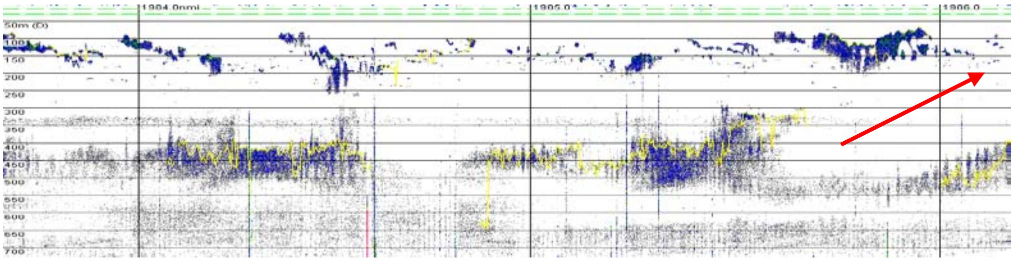


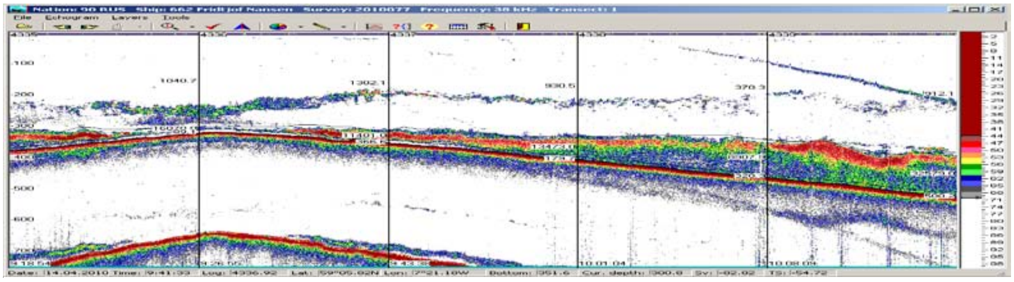
Figure 7. Blue whiting biomass for the combined survey by subarea as used in the assessment. March-April 2010.



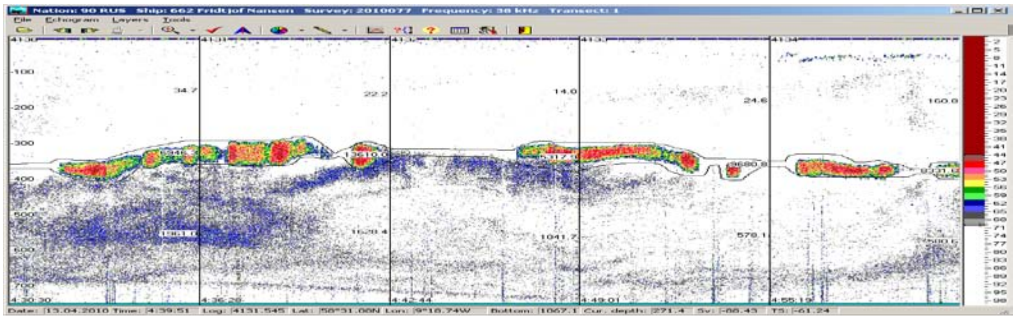
a). High density schools of blue whiting recorded by the RV Magnus Heinason. NASC value 11,868. Located on shelf slopes to the west of the Hebrides (Sub area III). Depth scale (m) shown on left of image. Sonar colour range



b). Example of low to medium density surface schools (70–100m) frequently encountered to the north of 58ºN by the RV Celtic Explorer. Trawl targeted surface schools (red arrow) yielded one single 8.6Kg monkfish (Lophius piscatorius) bottom depth 1,500m Sub area III. Vertical bands on echogram represent 1nmi (nautical mile) intervals. Depth scale (m) shown on left of image.



c). High density schools of blue whiting recorded by the RV Fridtjof Nansen in the Hebrides subarea along the shelf break. Recorded on FAMAS post-processing software Vertical bands on echogram represent 1nmi (nautical mile) intervals. Depth scale (m) shown on left of image.



d) High density schools of blue whiting recorded by the RV Fridtjof Nansen in the Hebrides subarea along the shelf break. Recorded on FAMAS post-processing software. Vertical bands on echogram represent 1nmi (nautical mile) intervals. Depth scale (m) shown on left of image.

Figure 8. Blue whiting and echograms of interest encountered during the combined International blue whiting March-April 2010.

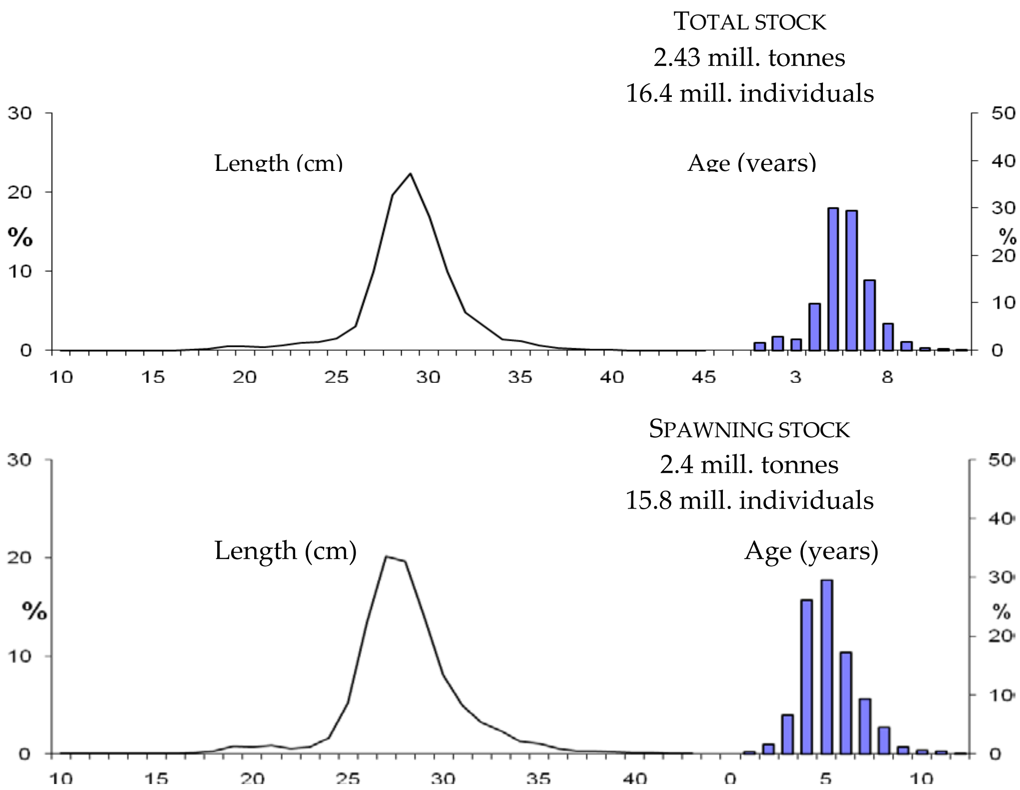


Figure 9. Length and age distribution for the combined survey data as total and spawning-stock biomass of blue whiting in western waters. March-April 2010.

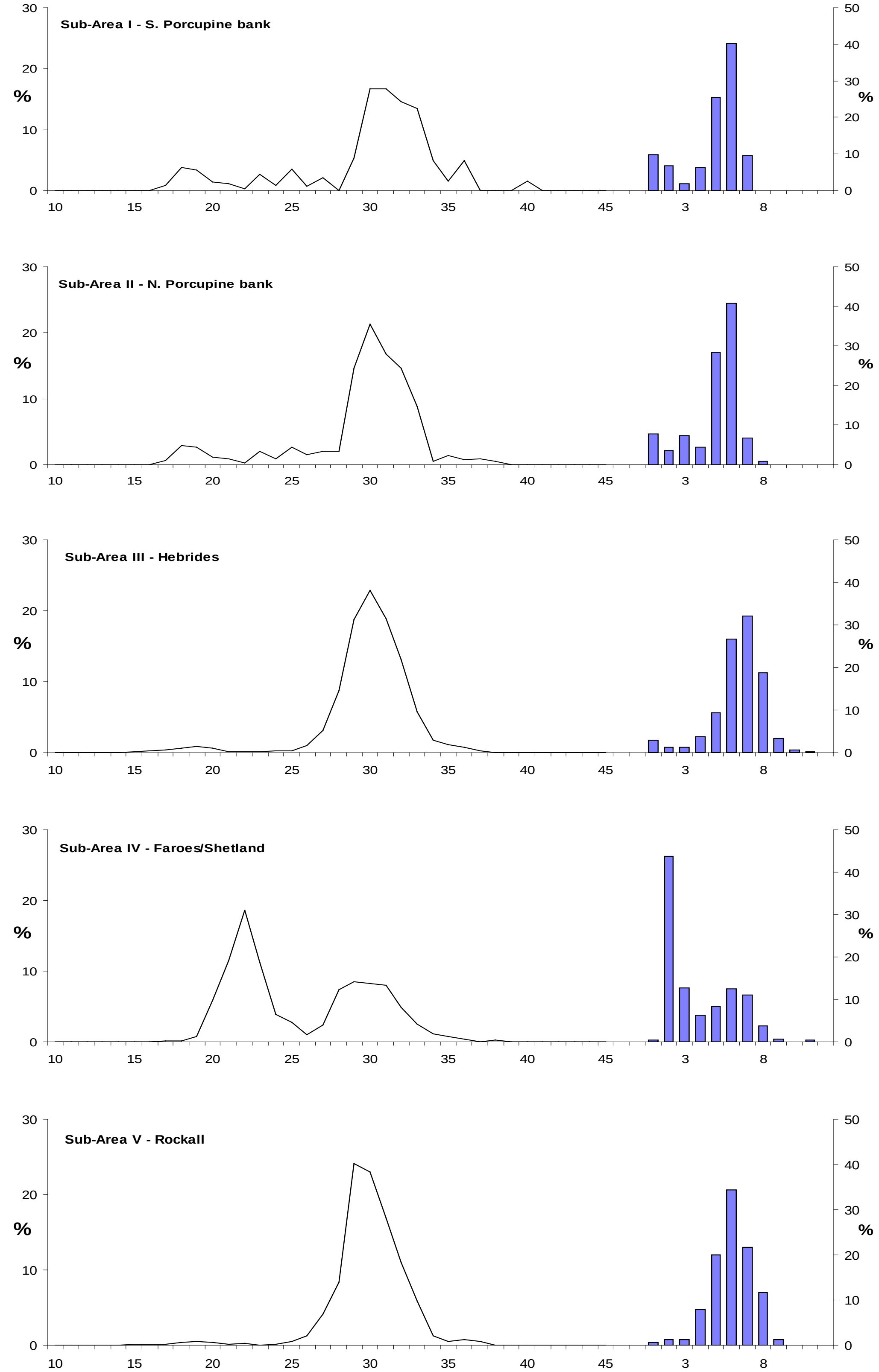


Figure 10. Length and age distribution (numbers) for combined survey data for blue whiting by subarea (I–V). March-April 2010.

