Annex 4b: IESNS

Working Document

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INTERNATIONAL ECOSYSTEM SURVEY IN NORDIC SEA (IESNS) IN April – June 2015

Maxim Rybakov[4], Tatjana Sergeeva[4], Olga Goncharova[4]
R/V Fridtjof Nansen

Øyvind Tangen[2], Valantine Anthonypillai[2], Are Salthaug[2], Åge Høines[2], Kjell Arne Mork[2], Webjørn Melle[2],
RV G. O. Sars

Karl-Johan Stæhr[3], Bram Couperus[6], Mathias Kloppmann[8]
RV Dana

Guðmundur J. Óskarsson[7], Sveinn Sveinbjörnsson[7], Héðinn Valdimarsson[7], Ástþór Gíslason
RV Árni Friðriksson

Eydna í Homrum[5], Ebba Mortensen[5], Poul Vestergaard[5], Jens Arni Thomassen[5], Leon Smith[5*]
RV Magnus Heinason

2 Institute of Marine Research, Bergen, Norway

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 April-June 2015, 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, RV G.O. Sars, Norway and RV Fridtjof Nansen, Russia participated in the International ecosystem survey in the Nordic Seas (IESNS). 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 Faroese, 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 compilation of data from this International survey stored in the PGNAPES databases and supported by national survey reports from each survey (Dana: Couperus, Staehr, Kloppmann 2015, Magnus Heinason: í Homrum, Mortensen, FAMRI 1516-2015, Arni Friðriksson: Oskarsson and Sveinbjornsson 2015, Fridtjof Nansen: Rybakov PINRO 2015 and G.O. Sars: not (yet) available.

Material and methods

Coordination of the survey was done during the WGIPS meeting jan. 2015. 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	28/5–23/5
G. O. Sars	Institute of Marine Research, Bergen, Norway	29/4-3/6
Fridtjof Nansen	PINRO, Russia	02/6–28/6
Magnus Heinason	Faroe Marine Research Institute, Faroe Islands	30/4- 14/5
Arni Friðriksson	Marine Research Institute, Island	29/4-22/5

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 that were not favourable. In the central area the weather conditions were generally good 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 EK60	Simrad EK60	Simrad EK60
Frequency (kHz)	**38**	**38**, 18, 70, 120, 200, 333	**38**, 18, 120, 200	**38**,200	**38,** 120
Primary transducer	ES38BP	ES 38B - Serial	ES38B	ES38B	ES38B
Transducer installation	Towed body	Drop keel	Drop keel	Hull	Hull
Transducer depth (m)	3	8.5	8	3	5.2
Upper integration limit (m)	5	15	15	7	10
Absorption coeff. (dB/km)	6.9	10.1	10	10.2	10
Pulse length (ms)	1.024	1.024	1.024	1.024	1.024
Band width (kHz)	2.425	2.425	2.425	2425	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	-20.8	-20.9	-20.8	-20.6
Sv Transducer gain (dB)					
Ts Transducer gain (dB)	25.33	25.17	24.64	25.57	25.52
s_A correction (dB)	-0.55	-0.61	-0.84	-0.7	-0.64
3 dB beam width (dg)					
alongship:	6.73	7.24	7.31	6.98	6.99
athw. ship:	6.77	7.26	6.95	7.07	6.99
Maximum range (m)	500	500	750	500	450
Post processing software	LSSS	LSSS	LSSS	Sonardata Echoview 6.1	LSSS

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), and "Notes from acoustic Scrutinizing workshop in relation to the IESNS", Reykjavík 3.-5. March 2015.

Generally, 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)		832	640	640	500
Vertical opening (m)	25-35	45–50	45–55	45–55	50
Mesh size in codend (mm)		40	40	40	16
Typical towing speed (kn)	3.0-40	4.0–4.5	3.0–4.5	3.0–4.0	3.7–4.8

Catches from trawl hauls were sorted and weighed; fish were identified to species level, when possible, and other taxa to higher taxonomic levels. Normally a subsample of 30–100 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 70–300 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 NASC-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 NASC-values were averaged over squares of 1° latitude × 2° longitude. For each square, the unit area density of fish in number per square nautical mile (N*nm-2) was calculated using standard equations (Foote *et al.*, 1987; Toresen *et al.*, 1998). The following target strength (TS) function was used:

Blue whiting: TS = 20 log(L) – 65.2 dB (rev. acc. ICES CM 2012/SSGESST:01)

Herring: TS = 20.0 log(L) – 71.9 dB

The target strength for herring is the traditionally one used while this target strength for blue whiting was first applied in 2012 (ICES 2012).

To estimate the total abundance of fish, the unit area abundance for each square was multiplied by the area in each statistical square then summed for all the 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.

As last year, the whole survey area was divided into 5 geographical strata (Figure 4). For each of the strata, east-west transects (except for stratum 6 in the Barents Sea with north-south transects) were decided prior to the survey. Within each stratum, parallel transects with equal distance were used. The distance between transects was based on available survey time, and the starting point of the first transect in each stratum was randomized. This approach allows for robust statistical analyses of uncertainty of the acoustic estimates.

A new software package (StoX) is under development at IMR, Norway. The first version of StoX was released earlier this year. StoX is an open source software with an infrastructure hosting various types of survey estimation programs for acoustic surveys and trawl surveys (swept area). The program is a stand-alone application build with Java for easy sharing and further development in cooperation with other institutes. The underlying high resolution data matrix structure ensures future implementations of e.g. depth dependent target strength and high resolution length and species information collected with camera systems. Despite this complexity, the execution of an index calculation can easily be governed from user interface and an interactive GIS module, or by accessing the Java function library and parameter set using external software like R. Accessing StoX from external software may be an efficient way to process time series or to perform boot-strapping on one dataset, where for each run, the content of the parameter dataset is altered. In the first version a stratified transect design is assumed (e.g. like the IESNS survey design this year) and standard statistical methods to estimate mean and variance of abundance can be be used. Other methods will be implemented, however, expert specification demands, documentation and statistical rigorousness is essential in the development of StoX. The software was tested on data collected on this year's IESNS survey and the biomass estimate was fairly similar (results will be presented at a later stage in a separate report). The StoX software will replace the BEAM program from next year onwards.

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. Beside the hydrographical sampling from the vessels listed above, hydrographical data from two fixed hydrographical transects (Langanes-NE and Langanes-E; Figure 5; total 14 stations) north east of Iceland were also used. They were sampled in the spring survey around Iceland by RV Bjarni Sæmundsson during 20-30 May 2015 using the same kind of CTD as the other vessels.

Zooplankton was sampled by a WPII on all vessels except the Russian vessel which used a Djedi 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 per m^2.

Results

Hydrography

The temperature distributions in the ocean at selected depths between surface and 400 m depths are shown in Figures 6-11. The temperatures at the surface ranged from 0°C in the Iceland Sea to 9°C in the southern part of the Norwegian Sea. The Arctic front was encountered slightly below 65°N east of Iceland extending eastwards towards the 0° Meridian where it turned almost straight northwards up 70°N. The front was visible throughout the observed water column. The warmer North Atlantic water formed a broad tongue that stretched far northwards along the Norwegian coast with temperatures > 7 °C to 71° N in the surface layers.

Relative to a 20 years long-term mean, from 1995 to 2014, the temperatures at all depths in the vicinity of the Faroese were considerable lower in 2015 compared to the long-term mean (Figures 12-15). There, the anomaly was maximum 2°C. The cold conditions reflect the relative low temperatures in the Sub Polar Gyre that have propagated northeastward into the southern Norwegian Sea. North of about 61°N the temperatures at all depth were in general higher than the long term mean for most of the area. In this area the temperatures were about 0.25-0.75 °C above the mean but in some areas the anomalies were higher (e.g., over the Vøring Plateu, northeast of Jan Mayen, and at the entrance to the Barents Sea).

Similar pattern was observed at 0-50 m depth at the standard hydrographic sections northeast off Iceland (Langanes E, Figure 5), where the temperature was lower than in the year before while the salinity was higher (Figures 16- and 17). However, for the deeper waters the temperature was at high level (Figure 18).

Zooplankton

Biomass of zooplankton dry weight and sampling stations are shown in Figure 19. Sampling stations were evenly spread over the area, and most oceanographic regions were covered. The zooplankton biomass was relatively uniform over the whole area, with the highest values northeast of Iceland and in coastal areas of northern Norway. The average value for the Norwegian Sea (between 14°W and 20°E) was 6.5 g dry weight m^{-2}, which is a decrease from last year's value (Figure 20). The average value for the continental slope south and west of Iceland (west of 14°W) was 1.3 g dry weight m^{-2}.

In the Barents Sea (east of 20°E), the mean zooplankton biomass was 0.80 g dry weight m^{-2}. It was noted that the Djedy net applied by the Russian vessel in Barents Sea seems to be less effective in catching zooplankton in comparison to WP2 net applied by other vessels in an overlapping area. Thus, the biomass estimates for the Barents Sea are not directly comparable to the other areas, but are comparable among years within the Barents Sea.

Norwegian Spring-spawning herring

Survey coverage in the Norwegian Sea was considered adequate in 2015 and in line with previous years. It is therefore recommended that the results can be used for assessment purpose. The herring was distributed over a comparable area as in 2014 but the highest density was observed further east than in the latest years (Figures 21 and 22). The center of gravity of the acoustic recordings of herring reflects the distribution and correspondingly shifted in a southeasterly direction compared to 2014 (Figure 23). Overall the herring density was relatively low. Different from previous four years, young herring (age 6 and younger) was observed north of 70°N, although much less than in 2010.

As in previous years the smallest fish were found in the eastern area of the Norwegian Sea where size and age were found to increase to the west and south (Figure 24). Correspondingly, it was mainly older herring that appeared in the southwestern areas (area III).