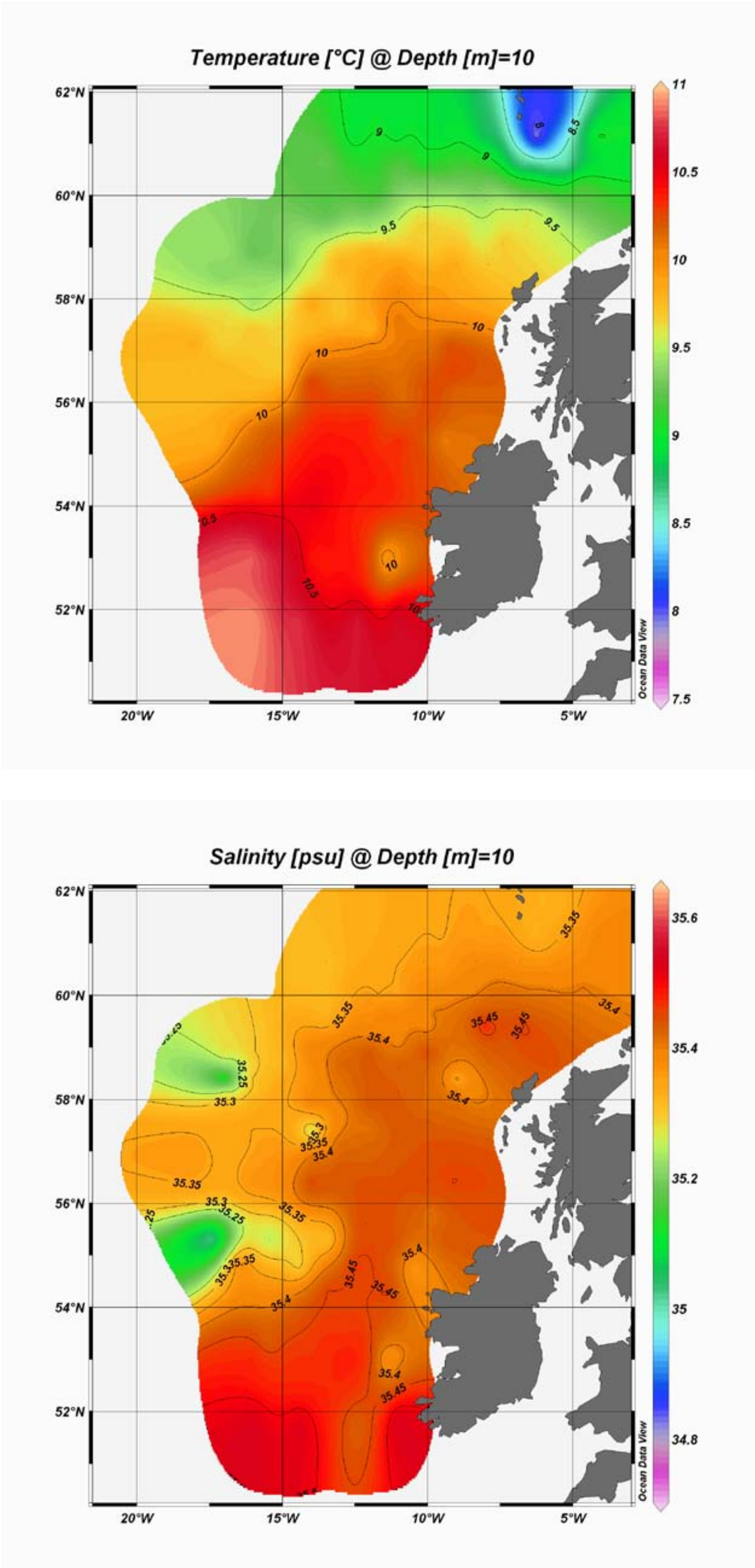


Figure 11. Horizontal temperature (top panel) and salinity (bottom panel) at 10m subsurface as derived from vertical CTD casts. March-April 2010.

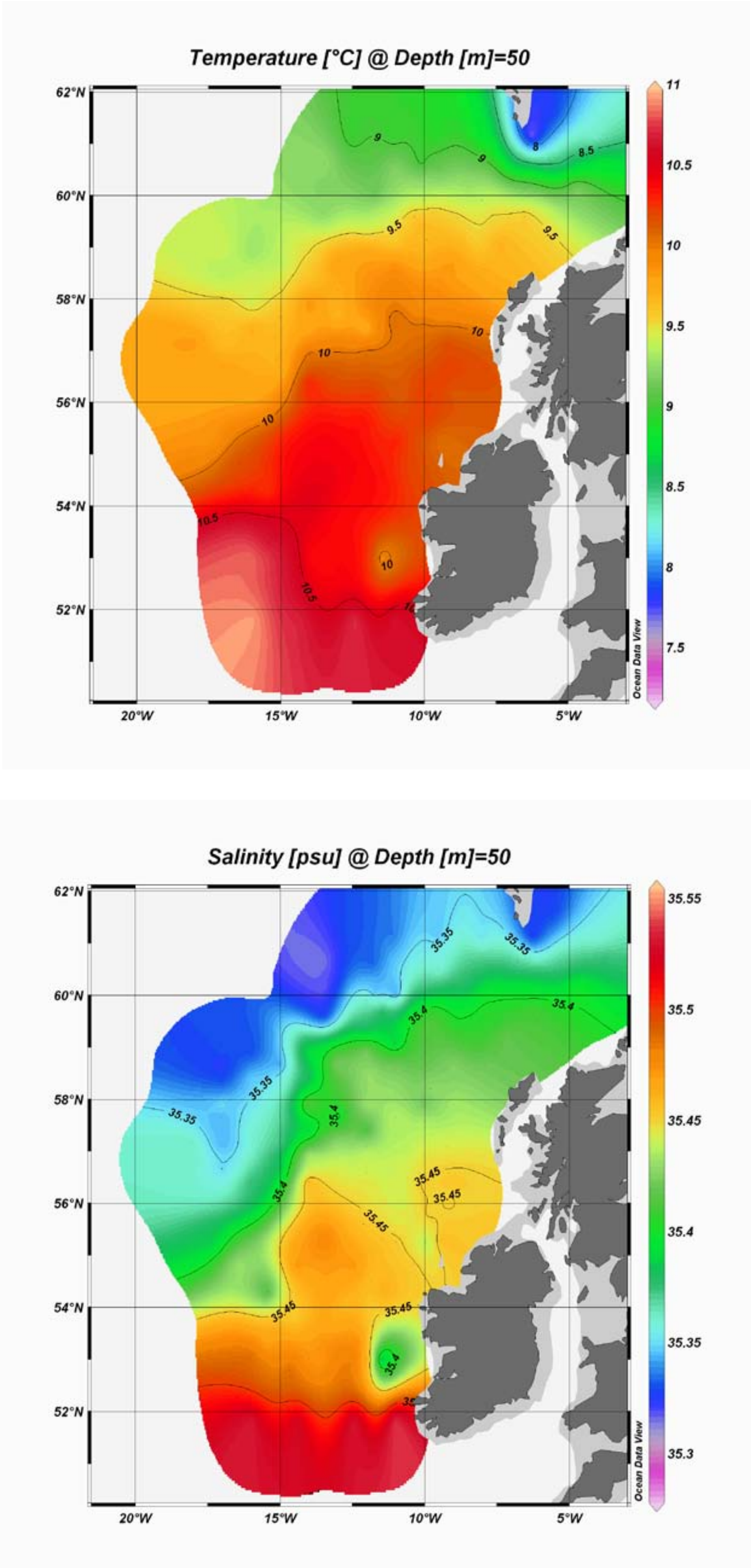


Figure 12. Horizontal temperature (top panel) and salinity (bottom panel) at 50m as derived from vertical CTD casts. March-April 2010.

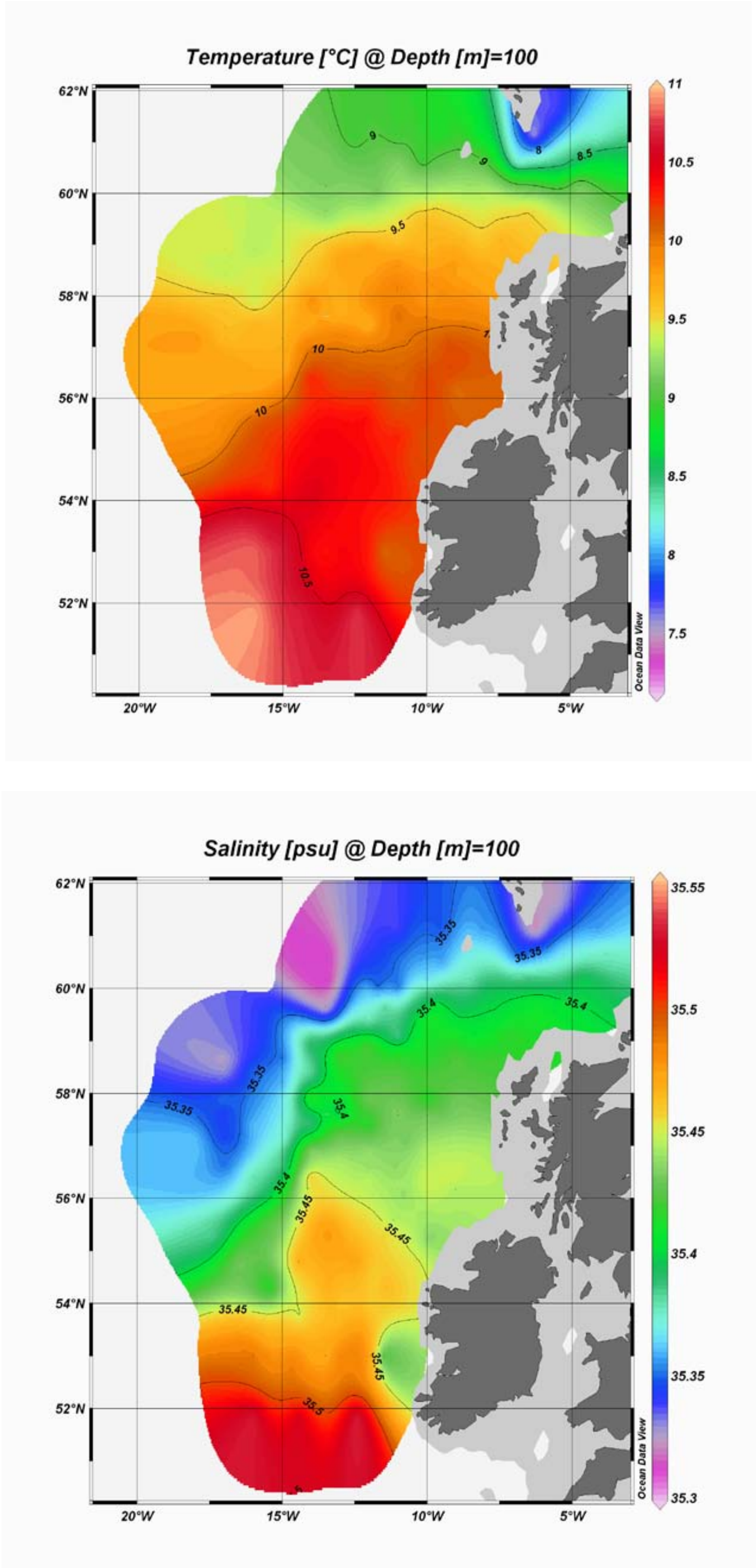


Figure 13. Horizontal temperature (top panel) and salinity (bottom panel) at 100m as derived from vertical CTD casts. March-April 2010.

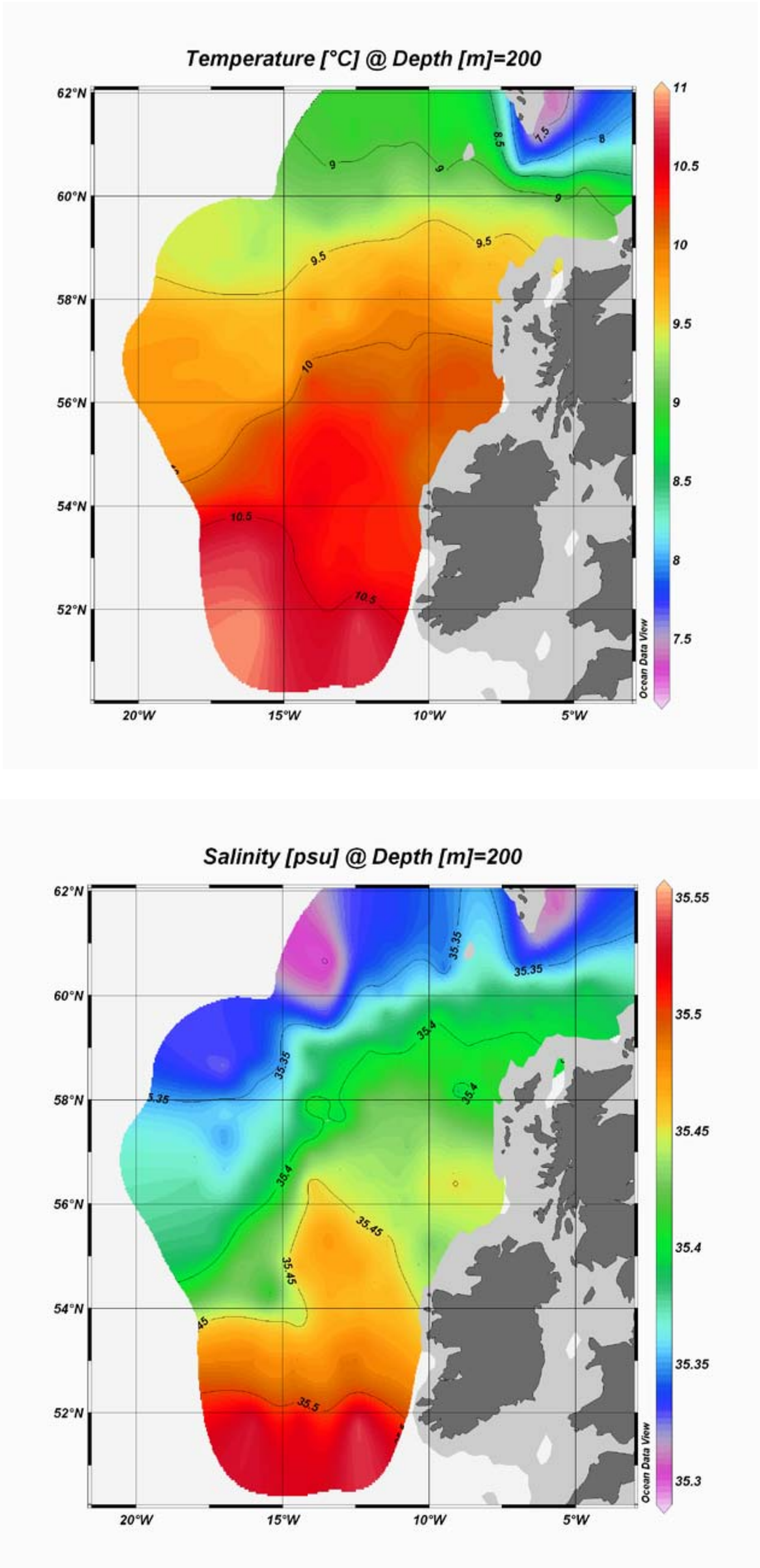


Figure 14. Horizontal temperature (top panel) and salinity (bottom panel) at 200m as derived from vertical CTD casts. Yellow circles indicate CTD positions. March-April 2010.