The herring stock is now dominated by 6 year old herring (2009 year class) in numbers but 9, 10 and 11 year old herring (the 2006, 2005 and 2004 year classes) are also numerous (Table 2). This is the first time since 2008 that the 2004 year class is not the most abundant. The 2009 year class appears to be the largest of the younger age groups even it appears to be only around 70% of average size of six year olds in the times series since 1997. In biomass, however, the 2004 year class is still the largest. The four year classes from 2004, 2005, 2006 and 2009 contribute 19%, 11%, 12% and 17% respectively to the total biomass in the Norwegian Sea. The relatively high abundance of the 2005 year class might be caused by age reading errors mentioned in the Discussion section.

The total biomass estimate of herring in the Norwegian Sea from the 2014 survey was 5.4 million tons. This estimate is 0.3 million tonnes higher than in 2014. The biomass decreased from 2009 to 2012, but in the last 4 years has been around 5 million tonnes (Figure 25).

The investigations of herring in the Barents Sea covered the area from 45°E to the 21°00′ E. The total abundance estimate was lower than in the last two years, with 2996 million individuals of age 1 (mean length of 12.4 cm and weight of 11.6 g), 8129 million individuals of age 2 (mean length of 18 cm and mean weight of 36.8 g), 957 million individuals of age 3 herring (mean length of 21.4 cm and mean weight of 62.8 g) and 265 million individuals of age 4 herring (mean length of 26.1 cm and mean weight of 109.2 g). Only very few older herring were observed.

The total number of herring recorded in the Norwegian Sea was 14.1 billion in the northeastern area and 6.9 billion in the southwestern area, compared to 13.0 and 9.6 billion in the northeastern and 7.4 and 6.9 billion in the southwestern area in 2013 and 2014, respectively.

Blue whiting

The total biomass of blue whiting registered during the IESNS survey in 2015 was 0.89 million tons (Table 3), which is an increase from the biomass estimate in 2014 (0.63). The stock estimate in number for 2015 is 16 billion, which is about 75% higher than in 2014. The increase in abundance is caused by more young fish in the stock. Age one is dominating the estimate (53% of the biomass and 76% by number).

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 area 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 also dominated by fish at age 1 both in terms of numbers and biomass.

The distribution of blue whiting in 2015 was similar to 2014, but with higher abundance estimates in the eastern and southern part of the Norwegian Sea, along the Norwegian continental slope, as well as southwest of Iceland. The main concentrations were observed both in connection with the continental slopes of Norway and south and southwest Iceland and in the open sea in the southern part of the Norwegian Sea (Figures 26 and 27). The mean length of blue whiting is shown in Figure 28. 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. However, the mackerel was mainly found in the eastern part of the survey area up to 67°N in May 2015, with few exceptions at western stations further south. It should be noted, however, that the sampling may not provide a representative picture of mackerel distribution because of its vertical distribution and relatively low trawling speed.

Stomach samples from the three pelagic species (herring, blue whiting and mackerel) were collected by the Norwegian and Faroese vessels. These samples have however, not been analyzed yet and will be reported by other means later.

The distribution of the pelagic fish stocks is apparently linked to the temperature within the distribution area as shown on profiles of the two transects across the whole Norwegian Sea (Figure 29). For example, the herring was not found in surface waters (0-100m) in waters below 3°C as in the western part of the Norwegian Sea, even if found in colder waters deeper down. Blue whiting was on the other hand limited to waters above 2°C.

Discussion

Hydrography

Discussions related to the oceanographic condition in April/July 2014 are provided in the results section above, while more general patterns are introduced in this section.

Two main features of the circulation in the Norwegian Sea, where the herring stock is grazing, are the Norwegian Atlantic Current (NWAC) and the East Icelandic Current (EIC). The NWAC with its offshoots forms the northern limb of the North Atlantic current system and carries relatively warm and salty water from the North Atlantic into the Nordic Seas. The EIC, on the other hand, carries Arctic waters. To a large extent this water derives from the East Greenland Current, but to a varying extent, some of its waters may also have been formed in the Iceland and Greenland Seas. The EIC flows into the southwestern Norwegian Sea where its waters subduct under the

Atlantic waters to form an intermediate Arctic layer. While such a layer has long been known in the area north of the Faroes and in the Faroe-Shetland Channel, it is only in the last three decades that a similar layer has been observed all over the Norwegian Sea.

This circulation pattern creates a water mass structure with warm Atlantic Water in the eastern part of the area and more Arctic conditions in the western part. The NWAC is rather narrow in the southern Norwegian Sea, but when meeting the Vøring Plateau off Mid Norway it is deflected westward. The western branch of the NWAC reaches the area of Jan Mayen at about 71°N. Further northward in the Lofoten Basin the lateral extent of the Atlantic water gradually narrows again, apparently under topographic influence of the mid-ocean ridge. It has been shown that atmospheric forcing largely controls the distribution of the water masses in the Nordic Seas. Hence, the lateral extent of the NWAC, and consequently the position of the Arctic Front, that separates the warm North Atlantic waters from the cold Arctic waters, is correlated with the large-scale distribution of the atmospheric sea level pressure.

The temperature east of Iceland in the 0-50m layer in May 2015 (Figure 16 and 17) was lower than in 2014, but this is smaller deviation than observed west, south and southeast of Iceland in the same survey (1-2°C lower in upper layers). Thus the colder conditions around the Faroes (Figures 12-14) are not considered to be related to increased flow in the East Icelandic current, but to the changed conditions in the North Atlantic Current and the lower temperature in the Sub Polar Gyre, seen as a negative SST anomaly and which has been progressing northeastwards during this spring. So the colder anomaly on the Iceland Faroes Ridge is probably more related to these colder conditions from the west and south and could be influencing the Norwegian Sea this summer. These colder surface (and upper layers) are related to strongly positive NAO and cold/fresh waters on the Canadian site of the Atlantic this winter and spring.

Plankton

The zooplankton biomass has been estimated since 1995 and the time series was re-evaluated by WGINOR in 2014 (Figure 20; ICES 2014). After a severe decline from 2003 until 2009 (~4 g/m^2), the biomass showed an upward trend for 5 years and reached 9.5 g/m^2 in 2014. In this year's survey the biomass index for plankton declined, and if it is related to the colder temperature this spring, predation pressure or by other means is unknown. Similar results were obtained from this year's hydrographic spring survey around Iceland where biomass of zooplankton was below average all around Iceland, except in the south were it was around average (http://www.hafro.is/undir.php?ID=19&nanar=1REF=3&fID=20733).

The reason for this fluctuation in the zooplankton 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. 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 zoo-plankton stocks. A fairly strong positive relationship between NAO and zooplankton biomass was observed, particularly during the late 1990s. However, this relationship seems to be less pronounced now, and the biomass index decline now despite a positive NAO the last two winters. The linkage between sea temperature and zooplankton abundance is also not fully understood and needs further explorations.

The zooplankton biomass in Barents Sea (east of 20°E) was lower (0.80 g m^{-2}) than in 2014, 2013 and 2012 (1.6, 1.5 and 1.7 g dry weight m^{-2}, respectively). However, as stated above, the biomass estimates for the Barents Sea taken with the Djedi net are not directly comparable to the other areas taken by WP2 nets, but are comparable among years within the Barents Sea. Also, it must be noted that this year's survey in Barents Sea was two weeks later than normally.

Summing up, the reason for the observed changes in zooplankton biomass is not clear to us and more research to reveal this is recommended. Quantitative researches on carnivorous zooplankton stocks (such as krill and amphipods) across the whole survey area, is an important step in that direction and needs a further effort by all participating countries.

The estimations of average biomass of zooplankton, discussed above, have included the whole areas covered by the survey vessels each year. However, it has been noted that the research effort can vary by a lot in the continental slope area south and west off Iceland. For that reason, and to get biomass indices representative for Norwegian Sea it self, it is recommended to re-estimate the whole time series and limit the area to east of 14°W and west of 17°E. The data are not yet all in the NAPES database so this could not be done at the meeting where this report was prepared, but will hopefully be done in relation to work of WGINOR (ICES 2014).

Norwegian spring-spawning herring

The Norwegian spring-spawning herring is characterized by large dynamics with regard to migration pattern. This applies to wintering, spawning and feeding area. The following discussion will mainly concentrate on the distribution and situation in the feeding areas in May, but no attempt was done to draw up the likely feeding migration that is believed to be comparable to recent years.

The amount of herring measured in the 2015 survey was 6% higher than in 2014. The biomass estimates in the last seven years has fluctuated with apparent downward trend since 2009 (Figure 25). The uncertainty, or the CV, round the estimates is estimated to be less than 30% for each of the age groups 3-12 for the years 2009 – 2013 (Stenevik, *et.al*., 2015).

The approach of dividing the survey area into strata, which was used in 2014 for the first time, is considered as valid improvements in terms of securing equivalent coverage among years and allow for robust statistical analyses of uncertainty of the acoustic estimates in the future.

In the last years there have been concerns regarding age reading of herring, because the age distributions from the different participants have showed differences. This is also the case in 2015 (Figure 30). For example, there was an apparent difference in the age distribution in Stratum 4 between the Icelandic and the Norwegian vessel with respect to age groups 10-12 years, which might be a consequence of a "drift" of 2004 year class into the 2003 and 2005 year classes during the ageing. However, the differences may also reflect differing spatial distribution of age groups, and partly, they may reflect variable growth conditions for the stock, and consequently growth rate as seen on the fish scales and otoliths. In spring 2014 an otolith and scale exchange was conducted, initiated by PGCCDBS (Godiksen, 2014). The report stated that the agreement among readers was low (67%) and it was recommended to conduct a larger scale exchange where both scales and otoliths are sampled from the same fish. Thus, the survey group stretch the need for an age-reading workshop for the primary herring age-readers prior to the 2016 IESNS survey. Consequently, the parties involved in the survey will in the coming months collect pairs of otoliths and scales for using at the workshop.

At the IESNS 2014 post-cruise meeting, there were concerns with the acoustic estimates, because the registrations of Dana and G.O. Sars on neighbouring transects were significantly different. The group identified two possible reasons for the discrepancy: 1) Time-lag or 2) differences in scrutiny procedures. Therefore it was stated that there was an urgent need for a workshop to review scrutinizing procedures. There is a planned scrutinizing workshop for all surveys within WGIPS in Hamburg in September 2015, but the group agreed, that IESNS needed a scrutinizing workshop prior to this year's survey. Thus, participants from all four vessels covering the adult herring stock met in Reykjavík in March 2015. The conclusions from that meeting were that the differences in scrutinizing procedures among the participants were believed to be of minor importance for the total estimate of Norwegian Spring Spawning herring in IESNS 2014 (Anon. 2015). Additionally, it was recommended that in the future the participants bring the acoustic data to the post-cruise meeting and spend some hours in the beginning to go through potential problems regarding the scrutinizing.

In IESNS 2015 there were again discrepancies between neighbouring transects of Dana and G.O. Sars on the Norwegian shelf. During the first hours of the meeting these discrepancies were analysed and discussed and the conclusion was that scrutinizing procedures were not believed to be the cause of the differences; rather it was believed to be related to patchy distribution of the herring.

Blue whiting

The abundance estimate of blue whiting in the IESNS survey 2015 showed an increase from the last years. A positive sign in development of the stock size was first observed in the 2011 survey where blue whiting at age 1 and 2 were in higher numbers than the previous years. This year, the number of 1 year old blue whiting was high in both the standard area (Table 4) and the total area west of 20°E (Table 3), and the biomass was dominated by 1 year old.

General recommendations and comments

Recommendation	Adressed to
1. The survey group recommends again that an age reading workshop will be held as soon as possible, and prior to the 2016 survey. This is to follow up on issues identified following analyses of otoliths and scales exchanges in 2014. Pairs of otoliths and scales from herring will be collected in the coming months for this purpose.	ACOM, WGWIDE, WGBIOP
2. Establishment of quantitative researches on carnivorous zooplankton stocks (such as krill and amphipods) across the whole survey area are recommended. It would require use of standardized fishing gears, such as the krill trawl used by Norway in recent years and Iceland in 2014.	Participating countries, WGWIDE, WGIPS

Next years post-cruise meeting

Preliminary dates are 14-16 June, in Ijmuiden, Netherland.

Concluding remarks

- The temperatures at all depths in the vicinity of the Faroese and southeast of Iceland were considerable lower in 2015 compared to the long-term mean, reflecting the relative low temperatures in the Sub Polar Gyre that have propagated northeastward into the southern Norwegian Sea.
- The index of plankton biomass in the Norwegian Sea declined after an increase since 2010.
- The biomass estimate of NSSH in 2015 was 6 % higher compared to last year.
- NSSH was dominated by the 2009 year class followed by the 2004 year class in numbers.
- No strong year classes of NSSH were observed in the Barents Sea indicating poor recruitment since 2004.
- The number of blue whiting measured in the 2015 survey area was 75% higher than in 2014.
- Age 1 (2014 yc) blue whiting is dominating the acoustic estimate in the “Standard area” (53% of the biomass and 76% by numbers).

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Tables

Table 1. Survey effort by vessel for the International ecosystem survey in the Nordic Seas in April-June 2015.

Vessel	Effective survey period	Effective acoustic cruise track (nm)	Trawl stations	Aged fish (HER)	Length fish (HER)	CTD stations	Plankton station
Dana	3/5-21/5	3320	30	419	1324	36	35
G.O.Sars	29/4–3/6	3887	68	595	1946	72	84
Fridtjof Nansen	02/6–27/6	3289	24	156	607	66	63
Magnus Heinason	30/4–14/5	1724	9	267	455	21	21
Árni Friðriksson	29/4–22/5	4021	29	766	2762	53	49
Total	29/4–27/6	16241	160	2203	7094	248	252

Table 2. Age and length-stratified abundance estimates of Norwegian spring-spawning herring in April-June 2015 for total area and abstracts of estimates for subareas I, II and III.

Length	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Number	Biomass	Weight
10	31															31	0.1	6
11	47															47	0.4	8
12	2918															2918	34.3	11.8
13	0	201														201	3.1	15.4
14		113														113	2	17.7
15		183														183	4.2	22.9
16		993														993	28.1	28.3
17		2782														2782	91.2	32.8
18		1545	0													1545	60.3	39
19		1700	241													1941	87.4	45
20		644	170													814	44.6	54.7
21		71	264													335	21.4	63.8
22		43	79													122	9.5	77.8
23		18	224													242	20.4	84.4
24		45	22	59												126	11.7	92.7
25		18	54	99												171	20.2	118.4
26		0	85	314												399	50.8	127.3
27		10	19	256	10											295	44.1	149
28			117	259	77	40	9	15								517	85.3	164.9
29			120	511	218	418	58	0	9							1334	246	184.4
30			0	691	369	611	332	74	0	0	37					2114	431.3	204
31			0	415	720	652	395	247	197	49	59					2734	601.2	219.9
32			0	155	202	642	38	9	59	38	38	20				1201	292.8	244
33			10	56	173	806	114	62	147	124	42	13	13	10		1570	412.7	263
34			0	0	100	493	175	284	630	502	554	79	51	9	9	2886	815.3	282.4
35			0	0	20	160	129	343	738	706	1367	260	110	51	20	3904	1163.7	298.1
36			0	15	0	20	35	178	442	465	998	356	267	131	41	2948	927	314.6
37								6	29	93	238	126	220	66	46	824	275.6	334.4
38								6	0	6	26	22	28	6	3	97	34.5	356.8
39										13	0	2	2	5	2	24	8.3	354.2
Number 10^6	2996	8366	1405	2830	1889	3842	1285	1224	2251	1996	3359	878	691	278	121	33411	5827.5	
Biomass 10^3 t	34.9	319	128.6	519.6	417.3	913.4	304.7	333	645.1	588.2	1007.9	270.5	218.7	87.8	38.6	5827.3		5827.5
Mean length cm	12.4	18.2	23.3	29.5	31.4	32.3	32.3	34.1	34.9	35.3	35.6	36.1	36.5	36.5	36.7			27.3
Mean weight g	11.6	38.1	91.5	183.7	220.8	237.8	237.3	272.1	286.6	294.8	299.9	308.3	316.9	315.3	318			174.4

Table 2. (cont'd)

Area I

Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total
Number 10^6	2996	8129	957	265	9	7	1	1	0	0	0					12365
Biomass 10^3 t	34.7	299	60.2	28.9	1.4	1.2	0.2	0.2	0	0	0					425.7
Mean length cm	12.4	18	21.4	26.1	28.7	29.4	30.1	28.8	0	0	0					17.1
Mean weight g	11.6	36.8	62.8	109	167	180	194	168	0	0	0					34.4

Area II

Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total
Number 10^6	0	245	401	2210	1681	2993	1080	841	1354	883	1603	350	312	104	39	14096
Biomass 10^3 t		20.7	60.4	418	366	690	250	222	383	258	479	106	96.9	32.5	11.9	3395

Area III

Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total
Number 10^6	0	0	47	354	201	842	204	383	896	1113	1756	528	378	174	82	6876
Biomass 10^3 t	0	0	8	72.2	49.6	222	54.1	111	262	330	528	165	122	55.2	26.8	2006.3

Area II and III

Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total
Number 10^6	0	245	448	2564	1882	3835	1284	1224	2250	1996	3359	878	690	278	121	21054
Biomass 10^3 t	0	20.7	68.4	491	416	912	305	333	645	588	1008	271	219	87.7	38.7	5401.5
Mean length cm		22.7	27.4	29.9	31.5	32.3	32.3	34.2	34.9	35.3	35.6	36.1	36.6	36.5	36.7	
Mean weight g		84.9	151	193	221	238	238	274	287	296	300	310	319	317	321	

Table 3. Age and length-stratified abundance estimates of blue whiting in April-June 2015, 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 10^6	Biomass 10^3 t	Mean Weight
14	8	0	0	0	0	0	0	0	0	0	0		8	0.1	15
15	36	7	0	0	0	0	0	0	0	0	0		43	0.8	20
16	429	0	0	0	0	0	0	0	0	0	0		429	10.2	24
17	1621	11	0	0	0	0	0	0	0	0	0		1632	46.6	29
18	3359	35	0	0	0	0	0	0	0	0	0		3394	112.6	33
19	3158	39	0	0	0	0	0	0	0	0	0		3197	122.8	38
20	1432	57	0	0	8	0	0	0	0	0	0		1497	65.5	44
21	472	85	11	0	0	0	0	0	0	0	0		568	29.3	52
22	108	412	30	6	0	0	0	0	0	0	0		556	35.3	64
23	19	881	83	6	0	0	0	0	0	0	0		989	73.0	74
24	9	844	207	21	0	0	0	0	0	0	0		1081	90.1	83
25	0	460	135	15	17	0	0	0	0	0	0		627	59.3	95
26	0	167	211	56	8	0	0	0	0	0	0		442	47.8	108
27	0	23	152	93	23	0	0	0	0	0	0		291	36.7	127
28	0	6	110	109	47	10	0	0	0	0	0		282	39.7	141
29	0	7	32	86	36	7	4	0	2	0	0		174	26.5	152
30	0	1	13	19	23	24	3	0	0	1	0	1	85	14.6	167
31	0	2	12	22	15	24	0	12	2	3	5	2	99	18.4	187
32	0	0	0	15	2	24	0	1	1	6	2	1	52	10.9	209
33	0	0	0	2	19	4	5	11	7	2	1	6	57	13.3	237
34	0	0	0	1	13	6	13	9	5	6	3	5	61	15.6	251
35	0	0	0	0	1	0	6	3	4	2	11	10	37	9.7	273
36	0	0	1	0	0	1	7	1	1	1	1	0	13	3.8	274
37	0	0	0	0	0	0	1	2	0	0	1	8	12	3.7	295
38	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	274
39	0	0	0	0	0	0	0	0	2	0	0	0	2	0.5	273
40	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	340
Number 10^6	10651	3037	997	451	212	100	39	39	24	21	24	33	15628	887	
Biomass 10^3 t	386	238.4	105.7	61.1	33.3	18.8	9.7	9.1	5.9	5	5.8	8.4		887.2	
Length cm	19	23.9	26.1	28.2	29.3	31.4	34.1	33.6	34.1	33.4	34.3	36		21.1	
Weight g	36.2	78.5	106.1	135.3	156.8	189.1	244.5	229.9	239.1	218.3	239.8	280		56.8	