Appendix 1. Uncertainty in the acoustic observations and its implications on the stock estimate

Ciaran O'Donnell

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 in previous years (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 1 nautical mile ESDU (elementary sampling distance units). 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 1 nautical mile). 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 here 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 2010 survey as well six earlier international surveys. Mean acoustic density over the survey area is 174.2 m^2/nm^2 (as compared to 378 m^2/nm^2 in 2009) with 95% confidence interval being 145…206 m^2/nm^2. Relative to the mean, the approximate 95% confidence limits are –16%...+18%, and 50% confidence limits are –6.4%...+5.7%. This level of acoustic uncertainty is similar as observed in previous years with the exception of 2007. Overall mean acoustic density has shown a consistent decrease annually since 2007 and in 2010 is at the lowest in the time-series.

Figure 2 summarizes the results and puts them in the biomass context. The results clearly show that the observed consistent decline in biomass from 2008 to 2010 is more uncertainty than could be accounted for from spatial heterogeneity alone and is regarded as statistically significant. However, due to the gap in area coverage in an area likely to contain blue whiting the overall estimate and the acoustic values used to generate these confidence intervals could be revised upwards. That said the overall trend indicates a continued decrease year-on-year in biomass for this stock.

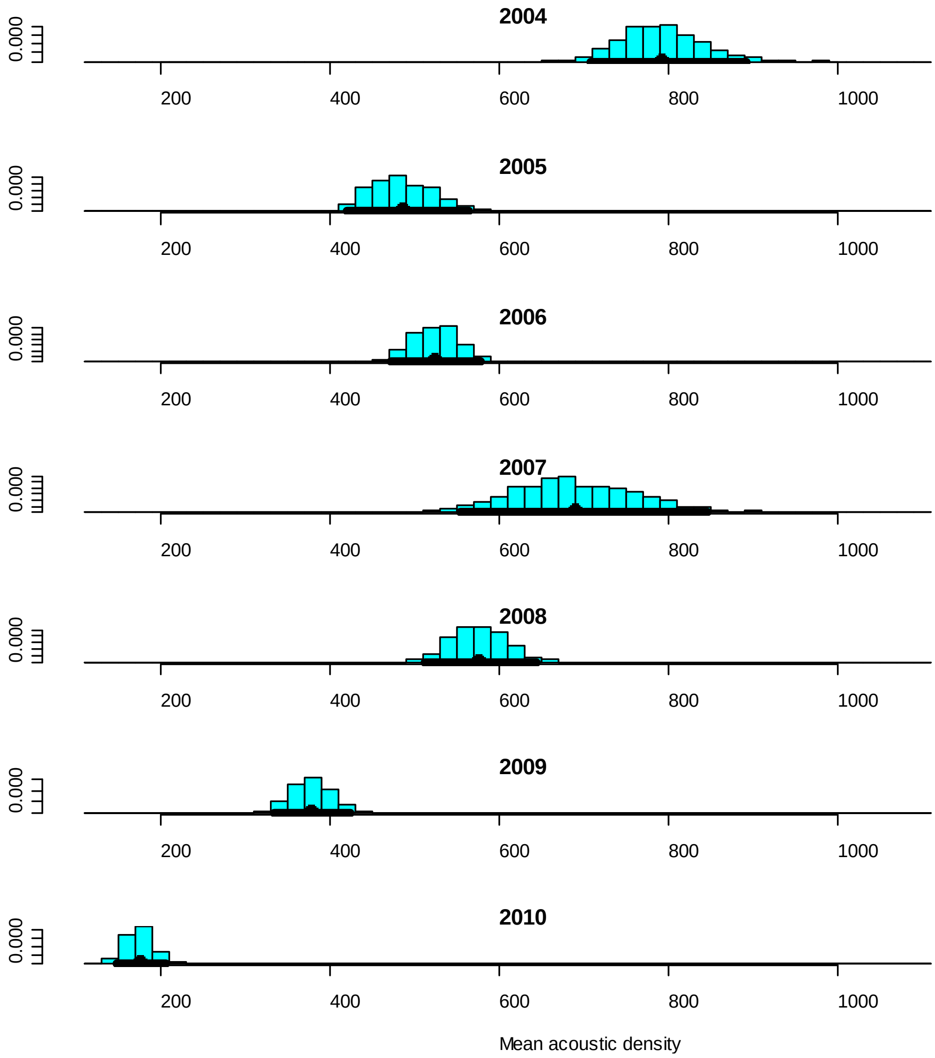


Figure 1. Distribution of mean acoustic density (in m²/nm²) by year based on 1000 bootstrap replicates of acoustic data from blue whiting surveys. Mean acoustic density is indicated with a black dot on the x-axis, while the horizontal bar shows 95% confidence limits.

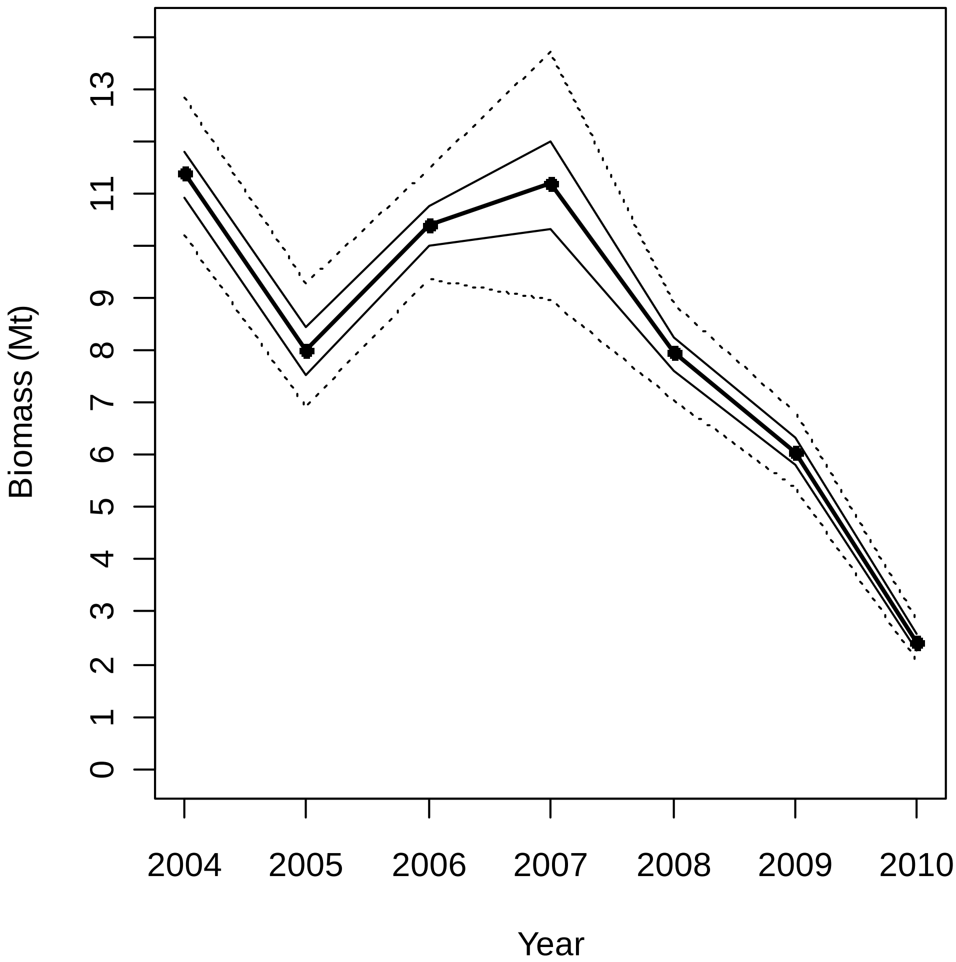


Figure 2. Approximate 50% and 95% confidence limits for blue whiting biomass estimates. The confidence limits are based on the assumption that confidence limits for annual estimates of mean acoustic density can be translated to confidence limits of biomass estimates by expressing them as relative deviations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

Appendix 2. Review of age determination of blue whiting by national participants.

Åge Høines and Øyvind Tangen

A review on the consistency of age readings was carried out using the data collected during the 2010 survey. Results show mixed agreement across participants for most age classes. The most striking difference is the Russian age readings compared to the others, with older ages for the smallest fish and opposite for the bigger fish. The Russian age readings also show higher variation in length across the age estimates.

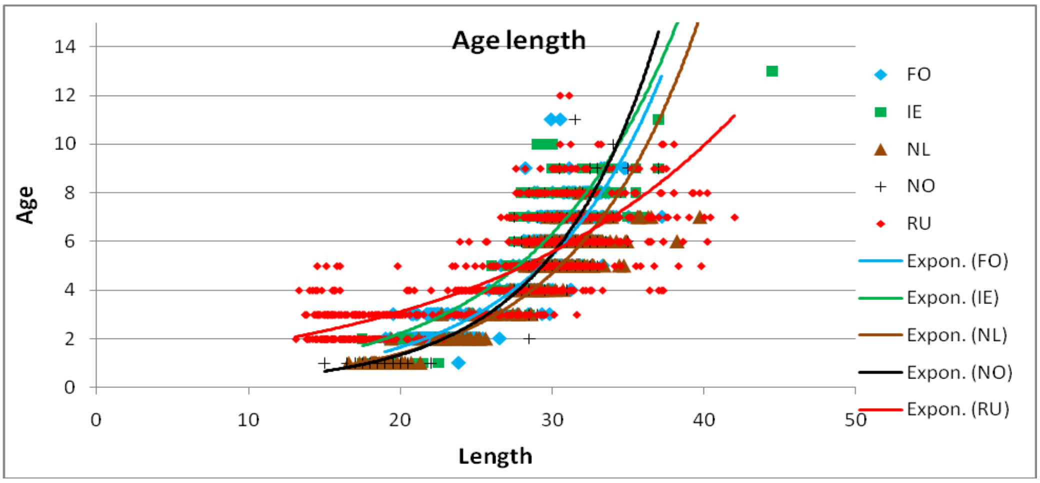


Figure 1. Profile of national age estimates as determined from otolith reading of trawl samples carried out over all individual blue whiting surveys in 2010 (FO; Faroes, IE; Ireland, NL: Netherlands, NO; Norway and RU; Russia).

Appendix 3. Agreed survey coverage and effort allocation as taken from the PGNAPES report 2009 for the 2010 blue whiting survey program

Ciaran O'Donnell

It is planned that five parties; Faroe Islands, the Netherlands (EU-coordinated), Ireland (EU-coordinated) Norway and Russia, will contribute to the survey of blue whiting stock survey in March-April 2010.

Survey timing and design were discussed in some detail. It was decided to that the survey should be reduced temporally from 4 to 3 weeks in a bid to reduce the effects of double counting of northward migrating schools. Careful considerations were given to the start and end time of this 3 week window so as to not adversely affect the integrity of the time-series while still providing synoptic coverage. The group agreed that the stock was well contained within the existing geographical bounds and that the allocation of effort was well balanced. The group also agreed that survey design, in terms of transect structure, is effective and should be maintained in 2010. To ensure transect coverage was not replicated the start points of each participant will be randomized in 2010.

Area allocation for each survey participant is listed below and Figure 1 shows the position of target areas described in the text.

Ship	Nation	Vessel time (days)	Active survey time (days)	Preliminary survey dates	Primary target area [secondary]
Celtic Explorer	EU (Ireland)	21	18	17/3–7/4	1 [2c]
G.O. Sars	Norway	18	14	21/3–4/4	1 [2a,b]
Magnus Heinason	The Faroes	14	11	25/3–7/4	2c [1]
Tridens	EU (Netherlands)	21	14	17/3–7/4	2a [1,3a]
Vilnus or F. Nansen	Russia	30	21	17/3-7/4	2a [1,2c]

Preliminary cruise tracks for the 2010 survey are presented in Figure 2.

As survey coordinator in 2010 Ireland has been tasked with communicating cruise tracks and survey coverage to the group. Detailed cruise lines for each ship will be agreed and circulated to the group as soon as final vessel availability and dates has been decided. As the survey is planned with inter-vessel cooperation in mind it is hoped that participants will stick to the planned transect positioning to ensure that survey effort is evenly allocated within the survey area as observed during the planning stages.