Area 2

Age	1	2	3	4	5	6	7	8	9	10	11	12+	Total
Number 10^6	9666	2000	587	313	115	43	13	17	10	17	16	8	12805
Biomass 10^3 t	341.2	152.3	61.5	40.5	15.7	7.4	2.7	3.9	2	3.8	3.7	1.9	637
Length cm	18.9	23.7	26.1	28	28.3	31.2	34.1	34.4	32.7	33.2	33.8	33.6	20.4
Weight g	35.3	76.2	104.7	130.2	135.7	175.3	222	228.7	200.6	207.3	218.7	220	49.7

Area 3

Age	1	2	3	4	5	6	7	8	9	10	11	12+	Total
Number 10^6	987	1038	408	139	95	58	28	22	16	5	7	25	2828
Biomass 10^3 t	44.8	86.1	44.2	20.6	17.5	11.4	7	5.2	3.9	1.2	2.1	6.5	250.5
Length cm	20.4	24.3	26.1	28.5	30.5	31.5	34.1	33	35	34.5	35.5	35.8	24.1
Weight g	45.5	83	108.1	146.7	182.4	199.4	254.4	230.8	265.3	261.2	289.9	290	88.7

Area 2 and 3 (Norwegian Sea)

Age	1	2	3	4	5	6	7	8	9	10	11	12+	Total
Number 10^6	10651	3037	997	451	212	100	39	39	24	21	24	33	15628
Biomass 10^3 t	386	238.4	105.7	61.1	33.3	18.8	9.7	9.1	5.9	5	5.8	8.4	887.2
Length cm	19	23.9	26.1	28.2	29.3	31.4	34.1	33.6	34.1	33.4	34.3	36	21.1
Weight g	36.2	78.5	106.1	135.3	156.8	189.1	244.5	229.9	239.1	218.3	239.8	280	56.8

Table 4. Blue whiting in "Standard Area" 8°W - 20°E and north of 63°N in IESNS 2015.

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	4	0	0	0	0	0	0	0	0	0	0	0	4	0.1	14.5
15	29	0	0	0	0	0	0	0	0	0	0	0	29	0.6	20.8
16	385	0	0	0	0	0	0	0	0	0	0	0	385	9.1	23.6
17	1458	12	0	0	0	0	0	0	0	0	0	0	1470	41.9	28.5
18	2933	37	0	0	0	0	0	0	0	0	0	0	2970	98.5	33.2
19	2607	30	0	0	0	0	0	0	0	0	0	0	2637	101.1	38.3
20	1026	24	0	0	0	0	0	0	0	0	0	0	1050	45.6	43.4
21	235	44	6	0	0	0	0	0	0	0	0	0	285	14.7	51.5
22	42	271	18	6	0	0	0	0	0	0	0	0	337	21.6	64.1
23	0	475	23	6	0	0	0	0	0	0	0	0	504	37.4	74.1
24	9	426	86	18	0	0	0	0	0	0	0	0	539	44.8	83.1
25	0	247	70	8	16	0	0	0	0	0	0	0	341	32.5	94.8
26	0	80	122	42	8	0	0	0	0	0	0	0	252	27.4	108.6
27	0	15	98	59	15	0	0	0	0	0	0	0	187	23.6	126.5
28	0	0	51	73	27	4	0	0	0	0	0	0	155	21.6	139.1
29	0	7	24	56	20	7	2	0	2	0	0	0	118	17.6	150.7
30	0	1	13	19	12	15	3	0	0	1	0	1	65	10.9	165.5
31	0	2	3	14	9	7	0	5	2	3	5	2	52	9.6	183
32	0	0	0	6	3	6	0	1	1	6	3	1	27	5.8	204
33	0	0	0	2	5	4	2	3	3	3	1	2	25	5.2	225.4
34	0	0	0	1	4	2	5	5	1	3	4	1	26	6.1	238.8
35	0	0	0	0	1	0	3	3	1	2	4	4	18	4.6	259.3
36	0	0	1	0	0	1	2	1	1	1	1	0	8	2.4	263.6
37	0	0	0	0	0	0	1	3	0	0	1	2	7	2	290.6
38	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	274
39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	394.1
40	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	340
41													0		
42													0		
43													0		
Number 10^6	8728	1671	515	310	120	46	18	21	11	19	19	13	11491	585	
Biomass 10^3 t	308.6	129.6	56.4	41.5	17.5	8.4	3.9	4.9	2.4	4.4	4.3	3	584.9		584.9
Length cm	18.9	23.8	26.4	28.1	29	31.2	33.6	34.2	33	33.2	33.9	35			20.5
Weight g	35.4	77.5	109.2	133.3	147.3	179.9	222.4	232.7	211.6	215.3	228.2	229.5			50.9

Figures

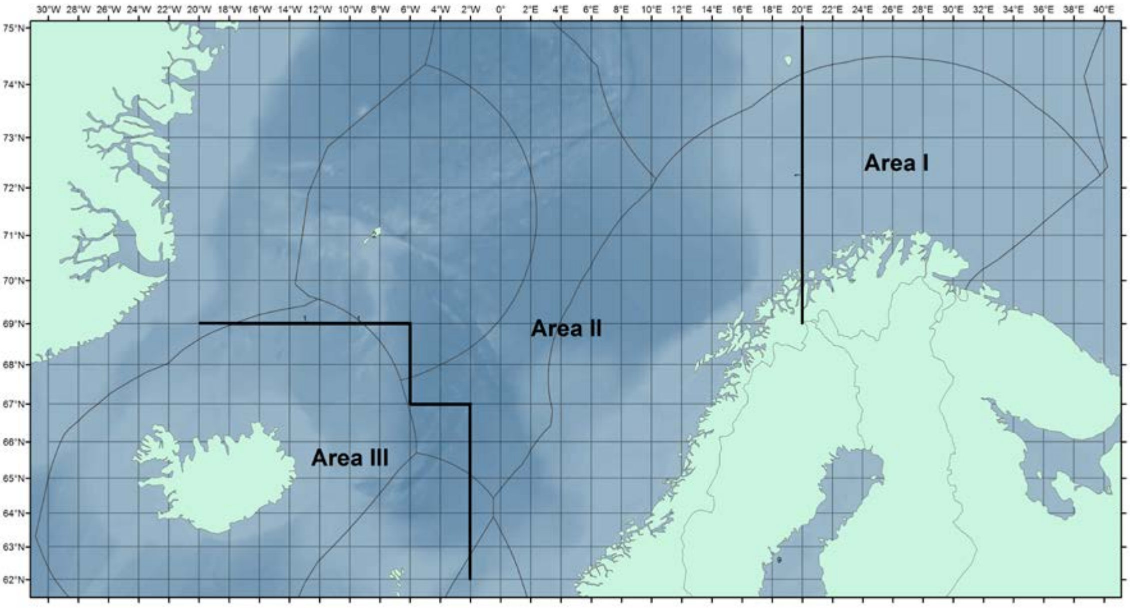

Figure 1. Areas defined for acoustic estimation of blue whiting and Norwegian spring-spawning herring in the Nordic Seas.

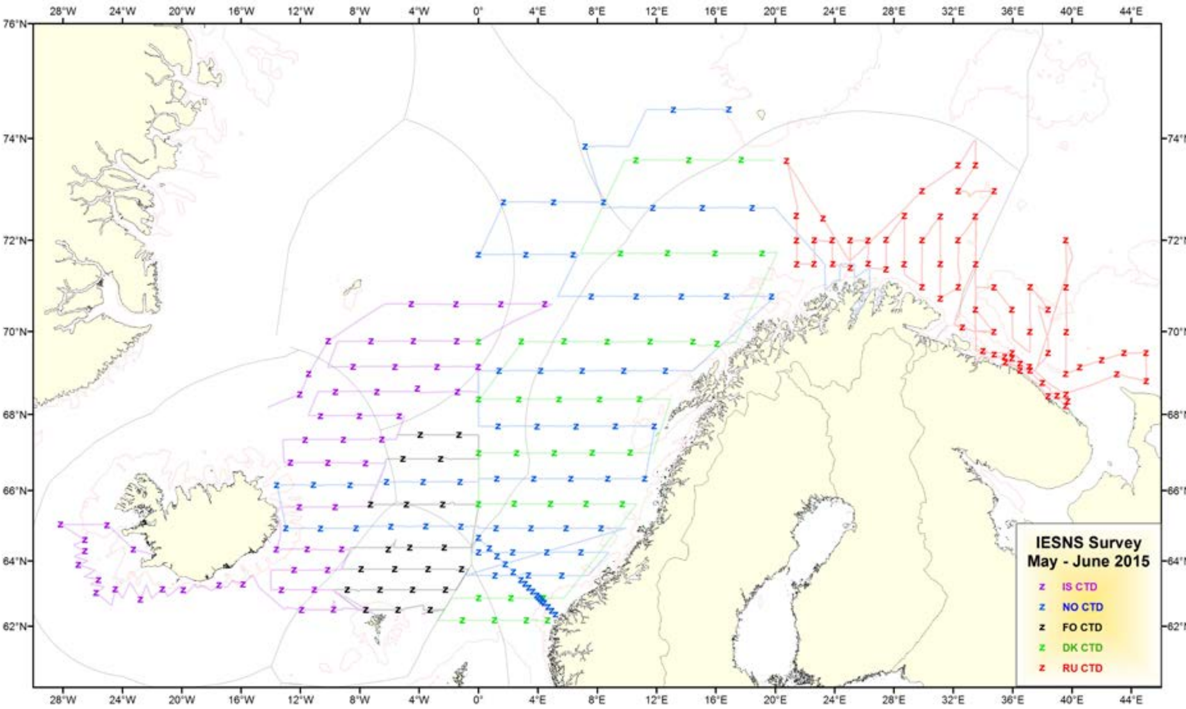

Figure 2. Cruise track and CTD stations by country for the International ecosystem survey in the Nordic Seas in April-June 2015.

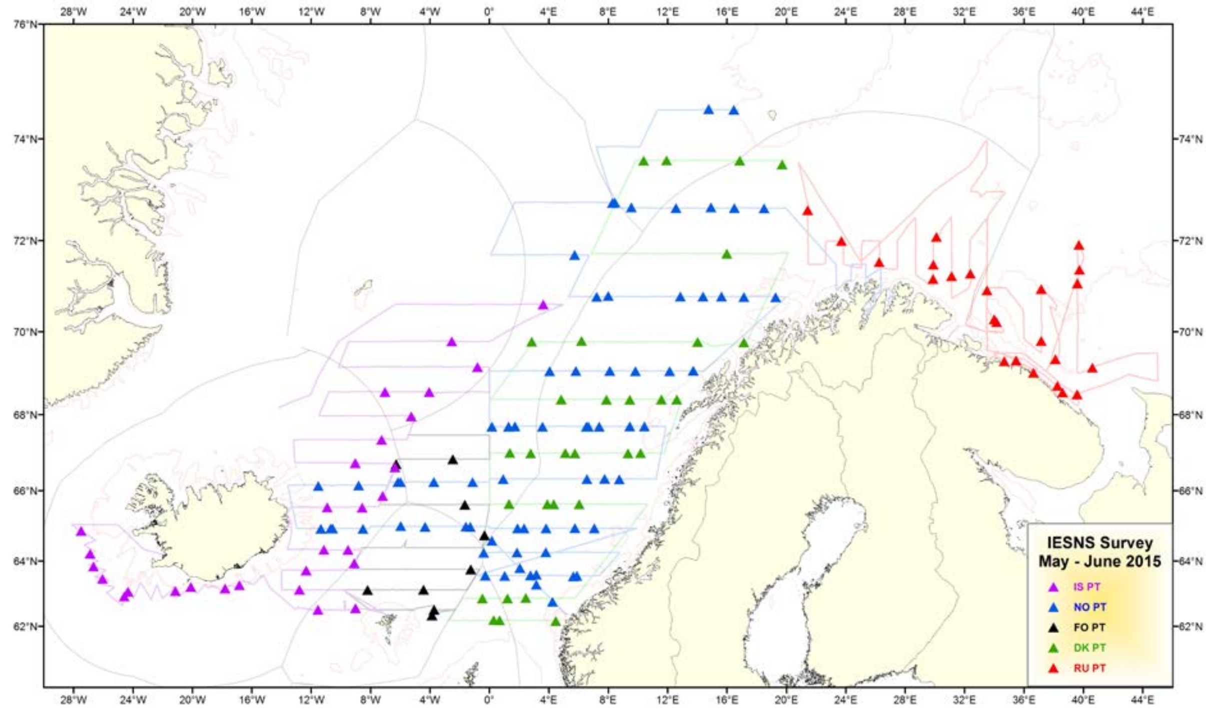

Figure 3. Cruise tracks during the International North East Atlantic Ecosystem Survey in April-May 2015 and location of trawl stations.

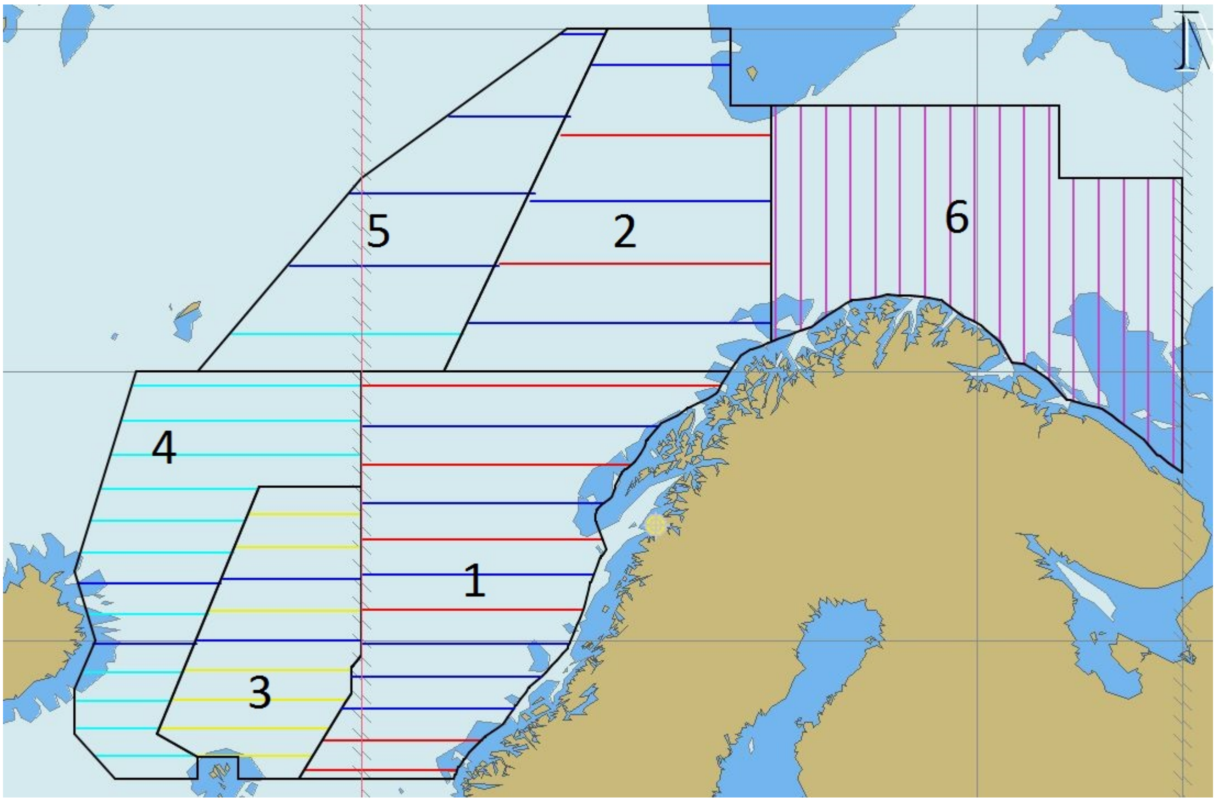

Figure 4. The strata and transects used in the IESNS survey 2015.

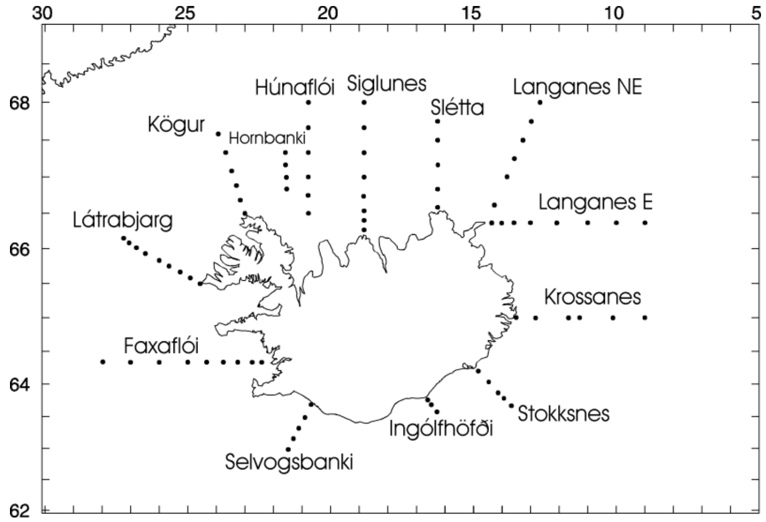

Figure 5. Location of the fixed Icelandic hydrographic sections referred to in the text and Figures 16-18.

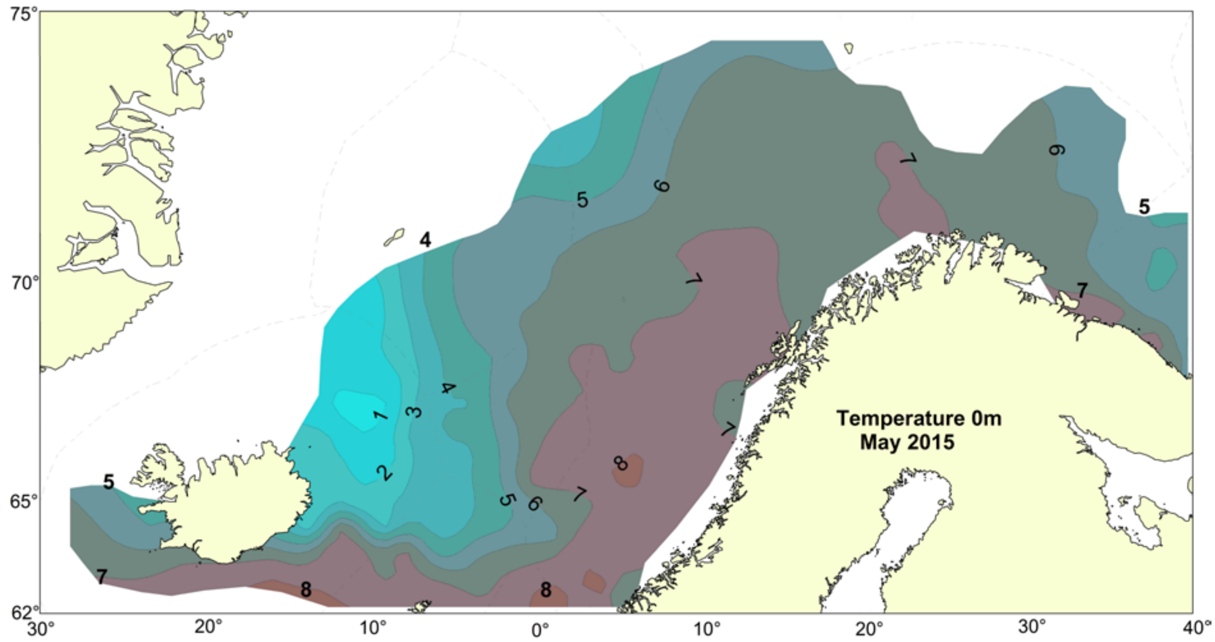

Figure 6. The horizontal sea surface temperature distribution in April-June 2015.