The survey will be carried according to survey procedures described in the "Manual for Acoustic Surveys on Norwegian Spring-spawning Herring in the Norwegian Sea and Acoustic Surveys on Blue whiting in the Eastern Atlantic" (PGNAPES report 2008).

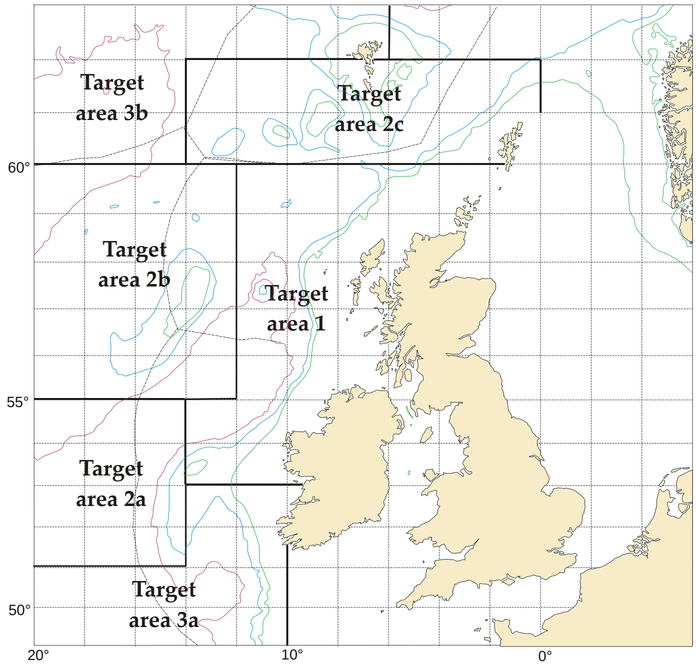


Figure 1. Target areas for the International blue whiting spawning stock surveys.

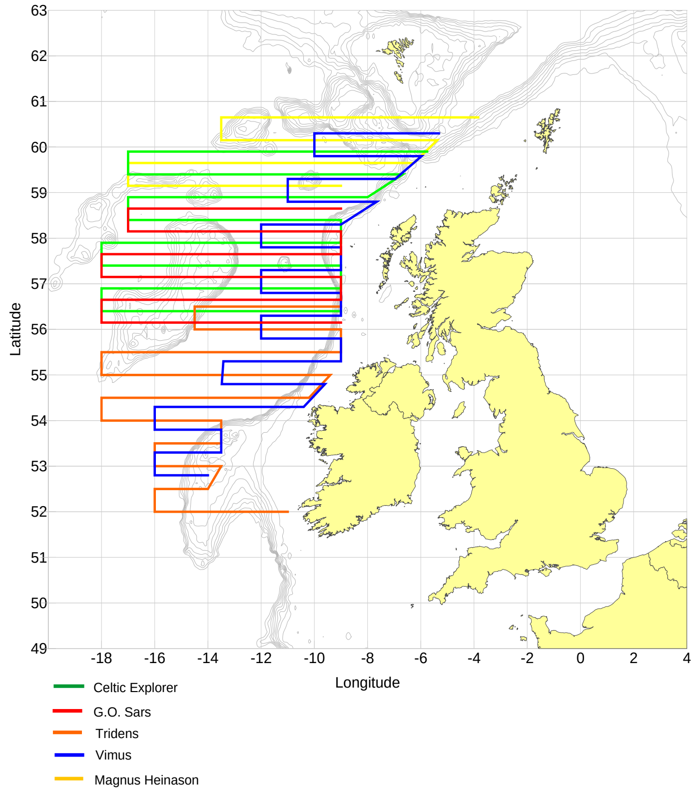


Figure 2. Preliminary survey tracks for the 2010 International blue whiting spawning stock.

Annex 3: International ecosystem survey in the Nordic Seas

Working Document

Working Group on Northeast Atlantic Pelagic Ecosystem Surveys

Hamburg, Germany, 17–20 August 2010

Working Group on Widely distributed Stocks

ICES, Vigo, 28 August–4 September 2010

INTERNATIONAL ECOSYSTEM SURVEY IN NORDIC SEA IN APRIL – MAY 2010

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RV Fridtjof Nansen

Øyvind Tangen[2], Valentina Anthonypillai[2], Webjørn Melle[2], Ering Kåre Stenevik[2], Åge Høines[2]

RV G. O. Sars

Bram Couperus[6], Mathias Kloppmann[8], Karl-Johan Stæhr[3], Ryan Saunders[1]

RV Dana

Guðmundur J. Óskarsson[7], Sveinn Sveinbjörnsson[7]
RV Árni Friðriksson
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3 DTU-Aqua, Denmark

4 PINRO, Murmansk, Russia

5 Faroese Marine Research Institute, Tórshavn, Faroe Islands

6 IMARES, IJmuiden, The Netherlands

7 Marine Research Institute, Reykjavik, Iceland

8 vTI-SF, Hamburg, Germany

Introduction

In May-June 2010, five research vessels; RV Dana, Denmark (joined survey by Denmark, Germany, Ireland, The Netherlands, Sweden and UK), RV Magnus Heinason, Faroe Islands, RV Arni Friðriksson, Island, and RV G. O. Sars, Norway and RV Fridjof Nansen, Russia participated in the International ecosystem survey in the Nordic Seas. The survey area was split into three Subareas: Area I, Barents Sea area, Area II, Northern and central Norwegian Sea Area, and Area III, the South-Western Area (Figure 1). The aim of the survey was to cover the whole distribution area of the Norwegian Spring-spawning herring with the objective of estimating the total biomass of the herring stock, in addition to collect data on plankton and hydrographical conditions in the area. The survey was initiated by the Faroes, Iceland, Norway and Russia in 1995. Since 1997 also the EU participated (except 2002 and 2003) and from 2004 onwards it was more integrated into an ecosystem survey. This report is based on national survey reports from each survey (Dana: Anon., 2010a, Magnus Heinason: FAMRI 2010, Arni Friðriksson: MRI 2010 Fridtjof Nansen: PINRO 2010 and G. O. Sars: not (yet) available).

Material and methods

Coordination of the survey was initiated at the meeting of the Planning Group on Northeast Atlantic Pelagic Ecosystem Surveys (PGNAPES, formerly Planning Group on Surveys on Pelagic Fish in the Norwegian Sea, but now WGNAPES, Working Group on Surveys on Pelagic Fish in the Norwegian Sea) in August 2009 (ICES 2009/RMC:06), and continued by correspondence until the start of the survey. The participating vessels together with their effective survey periods are listed in the table below:

Vessel	Institute	Survey period
Dana	Danish Institute for Fisheries Research, Denmark	30/4–25/5
G. O. Sars	Institute of Marine Research, Bergen, Norway	6/5–2/6
Fridtjof Nansen	PINRO, Russia	14/5–1/6
Magnus Heinason	Faroese Fisheries Laboratory, Faroe Islands	29/4–12/5
Arni Friðriksson	Marine Research Institute, Island	26/4–19/5

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

In general, the weather condition did not affect the survey even if there were some days at sea that were not favourable. In the eastern area the weather conditions were generally excellent during the survey.

The survey was based on scientific echosounders using 38 kHz frequency. Transducers were calibrated with the standard sphere calibration (Foote *et al.*, 1987) prior to the survey. Salient acoustic settings are summarized in the text table below.

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

	Dana	G. O. Sars	Arni Friðriksson	Magnus Heinason	Fridtjof Nansen
Echo sounder	Simrad EK 60	Simrad EK 60	Simrad EK 60	Simrad EK 500	ER 60
Frequency (kHz)	**38**, 18, 120	**38**, 18, 70, 120, 200, 333	**38**, 18, 120	**38**	**38**, 120
Primary transducer	ES38BP	ES 38B - Serial	ES38B	ES38B	ES38B
Transducer installation	Towed body, hull	Drop keel	Drop keel	Hull	Hull
Transducer depth (m)	3 (when hull 6)	8.7	8	3	7
Upper integration limit (m)	5	15	15	7	10
Absorption coeff. (dB/km)		9.6	10	10	10
Pulse length (ms)	Medium	1.024	1.024	Medium	1.024
Band width (kHz)	Wide	2.425	2.425	Wide	2.425
Transmitter power (W)	2000	2000	2000	2000	2000
Angle sensitivity (dB)	21.9	21.9	21.9	21.9	21.9
2-way beam angle (dB)	-20.5	-20.6	-20.9	-20.9	-20.9
Sv Transducer gain (dB)				27.22	27.3
Ts Transducer gain (dB)		27.64	24.64	27.4	27.64
s_A correction (dB)		-0.73	-0.84	None	-0.61
3 dB beam width (dg)					
alongship:	6.8	6.9	7.31	7.05	6.9
athw. ship:	6.86	6.8	6.95	6.83	6.8
Maximum range (m)	750	750	750	750	750
Post processing software	Simrad BI500	LSSS	Simrad BI500	Sonardata Echoview 4.3	FAMAS

Post-processing software differed among the vessels but all participants used the same post-processing procedure, which is according to an agreement at a PGNAPES scrutinizing workshop in Bergen in February 2009 (ICES WKCHOSCRU 2009).

As a general, acoustic recordings were scrutinized with the different software (see table above) on daily basis and species identified and partitioned using catch information, characteristic of the recordings, and frequency between integration on 38 kHz and on other frequencies by a scientist experienced in viewing echograms.

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

	Dana	G. O. Sars	Arni Friðriksson	Magnus Heinason	Fridtjof Nansen
Circumference (m)		586	640	640	560
Vertical opening (m)		25–35	45–50	45–55	40–50
Mesh size in codend (mm)		22	40	40	16
Typical towing speed (kn)		3.0–4.0	3.0–4.0	3.0–4.0	3.5–4.0

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

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

Blue whiting: TS = 21.8 log(L) – 72.8 dB

Herring: TS = 20.0 log(L) – 71.9 dB.

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

The hydrographical and plankton stations by survey are shown in Figure 2. All vessels collected hydrographical data using a SBE 911 CTD. Maximum sampling depth was 1000 m. Zooplankton was sampled by a WPII on all vessels except the Russian vessel which used a Dyedi net, according to the standard procedure for the surveys. Mesh sizes were 180 or 200 µm. The net was hauled vertically from 200 m or the bottom to the surface. All samples were split in two and one half was preserved in formalin while the other half was dried and weighed. On the Danish, the Icelandic and the Norwegian vessels the samples for dry weight were size fractionated before drying. Data are presented as g dry weight m^2.

Results

Hydrography

The temperature distributions in the ocean at selected depths between the surface and 400 m are shown in Figures 4–9.

Temperatures in the surface ranged between < 1°C northeast of Iceland (< 0°C north of Jan Mayen) and > 8°C in the southern part of the survey area. The polar front, that separates the warm North Atlantic waters from the cold Arctic waters, was encountered slightly below 65°N east of Iceland extending eastwards towards the 0° Meridian where it turned almost straight northwards up 70°N. North of 70°N it turned north-eastwards and intersected the boundary of the survey area at about 5°E. The front was discernible throughout the observed water column but was most pronounced only in the South (Figures 4 – 6), while further north it became apparent only below 100 m depth (Figures 7 – 9).

With depth, temperatures decreased to values < 0°C particularly north and west of the polar front while south and east of it the drop in temperature was not as pronounced. The warmer North Atlantic water formed a broad tongue that stretched far northwards along the Norwegian coast with temperatures > 6 °C in the surface layers. However, particularly in the surface layers a band of warmer water > 7°C was not as wide as in 2009 but narrower and more confined to areas closer to the Norwegian coast (Figures 4 – 5). With increasing depth this core of warm Atlantic water became even more confined to areas closer to the coast in the South and forming only a narrowband of warmer water centred along the 15° meridian in the North (Figures 6 – 9). Relative to a 15 years long-term mean, from 1995 to 2010, temperatures in 2010 were warmer over most of the Norwegian Sea compared to the long-term mean. At 100 m depth the difference is about 0 - 0.75°C, dependent on the area, but at the upper 20 m this difference can be 1°C. In the western areas, however, a cooling is observed compared to the mean.

Surface temperatures of the East Icelandic Current were lower than in the year before. Contrasting to the previous three years, the cold arctic water that characterizes the area off the east coast of Iceland was also observed further south and east down to 65°N and 8 to 10°W.

In the Barents Sea the water temperature exceeded the long-term mean values by 0.5 – 1.0 °C practically in all depth layers and not much differing from the 2009 situation. Thus, 2010 again falls into the category of warm years for the Barents Sea. However, there were only weak indications of warmer North Atlantic water entering the Barents Sea while temperatures decreased gradually to values < 3°C eastwards (Figures 4 – 9).

Zooplankton

Biomass of zooplankton and sampling stations are shown in Figure 10. Sampling stations were relatively evenly spread over the area, and most oceanographic regions were covered. Cruise lines were prolonged into Arctic water near Jan Mayen to improve sampling of Arctic water compared to previous years. The highest zooplankton biomasses were observed in the eastern Norwegian Sea close to the Northern Norway coast, and in Arctic water between Iceland and Jan Mayen. However, in general biomass was low in all areas. Recorded zooplankton biomass in the two areas west and east of 2°W equalled 2.9 and 5.9 g dry weight m^{-2}, while total mean was 4.4 g dry weight m^{-2}.