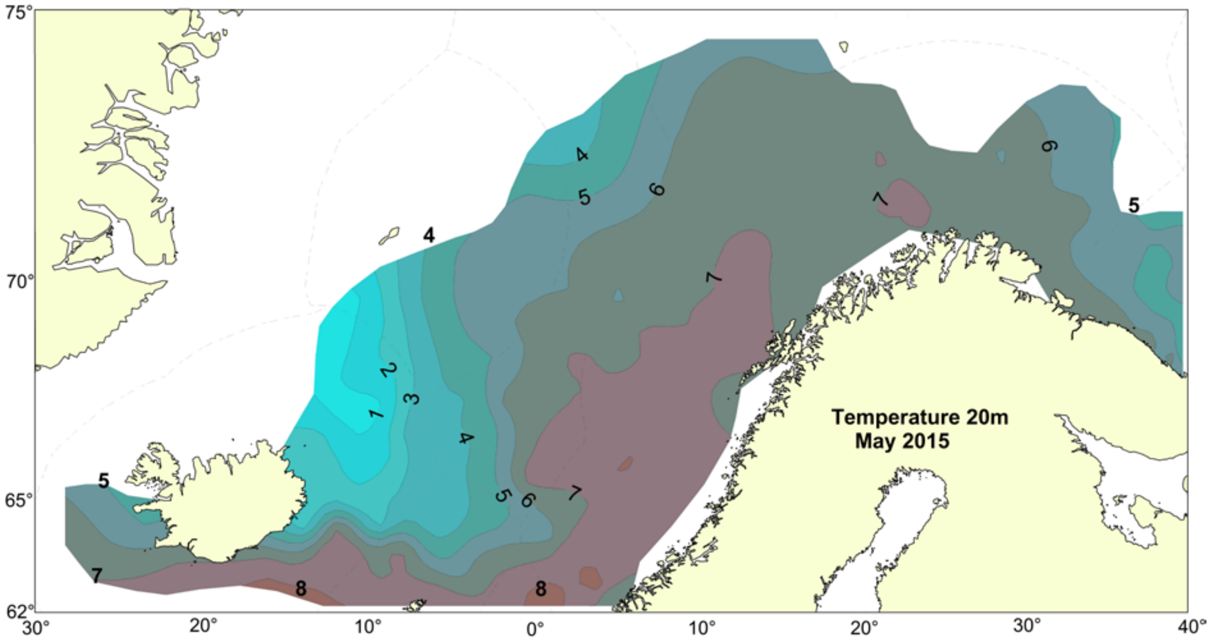

Figure 7. The horizontal distribution of temperatures at 20 m depth in April-June 2015.

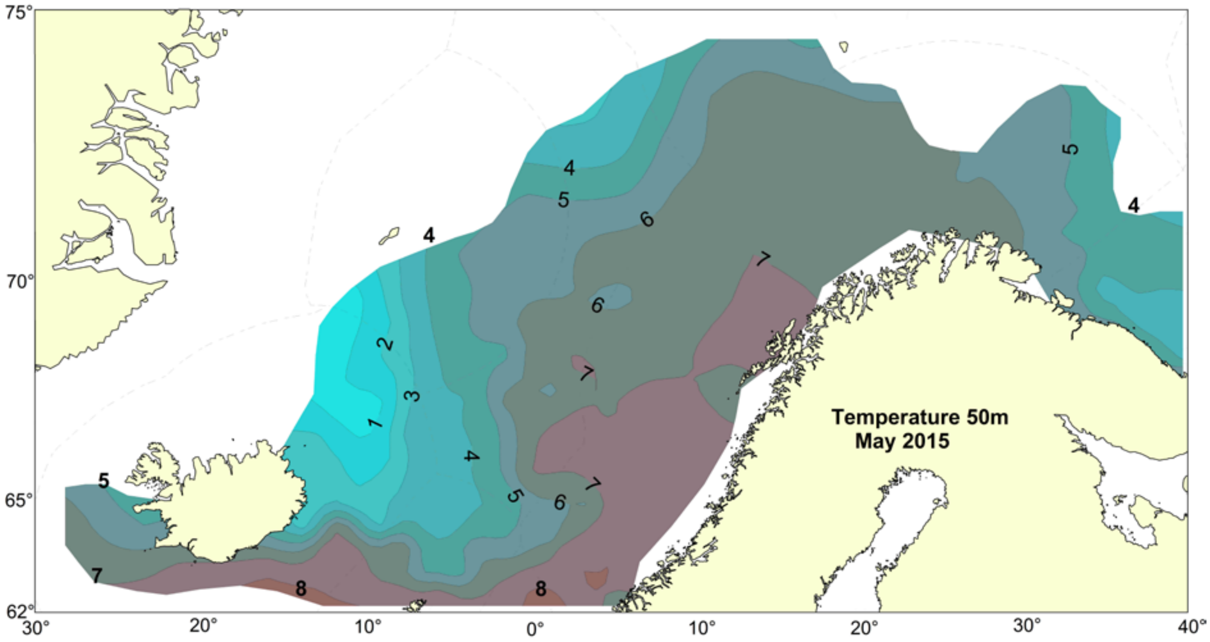

Figure 8. The horizontal distribution of temperatures at 50 m depth in April-June 2015.

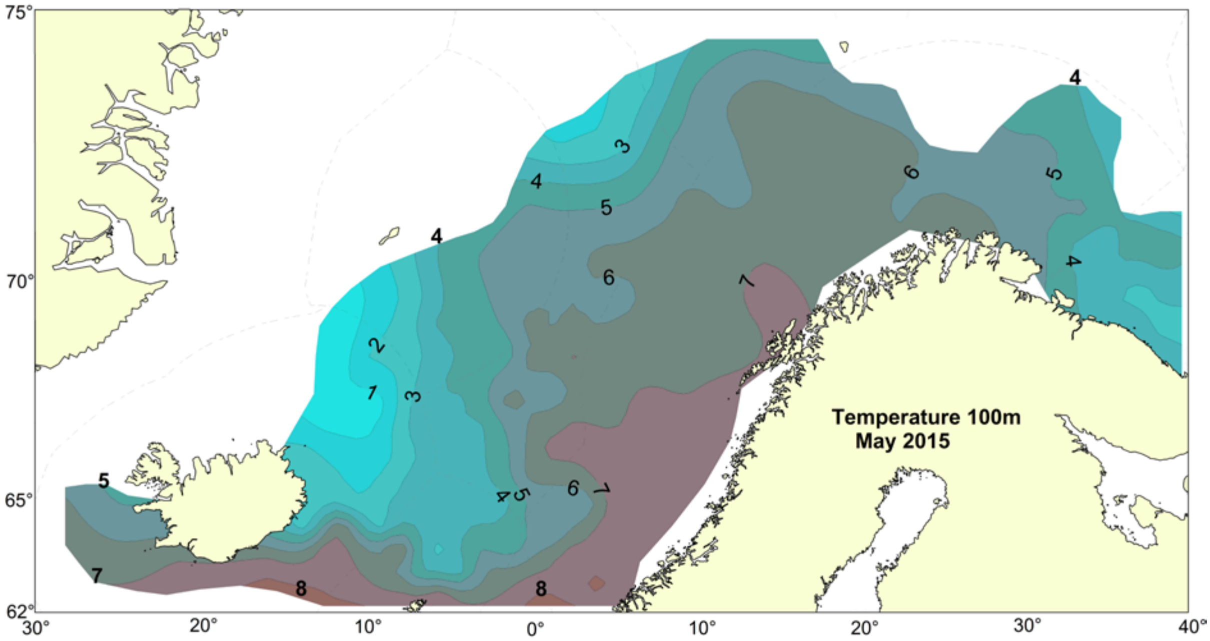

Figure 9. The horizontal distribution of temperatures at 100 m depth in April-June 2015.