In the Barents Sea zooplankton biomass was low in all areas. Mean biomass of the Barents Sea was 1.7 dry weight m^{-2}.

Norwegian Spring-spawning herring

Survey coverage in the Norwegian Sea was considered adequate in 2010 and in line with previous years. Herring were recorded throughout most of the surveyed area in the Norwegian Sea, except for the northeastern part and the Jan Mayen zone (Figure 11), which is the main difference from the survey in 2009. The highest values were recorded in the central Norwegian Sea and the at the eastern edge of the cold waters of the East Icelandic Current. Compare to 2009, there were less herring in the western most area presumably causing a slight eastward displacement of the centre of gravity of the acoustic recordings in 2010 as compared to 2009.

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 12). Correspondingly, it was mainly older herring that appeared in the southwestern areas (area III), especially the 2002 year class.

The herring stock is now dominated by 6 year old herring (2004 year class) in number but 8, 7 year old herring (2002 and 2003 year classes) are also numerous (Table 2). These three year classes contribute 30%, 20% and 17%, respectively, of the total biomass.

The abundance estimates from this year's survey are lower than expected. For example, the past estimates of the 2002 year class indicate that it is very strong but the current estimate give a less optimistic estimates of its size. The estimate for the 2004 year class is closer to what was expected and support the view from last year that this year class is strong and comparable to the 1998 and 1999 year classes. Overall, the 2003 year class appeared now to be at similar size as the 2002 year class that has been considered large in recent years. If this is related to problems and inaccuracy in ageing is uncertain but there are no indications of it currently but it should be examined.

In the Barents Sea immature herring (Area I see Figure 1) were generally distributed in the southwest part of Russian zone, south and central part of "Grey" area and along 12-miles Norwegian zone. The herring were mostly recorded as single schools mainly in the upper 50 m layer of the water masses. Very often the herring schools were distributed near at a surface of the sea and were inaccessible to registration, but were marked in pelagic trawls. In this connection underestimation immature a herring in the Barents Sea is possible. In eastern part of surveyed area more smaller and young herring dominated as compared to the western part of the Barents Sea.

The herring in the Barents Sea were composed of the many year classes, but 2009 year class dominated in this area. There were no strong year classes detected. Herring in the Barents Sea were estimated at 13.6 billion individuals corresponding to a biomass of 0.11 million tonnes (Table 2).

The total number of herring recorded in the Norwegian Sea was 18.0 billion in the northeastern area and 8.8 billion in the southwestern area, compared to 34.5 billion and 12.6 billion in last year, respectively. This corresponds to a total acoustic herring estimate for the Norwegians Sea and the Barents Sea of 6.0 million tons compared to 10.7 million tons in 2009 and 10 million tons in 2008.

Blue whiting

The total biomass of blue whiting registered during the May 2009 survey was 0.26 million tons (Table 3), which is very low (the corresponding estimates from 2006, 2007, 2008 and 2009 were 6.2, 2.4, 1.1 and 0.9 mill. tons, respectively). The stock estimate in number for 2010 is 1.7 billion, which is about 30% of the 2009 estimate. The reduction in the estimate is seen in all year classes, but most severe for the 2002 to 2004 year classes or 75–90%. The small amount of two year olds seen in this year's survey was found around the Faroes.

An estimate was also made from a subset of the data or a "standard survey area" between 8°W–20°E and north of 63°N, which has 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 standard survey area estimate is used as an abundance index in WGWIDE. The age-disaggregated total stock estimate in the "standard area" is presented in Table 4, showing that the blue whiting in this index area was dominated by age groups 5–8 year old.

Blue whiting were observed mostly in connection with the continental slope in south and east and very little were found in the open sea (Figure 13). The mean length of blue whiting is shown in Figure 14. It should be noted that the spatial survey design was not intended to cover the whole blue whiting stock during this period.

Mackerel

In later years an increasing amount of mackerel has been observed in the Norwegian Sea during the combined survey in May targeting herring and blue whiting. The edge of the distribution has also been found progressively further north and west. In 2008 during the Faroese survey, mackerel was found in the southeastern part of the investigated area, and all the way up to 64°N in 2009 but 63°N in 2010 (Figure 15). The trawl catches of mackerel in the whole survey are in agreement with the acoustic measurements (Figure 16) and show that at this time of the year the mackerel is only found on the southernmost area in the western part covered by the survey but reaches further north at the eastern part. Like in 2009, the 2005 year class dominated in the total catches of the combined survey (Figure 17).

Discussion

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

The amount of herring measured in the survey was less than expected and anticipated from the stock assessment in 2009 (ICES 2009/ACOM:12) and the surveys in recent years (ICES 2009/RMC:06). There could be several reasons for lower survey estimates including: (1) that the distribution area was not fully covered; (2) a mass mortality has taken place since last survey; (3) that the herring have different behaviour (higher in the water column above the acoustic transducers, showing more avoidance to the vessels, or moving vertically that influence their tilt angel and backscattering). We are not able to reject any of these three possible reasons, but belief that the distribution area was fairly well covered, giving a low credit to explanation no. 1. A survey with participations of Norway, Iceland and Faroese took place in July–August 2010 and it covered the distribution area of the mature stock. The results are not yet ready from it but they will be valuable for a comparison to the May survey results.

Concluding remarks

- The amount of herring measured acoustically was only around 2/3 of what was expected from last the years' surveys and assessments. The reason for it is uncertain.
- NSSH was dominated by the 2004 year class while especially the 2002 year class was much less numerous than expected.
- The 2004 year class of NSSH dominated in the northeastern area of the Norwegian Sea while the 2002 year class dominated in the southwestern area.
- No strong year classes of NSSH were observed in the Barents Sea indicating poor recruitment since 2004.
- The amount of blue whiting measured in the survey area was very low.
- The blue whiting stock show still no significant signs of recruiting *year class*es.
- The decline in the estimates of the blue whiting stock continues and the reduction is seen in all year classes, but most severe in the 2002 to 2004 year classes or 75–90%.
- The increasing trend in the abundance of mackerel and the widening of its northern and western distribution limits during summer seem to continue in 2010.

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Table 1. Survey effort by vessel.

Vessel	Effective survey period	Length of cruise track (nm)	Trawl stations	CTD stations	Plankton station
Dana	30/4–25/5	3.745	21	47	52
Johan Hjort	6/5–2/6	4.930	68	64	63
Fridjof Nansen	14/5–1/6	3.305	40	101	100
Magnus Heinason	29/4–12/5	1.890	13	26	24
Arni Friðriksson	26/4–19/5	4.460	34	85	72
Total	26/4–2/6	18.330	176	323	311

Table 2. Age and length-stratified abundance estimates of Norwegian spring-spawning herring in April-June 2010 for total area and abstracts of estimates for subareas II and III.

Length	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Number	Biomass	Weight
10	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	31	0.2	8
11	103	0	0	0	0	0	0	0	0	0	0	0	0	0	0	103	0.9	9
12	278	0	0	0	0	0	0	0	0	0	0	0	0	0	0	278	3.2	12
13	186	0	0	0	0	0	0	0	0	0	0	0	0	0	0	186	2.5	14
14	62	0	0	0	0	0	0	0	0	0	0	0	0	0	0	62	1.2	19
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.
16	81	0	0	0	0	0	0	0	0	0	0	0	0	0	0	81	2	24
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.
18	0	38	0	0	0	0	0	0	0	0	0	0	0	0	0	38	1.7	45
19	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0.7	56
20	0	43	0	0	0	0	0	0	0	0	0	0	0	0	0	43	2.7	62
21	0	76	0	0	0	0	0	0	0	0	0	0	0	0	0	76	5.5	73
22	0	86	0	0	0	0	0	0	0	0	0	0	0	0	0	86	7.4	86
23	0	45	137	0	0	0	0	0	0	0	0	0	0	0	0	182	18.5	102
24	0	63	192	8	0	0	0	0	0	0	0	0	0	0	0	263	27.9	106
25	0	0	256	514	0	0	0	0	0	0	0	0	0	0	0	770	92.9	121
26	0	0	439	507	0	0	0	37	0	0	0	0	0	0	0	983	123.8	126
27	0	0	10	552	8	110	0	0	0	0	0	0	0	0	0	680	99.7	147
28	0	0	158	584	193	7	0	0	0	0	0	0	0	0	0	942	152.4	162
29	0	0	0	181	650	847	0	0	0	0	0	0	0	0	0	1678	307.3	183
30	0	0	3	503	798	1734	31	0	0	0	0	0	0	0	0	3069	600.5	196
31	0	0	0	377	287	2674	477	52	0	0	0	0	0	0	0	3867	826.3	214
32	0	0	0	69	86	1808	1756	725	31	0	0	20	0	0	0	4495	1066.1	237
33	0	0	0	34	95	872	1305	1572	53	39	131	13	0	0	0	4114	1047.9	255
34	0	0	0	0	36	230	372	1567	174	257	158	36	0	0	0	2830	780.3	276
35	0	0	0	0	3	0	199	535	105	136	298	154	17	0	0	1447	432.3	297
36	0	0	0	0	0	0	6	30	27	72	151	98	7	12	14	417	131.9	316
37	0	0	0	0	0	0	0	1	0	9	66	9	13	1	2	101	33.4	335
38	0	0	0	0	0	0	0	0	0	0	0	0	4	4	9	17	6	384
39	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	4	1.4	375
40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.
41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.
42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.
43	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0.4	521
44																		
45																		
Number 10^6	81	364	1195	3329	2156	8282	4146	4519	390	513	804	331	45	17	25	26857	5777	

Table 2 (Cont'd)

Area I

Age	1	2	3	4	5	6	7	8	9	10	11	12+		
Biomass 10^3	71.9	46.7	5.9										124.5	124.5
Length cm	11.6	15.9	22.5											12.6
Weight g	9.2	23.8	65											12.6

Area II

Age	1	2	3	4	5	6	7	8	9	10	11	12+		
Biomass 10^3 t	10	29	148	529	365	1410	539	337	26	39	33	10	3475	3475.2
Length cm	13.1	22	25.9	28.3	30.3	31.4	33.1	33.5	34.5	34.7	35.4	36		29.9
Weight g	14	81	124	160	192	212	242	250	269	273	286	302		192

Area III

Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+		
Biomass 10^3 t				9	58	380	482	859	83	108	203	89	15	6	10	2302	2302
Length cm				33.5	31.7	32	32.9	34	34.7	35.1	35.3	35.4	36.8	37	36.5		33.6
Weight g				262	228	232	250	271	283	292	296	299	326	331	316		262.6

Total

Length	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+		
Biomass 10^3 t	81.9	76	154.2	537.5	423.7	1790.2	1020.5	1195.7	108.9	147.2	236.6	98.9	14.5	5.5	10.3	6026	6026
Length cm	13.1	22.0	25.9	28.4	30.4	31.5	33.0	33.9	34.6	35.0	35.3	35.5	36.8	37.0	36.6		31
Weight g	14	81	124	162	197	216	246	265	279	287	294	299	326	331	320		210

Table 3. Age and length-stratified abundance estimates of blue whiting in April-June 2010, west of 20°E for total area and abstracts of estimates for subareas II and III.

Length	1	2	3	4	5	6	7	8	9	10	11	12+	Number	Biomass	Weight
10													0		
11													0		
12													0		
13													0		
14													0		
15													0		
16													0		
17													0		
18													0		
19													0		
20													0		
21													0		
22		6	0	0	0	0	0	0	0				6	0.4	67
23		62	0	0	0	0	0	0	0				62	4.3	70
24		72	4	0	0	0	0	0	0				76	6.6	87
25		117	65	0	0	0	0	0	0				182	17.8	98
26		25	30	18	0	0	0	0	0				73	7.9	109
27		0	10	0	10	44	17	0	0				81	11.8	146
28		0	0	25	25	17	0	0	0				67	8.9	132
29		0	0	15	93	10	1	1	0				120	16.6	138
30		0	0	2	166	75	11	52	0				306	49.1	160
31		0	0	10	66	105	34	3	0				218	36.7	169
32		0	0	0	53	113	18	28	0				212	43.3	204
33		0	0	0	0	76	19	45	0				140	28.9	207
34		0	0	0	20	21	32	8	11				92	18.4	199
35		0	0	0	4	0	7	10	13				34	8.6	254
36		0	0	0	0	0	0	4	8				12	3.5	281
37		0	0	0	0	0	0	1	3				4	1	239
38													0		
39													0		
40													0		
41													0		
42													0		
43													0		
Number 10^6	0	282	109	70	437	461	139	152	35	0	0	0	1685	264	

Total area

Length	1	2	3	4	5	6	7	8	9	10	11	12+		
Biomass 10^3 t		25.1	11.1	9.3	69.9	81.6	26.7	31.8	8.3				264	263.9
Length cm		24.8	25.9	28.7	30.7	31.5	32.2	32.5	35.6					29.9
Weight g		89.3	102.3	132.2	159.7	176.9	191.9	209	236.6					157

Area II

Age	1	2	3	4	5	6	7	8	9	10	11	12+		
Biomass 10^3 t		0.1		2.3	26.3	38.1	15.4	26.2					108.4	108.4
Length cm				31.3	31	30.6	30.7	32.1						31.1
Weight g				190.5	191.3	186.8	188.2	205.5						192.3

Area III

Age	1	2	3	4	5	6	7	8	9	10	11	12+		
Biomass 10^3 t		25.1	11.1	7	43.6	43.5	11.3	5.6	8.3				155.5	155.5
Length cm		24.8	25.9	28.2	30.6	32.2	34.3	34.8	35.6					29.4
Weight g		89.3	102.3	120.1	145.2	169	197.1	227.2	236.6					138.5

Table 4. Blue whiting "Standard Area" 8°W - 20°E and north of 63°N.