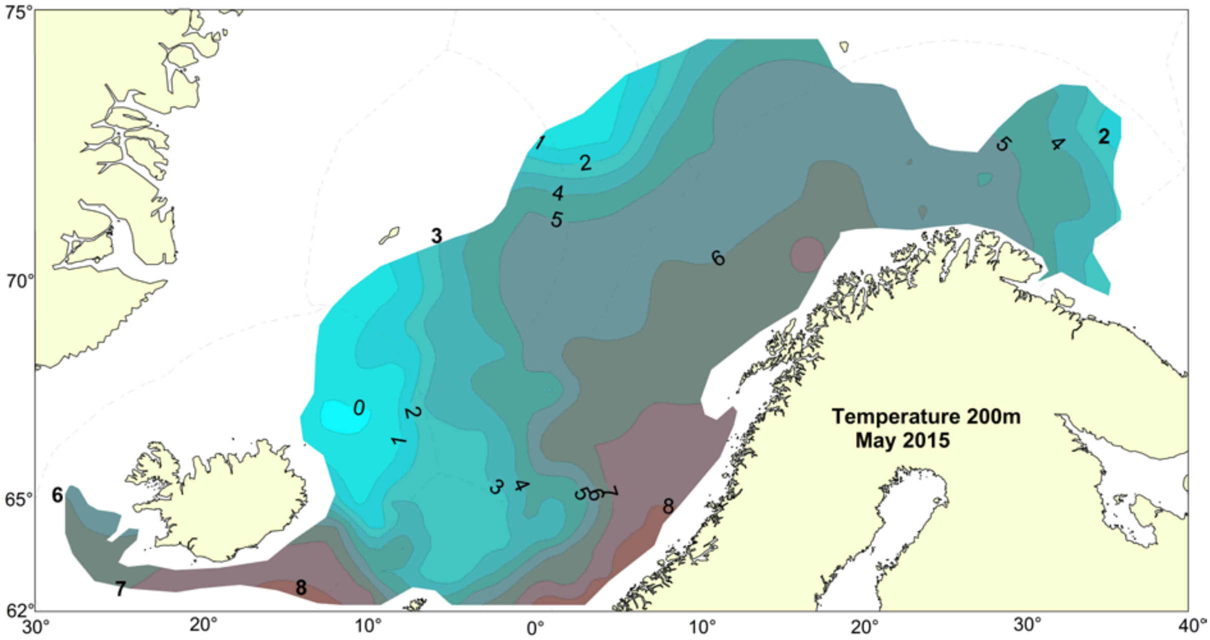

Figure 10. The horizontal distribution of temperatures at 200 m depth in April-June 2015.

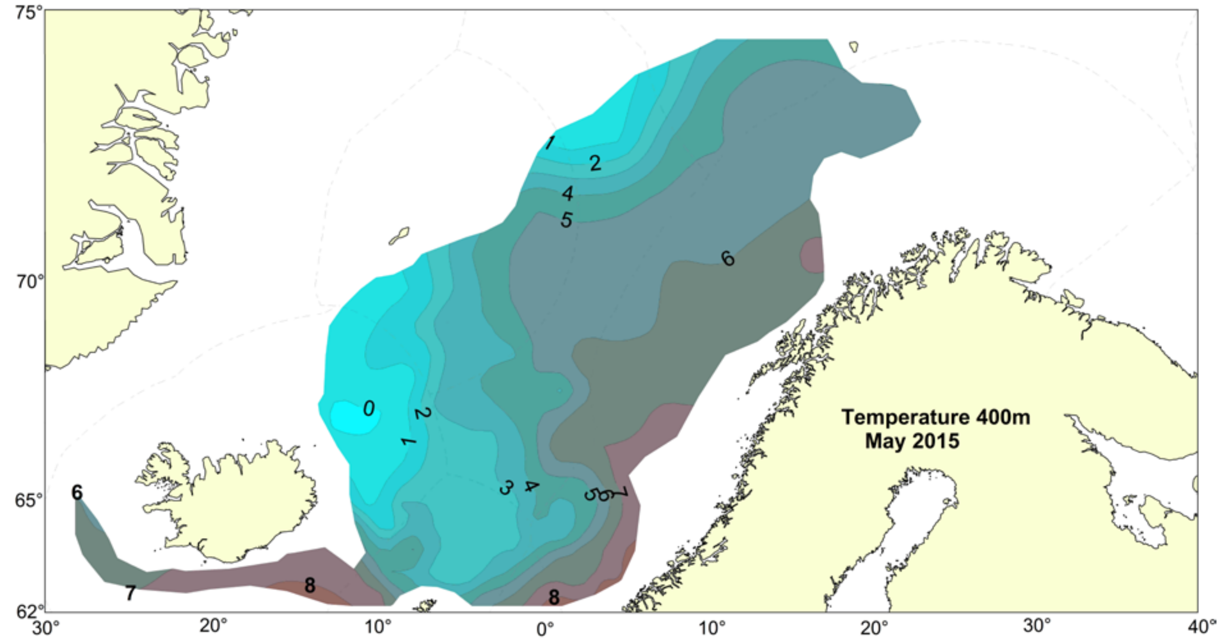

Figure 11. The horizontal distribution of temperatures at 400 m depth in April-June 2015.

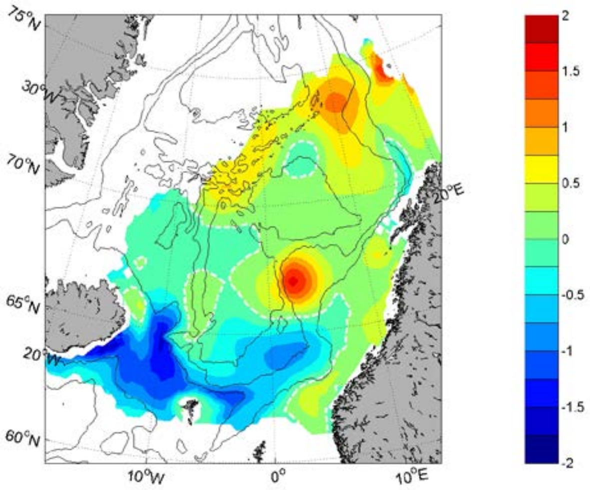

Figure 12. Temperature anomaly at 20 m depth for May 2015. Reference period: 1995-2015.

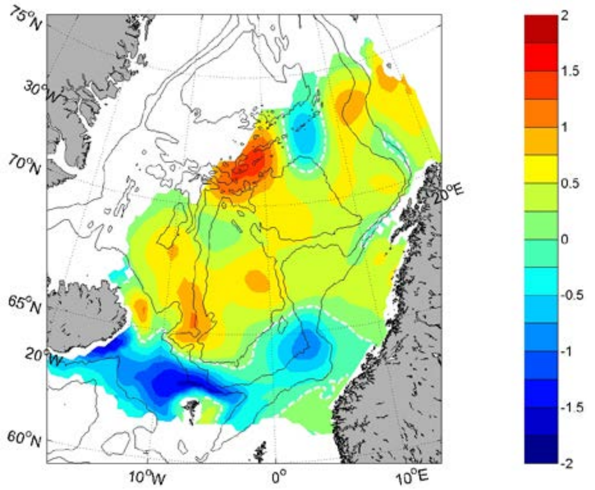

Figure 13. Temperature anomaly at 100 m depth in May 2015. Reference period: 1995-2015.

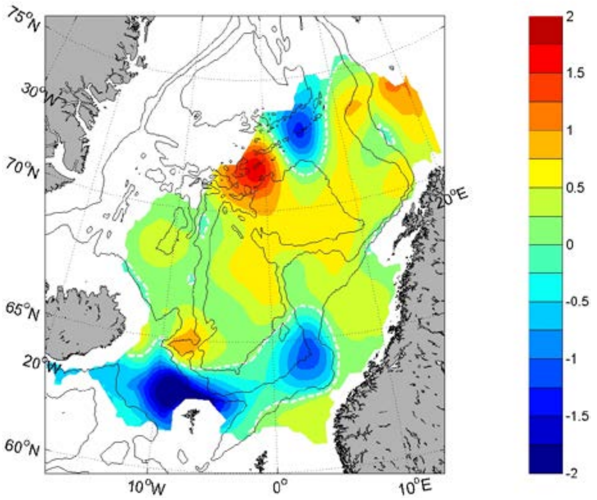

Figure 14. Temperature anomaly at 200 m depth in May 2015. Reference period: 1995-2015.

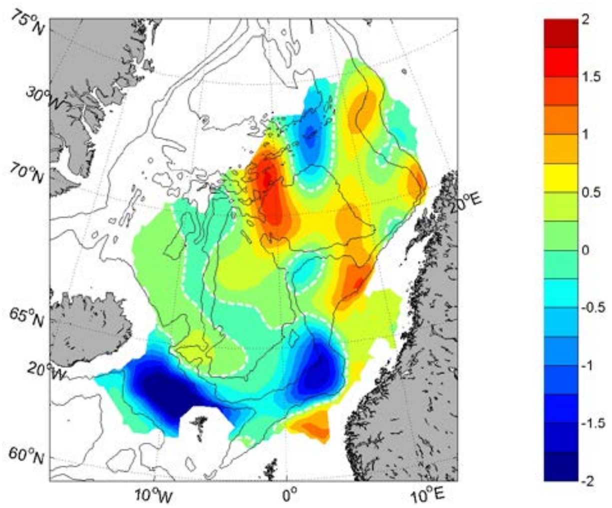

Figure 15. Temperature anomaly at 400 m depth in May 2015. Reference period: 1995-2015.