Length	1	2	3	4	5	6	7	8	9	10	11	12+	Number	Biomass	Weight
10													0		
11													0		
12													0		
13													0		
14													0		
15													0		
16													0		
17													0		
18													0		
19													0		
20													0		
21													0		
22													0		
23													0		
24													0		
25													0		
26													0		
27				0	10	44	17	0					71	10.6	149
28				0	0	14	0	0					14	2.4	162
29				0	19	1	1	0					21	3.6	171
30				2	35	40	10	45					132	23.8	181
31				8	4	18	27	2					59	12.2	209
32				0	26	32	13	20					91	20.9	230
33				0	0	16	0	20					36	7.8	222
34				0	9	0	0	8					17	4.3	252
35				0	4	0	0	3					7	2.1	277
36													0		
37													0		
38													0		
39													0		
40													0		
41													0		
42													0		
43													0		
Number 10^6	0	0	0	10	107	165	68	98	0	0	0	0	448	87.7	

Age	1	2	3	4	5	6	7	8	9	10	11	12+		
Biomass 10^3 t				2	21.2	31.1	12.9	20.6					87.8	87.8
Length cm				31.3	31.1	30.3	30.5	32						30.9
Weight g				203.3	198.8	187.4	193.5	208.6						196

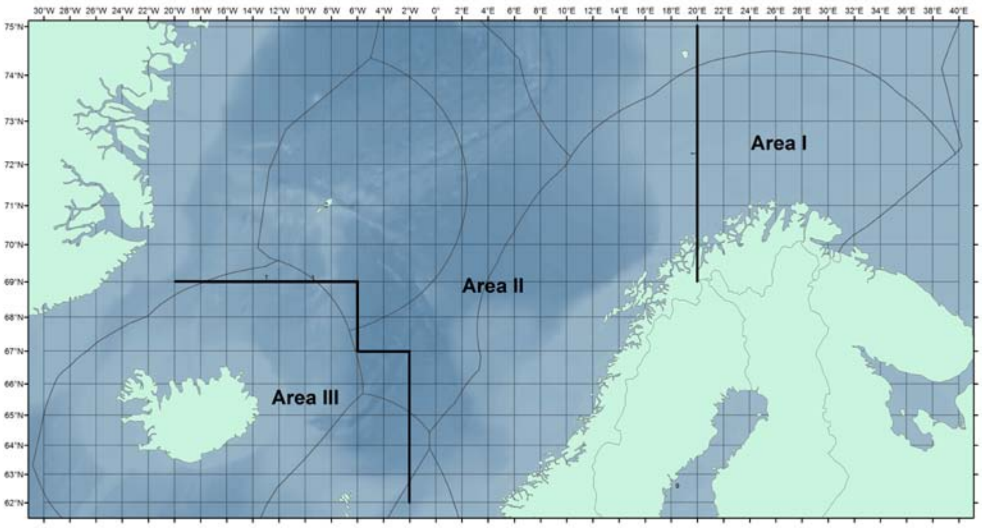

Figure 1. Areas defined for acoustic estimation of blue whiting and Norwegian spring-spawning herring in the Nordic Seas.

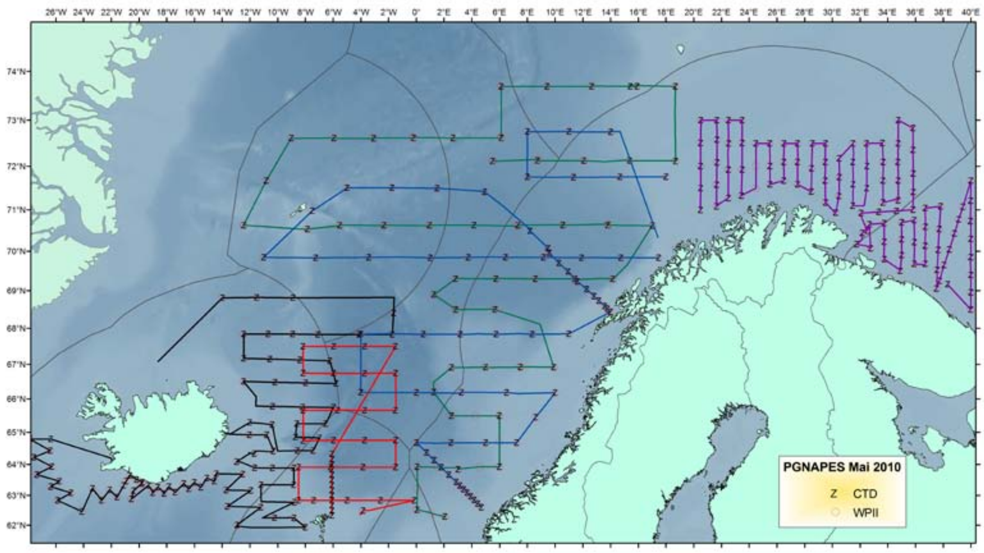

Figure 2. Cruise track and CTD stations by country for the International ecosystem survey in the Nordic Seas in April-June 2010.

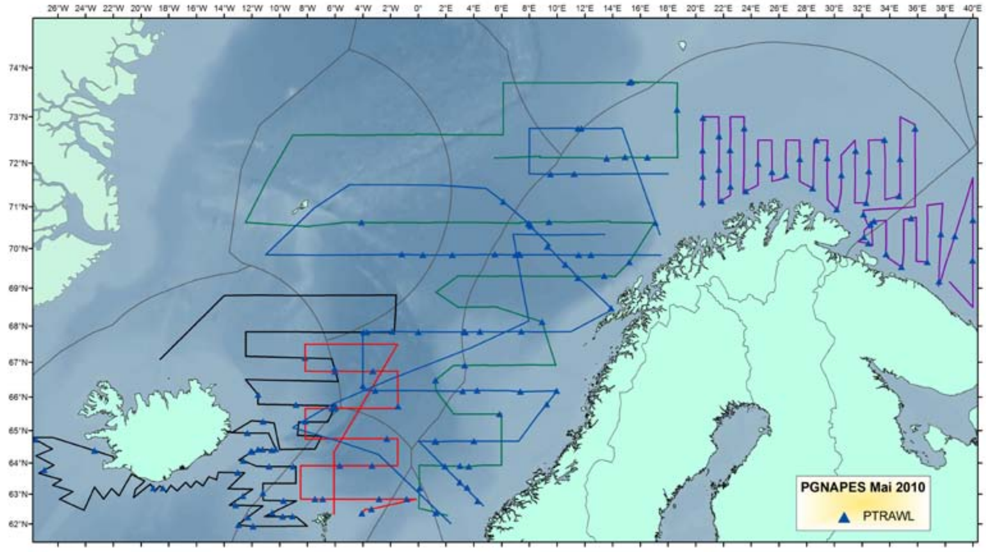

Figure 3. Cruise tracks during the International North East Atlantic Ecosystem Survey in April-May 2010 and location of trawl stations.

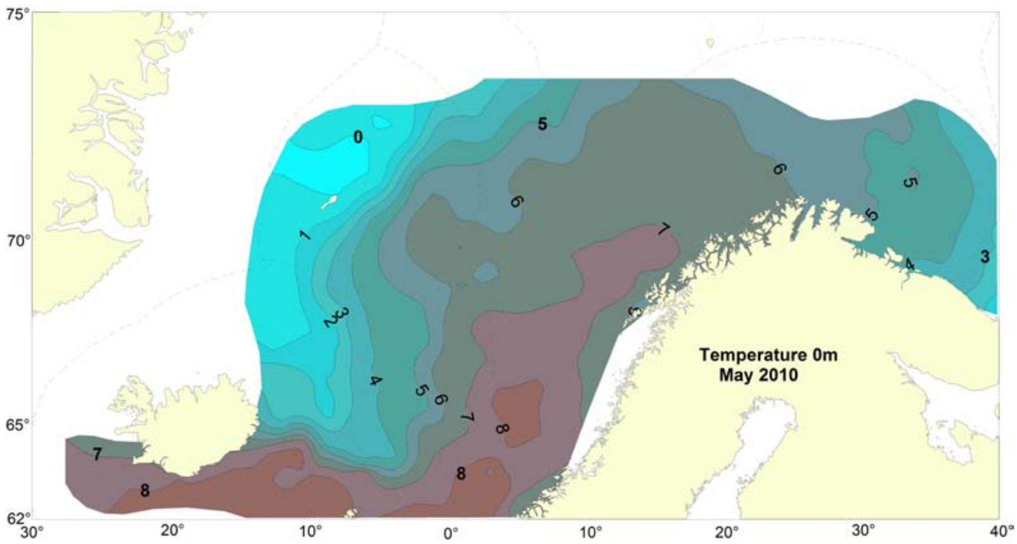

Figure 4. The horizontal sea surface temperature distribution in April-June 2010.

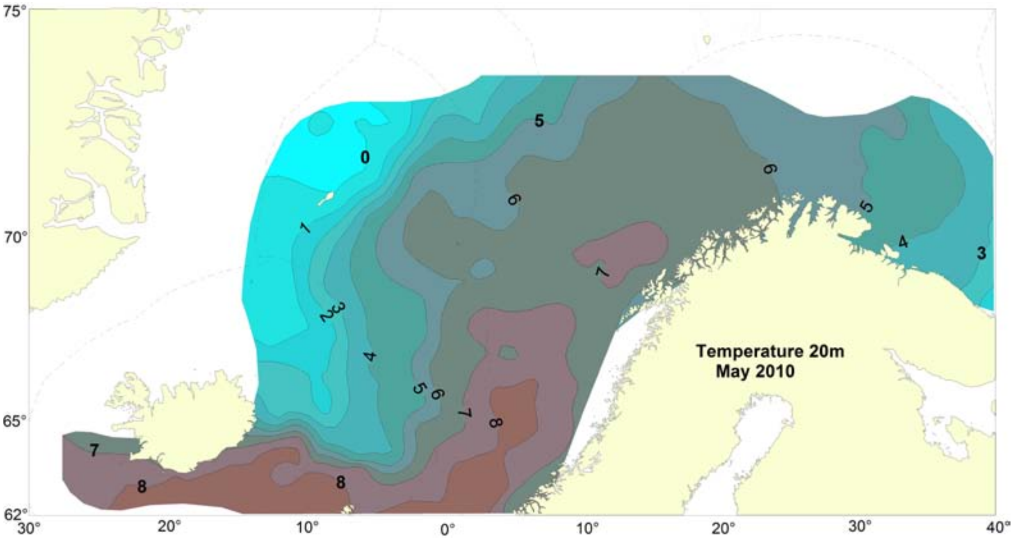

Figure 5. The horizontal distribution of temperatures at 20 m depth in April-June 2010.

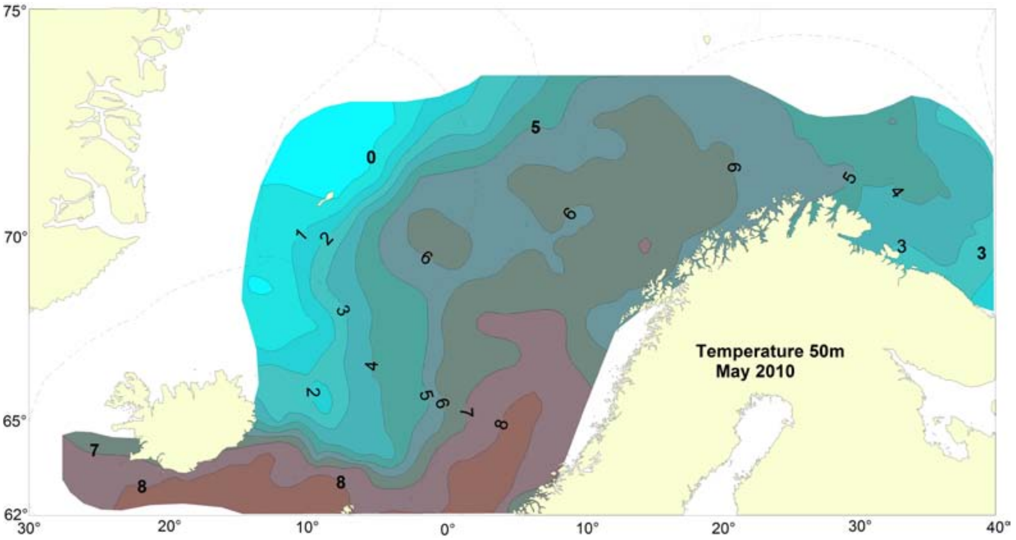

Figure 6. The horizontal distribution of temperatures at 50 m depth in April-June 2010.

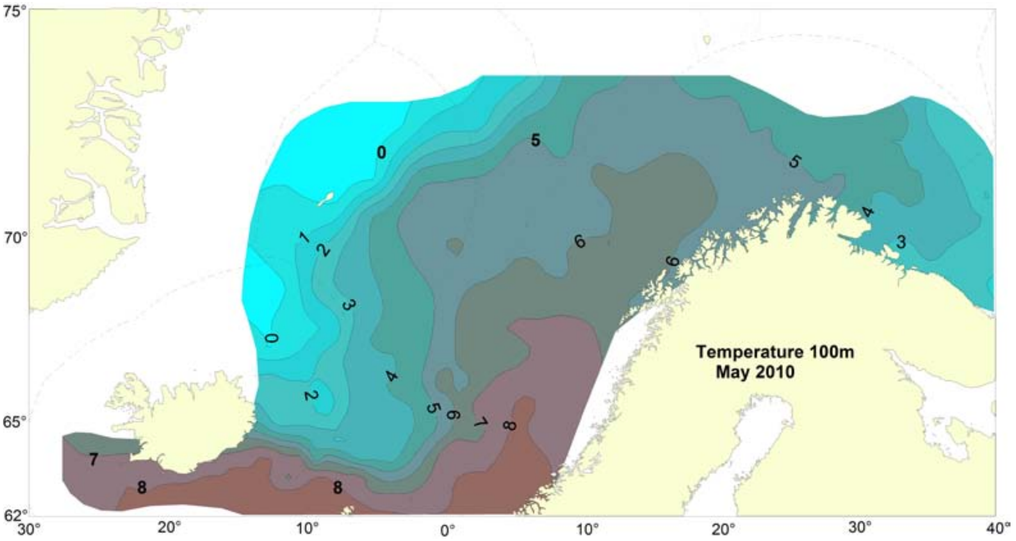

Figure 7. The horizontal distribution of temperatures at 100 m depth in April-June 2010.

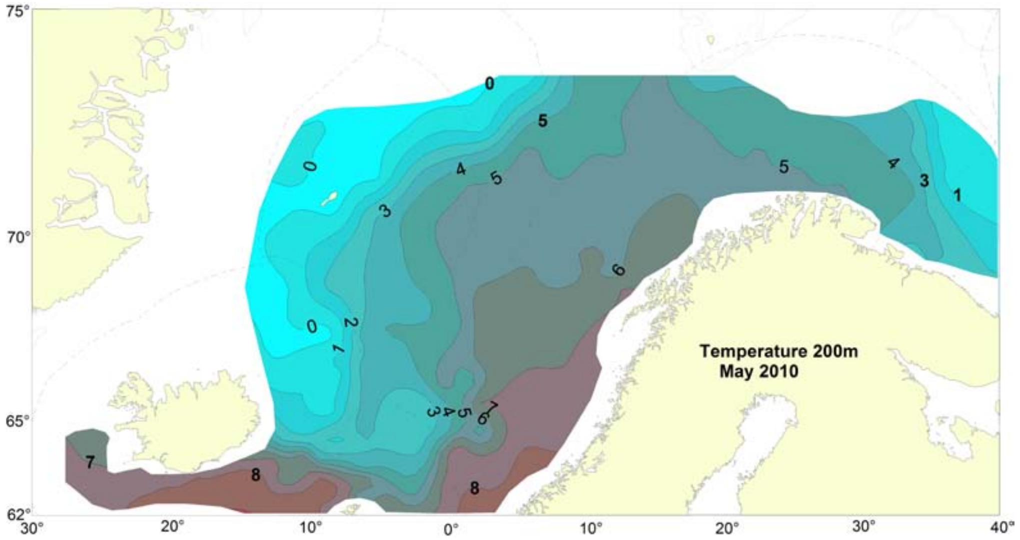

Figure 8. The horizontal distribution of temperatures at 200 m depth in April-June 2010.

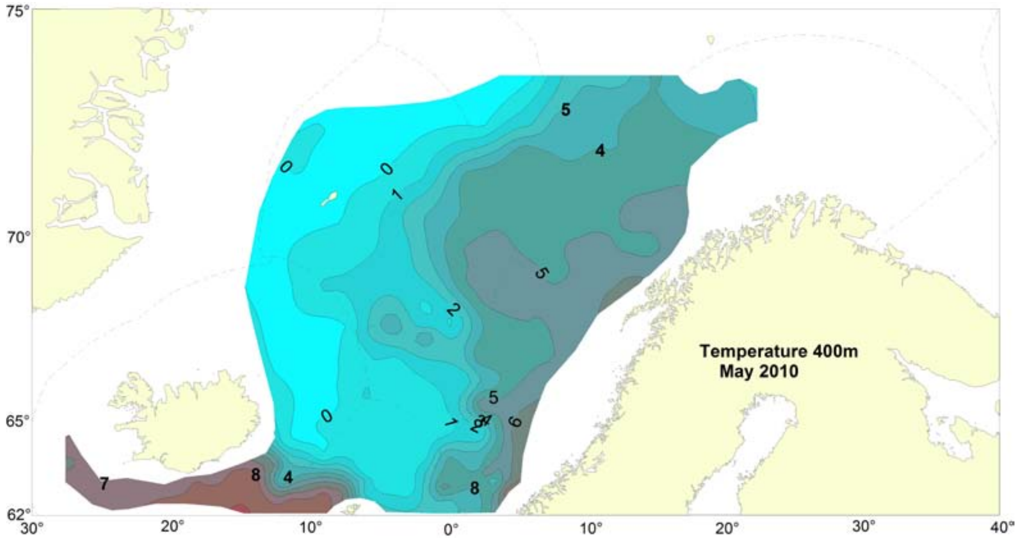

Figure 9. The horizontal distribution of temperatures at 400 m depth in April-June 2010.

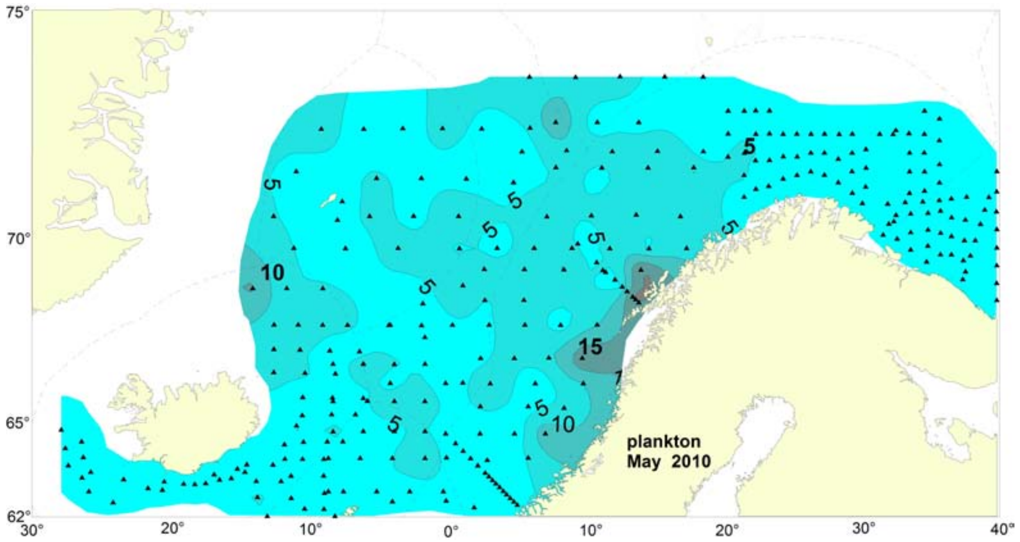

Figure 10. Zooplankton biomass (g dw m-2; 200–0 m in April-June 2010.

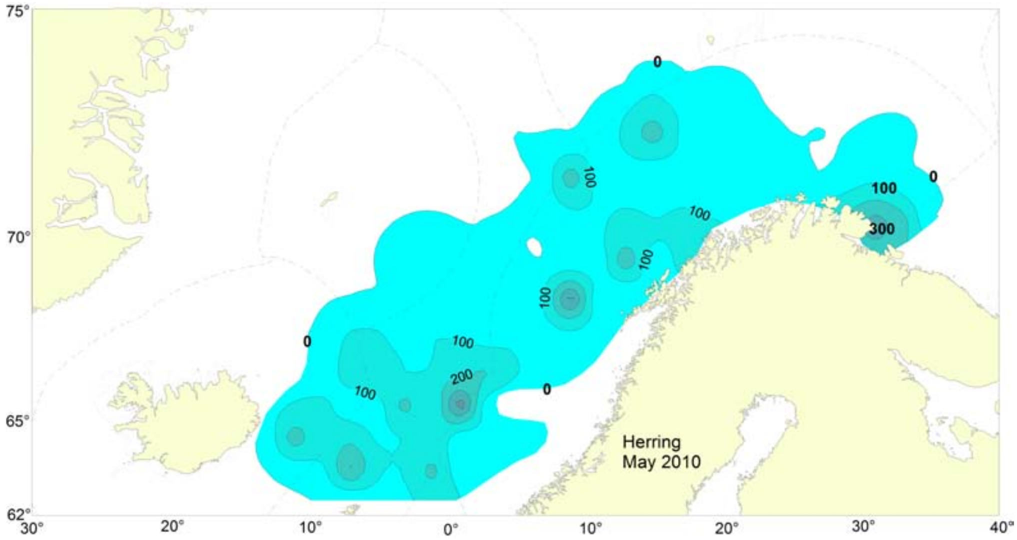

Figure 11. Distribution of Norwegian spring-spawning herring as measured during the International survey in April-June 2010 in terms of sA-values (m²/nm²) based on combined 5 nm values.

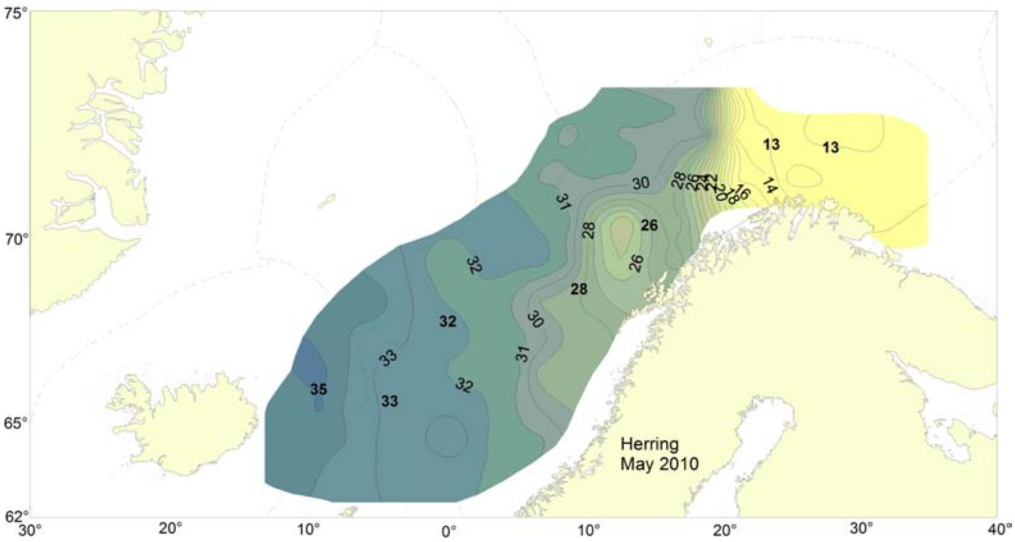

Figure 12. Mean length (cm) of Norwegian spring-spawning herring recorded in the North-east Atlantic Ecosystem Survey in April–June 2010.

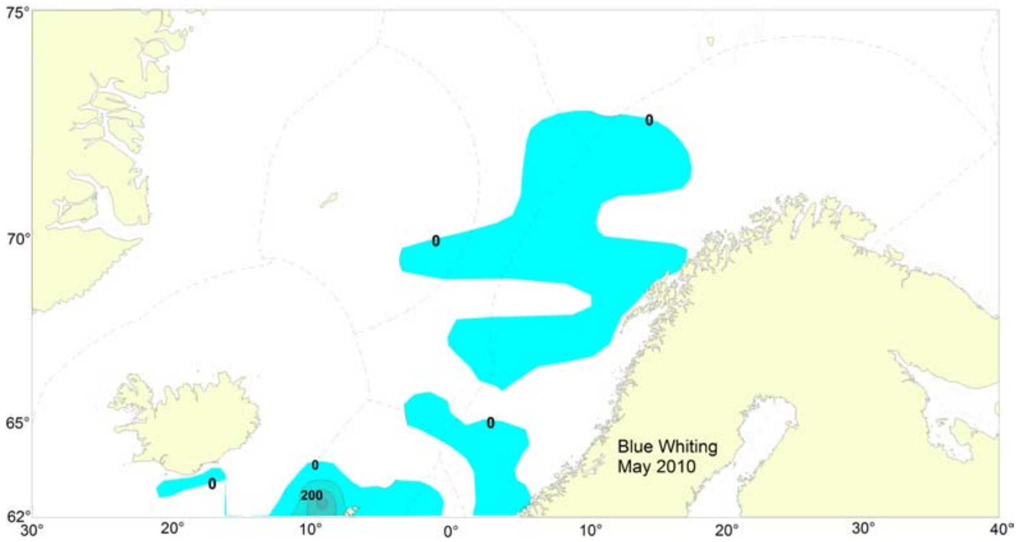

Figure 13. Distribution of blue whiting as measured during the International survey in April-June 2010 in terms of s_A-values (m^2/nm^2) based on combined 5 nm values. The standard area used in assessment (NPBWWG) is shown on the map.

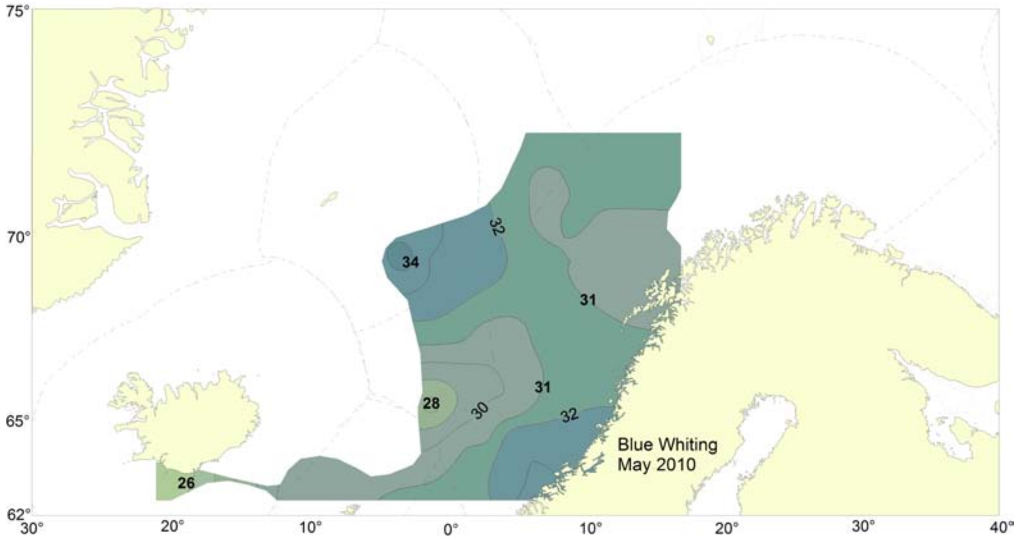

Figure 14. Mean length (cm) of blue whiting recorded in the North-east Atlantic Ecosystem Survey in April–June 2010.

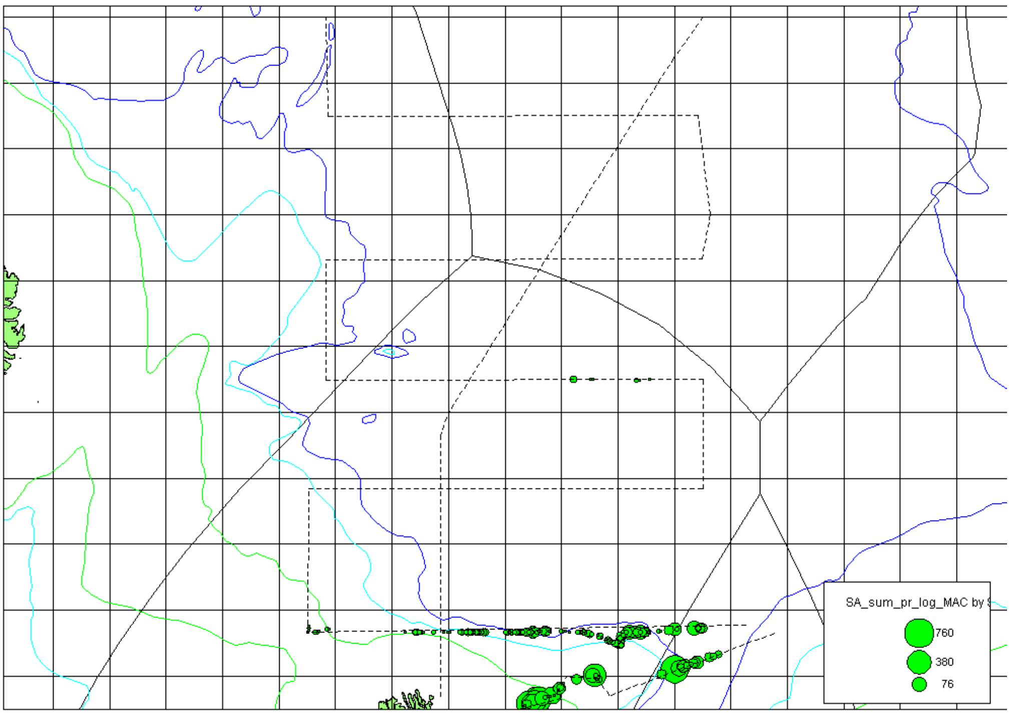

Figure 15. The sum of the sA values of Mackerel per each nm (sA mm/nm²) along the cruise tracks from the RV *"Magnus Heinason"* during 28/4–12/5 2010.

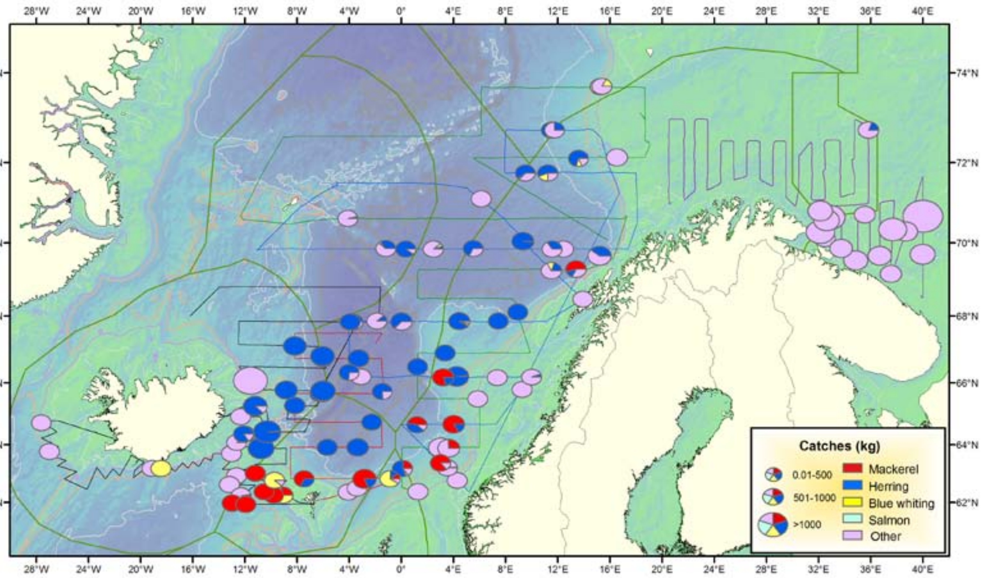

Figure 16. Distribution and spatial overlap between mackerel (red), herring (blue), blue whiting (yellow) and salmon (violet) according to trawl catches of the vessels participating in the survey during April-June. Note that "other" in the Barents Sea indicates juvenile herring.

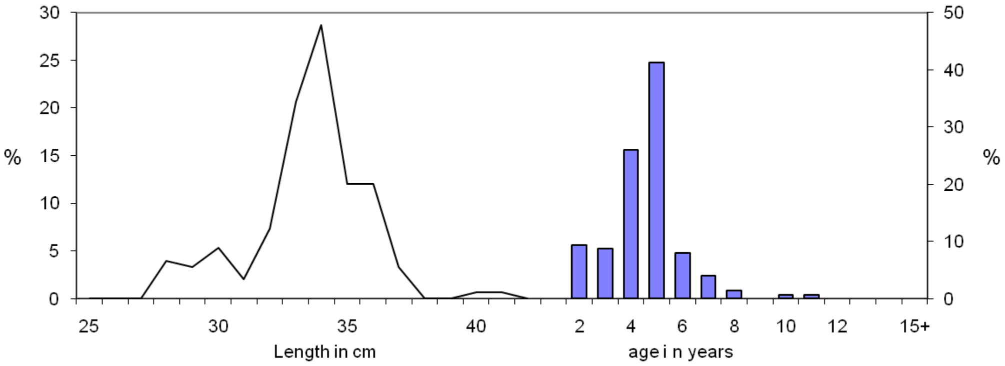

Figure 17. Age distribution of mackerel in the Norwegian Sea in the North-east Atlantic Ecosystem Survey in April–June 2010.

Annex 4: Terms of Reference 2011

2010/2/SSGESST00 The **Working Group on Northeast Atlantic Pelagic Ecosystem Surveys** (WGNAPES), chaired by Ciaran O'Donnell, Ireland, will meet in Kaliningrad, Russian Federation from 16–19 August 2011 to:

a) critically evaluate the surveys carried out in 2011 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 2011 survey data and provide the following data for the Working Group for Widely Distributed Stocks (WGWIDE):

  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 such as mackerel.

c) describe the migration pattern of the Norwegian spring-spawning herring, blue whiting and mackerel stocks in 2010 on the basis of biological and environmental data;

d) Respond to the findings of the Working Group on Redfish Surveys

  v) plan and coordinate the surveys on the pelagic resources and the environment in the North-East Atlantic in 2012 including the following:

  vi) the international acoustic survey covering the main spawning grounds of blue whiting in March-April 2012.

  vii) the international coordinated survey on Norwegian spring-spawning herring, blue whiting and environmental data in May-June 2012.

  viii) national investigations on pelagic fish and the environment in June-August 2012.

WGNAPES will report by 1 September 2011 (via SSGESST) for the attention of SCICOM 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 Working Group is a potential meeting place for interdisciplinary discussion and considerations on ecosystem approach to management of fisheries. ToR a) Two international and some national surveys with coordinated by WGNAPES. The Working Group describes the procedures for acoustic, hydrographic, plankton, and fish sampling to be used during the surveys. ToR b) The abundance indices estimates of Norwegian Spring-spawning Herring and Blue Whiting produced from surveys are used in ICES Northern Pelagic and Blue Whiting Fishery Working Group (NPBWWG) in assessment. The collection of environmental data improves the basis for ecosystem modelling of the Northeast Atlantic. ToR c) The Working Group describes the migrations of the stocks and considers possible stock – environment interactions. ToR d) 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 Working Group will be to coordinate and quality control surveys in the area where redfish is recorded. In the coming years, the Working Group should also evaluate the surveys and analyse and report the results. For a survey in 2009, there may be a need for coordination during spring 2010 through consultations between interested parties. ToR e) The Working Group contributes significantly to improving abundance surveys essential to fish stock assessment of herring and blue whiting and improving the collection of data for ecosystem modelling of the Northeast Atlantic. The Working 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 evaluate platform and sampling tools-survey gear differences. In general, the remit of this group addresses Action Numbers 1.2.2, 1.3 and 1.11.
Resource Requirements :	None
Participants:	15
Secretariat Facilities	Standard report production.
Financial	None
Linkages to Advisory Committees	ACOM
Linkages to other Committees or Groups	WGWIDE, WGNAS
Linkages to other Organisations	None

Annex 5: Recommendations

Listed below is a range of recommendations compiled by the WGNAPES:

RECOMMENDATION	FOR FOLLOW UP BY:
1.Developemnt of standardized set of survey methods for the mackerel/trawl acoustic surveys in the Norwegian Sea. Methods should be developed in association with WGIPS and with input from WGWIDE. Once complete these methods should be included in the updated survey manual.	Participant countries
2. The group welcomed the presence of Michael St John from the EURO-Basin project at the meeting. The group recommends the development of links between survey data collected within WGNAPES and the project to realize the full potential of these data. A member of the project will attend WGNAPES in 2011 to provide overview of data potential.	EURO-Basin
3.The continued development into 2011 of the deep-sea species photo guide initiated during the 2008 PGNAPES meeting.	Participant countries
4. In light of the large discrepancies in maturity reported for both blue whiting and herring during the May survey, group members are encouraged to participate in the upcoming maturity workshop (WKMSHS) in spring 2011.	Participants institutes