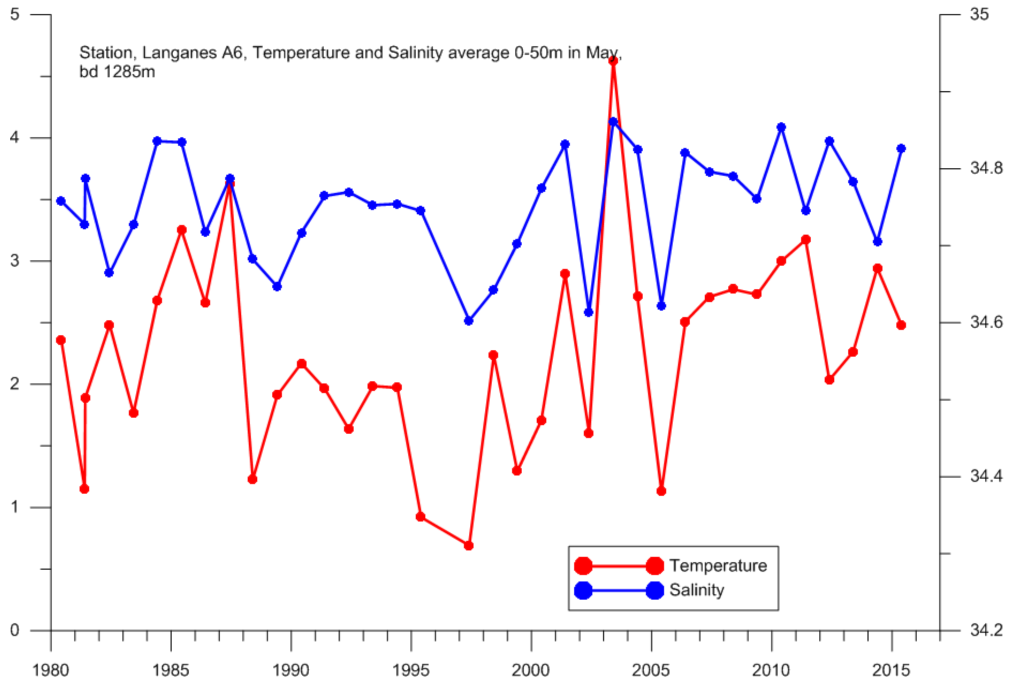

Figure 16. Temperature and salinity in May 2015 east of Iceland, at station Langanes A6 (66°22′N, 11°00′W). Depth averaged 0-50m.

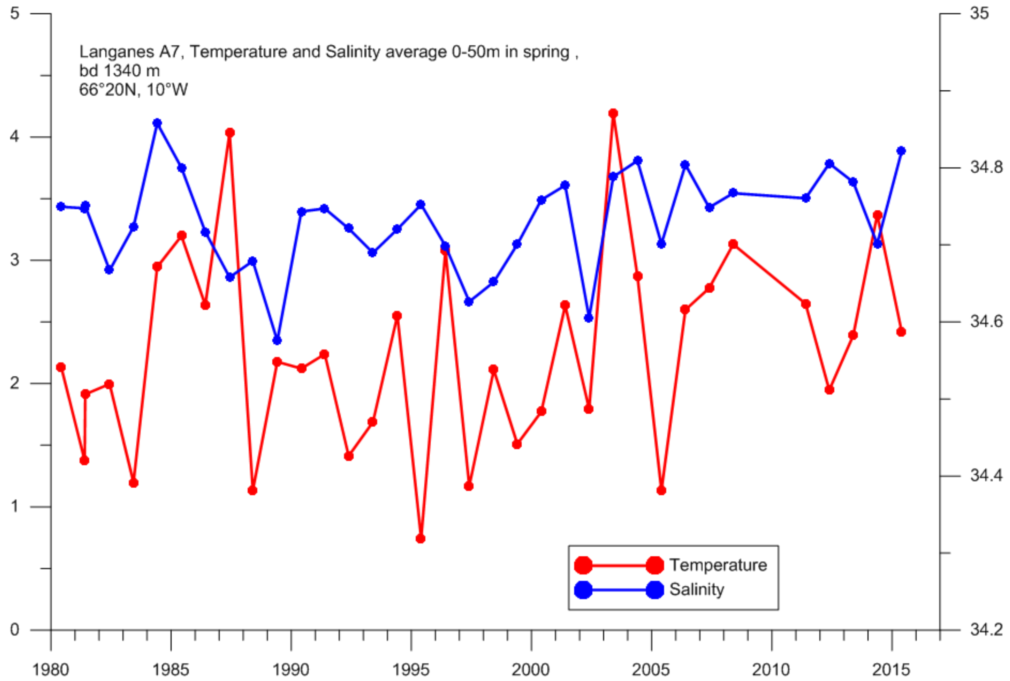

Figure 17. Temperature and salinity in May 2015 east of Iceland, at station Langanes A7 (66°22′N, 10°00′W). Depth average 0-50m.

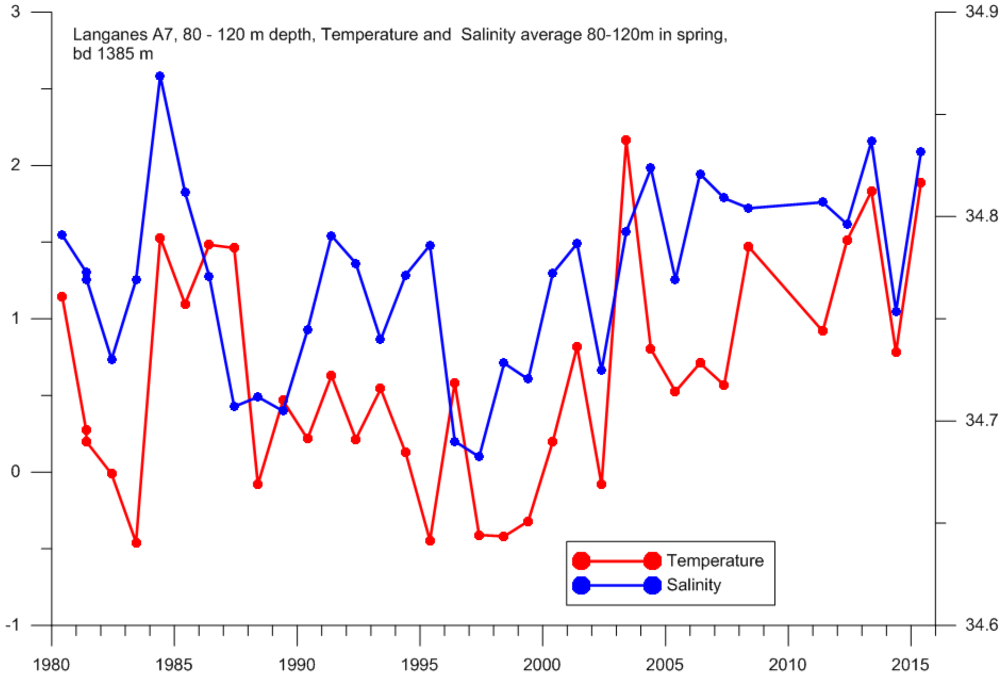

Figure 18. Temperature and salinity in May 2015 east of Iceland at station Langanes A7 (66°22′N, 10°00′W). Depth average 80-120m.

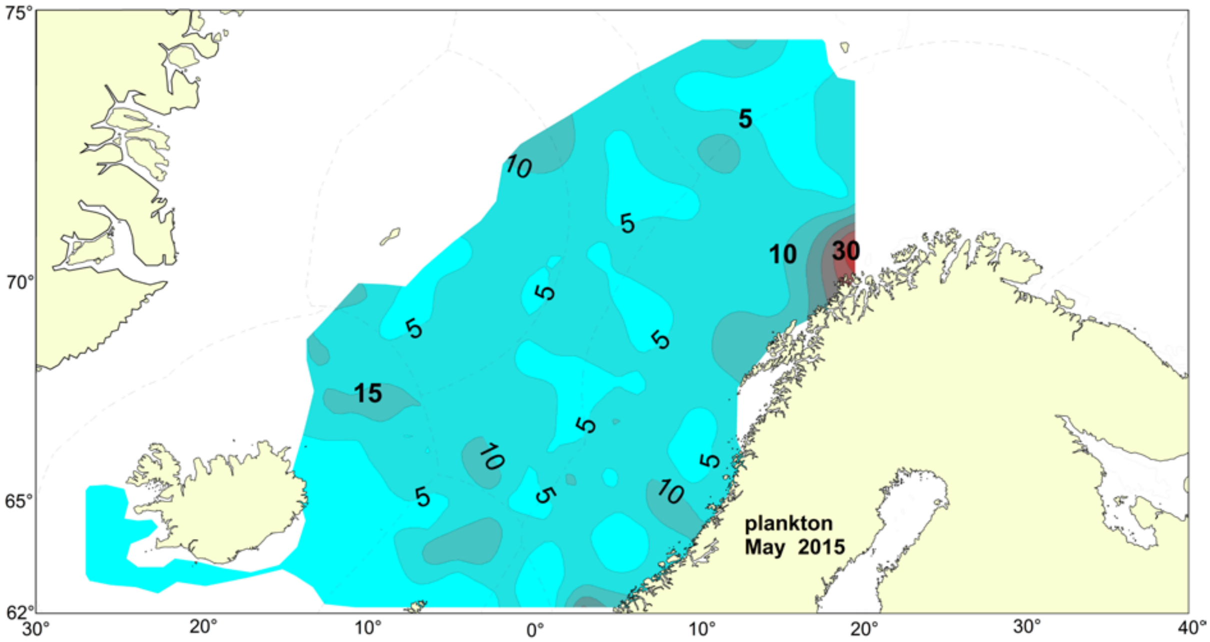

Figure 19. Zooplankton biomass (g dw m-2; 200–0 m in April-June 2015.

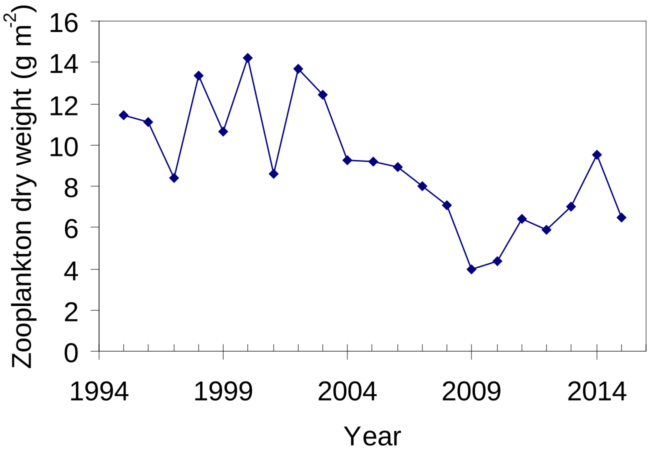

Figure 20. The annual mean dry weight of zooplankton across the whole coverage area in the May surveys in the Norwegian Sea and adjacent waters from 1997 to 2015.

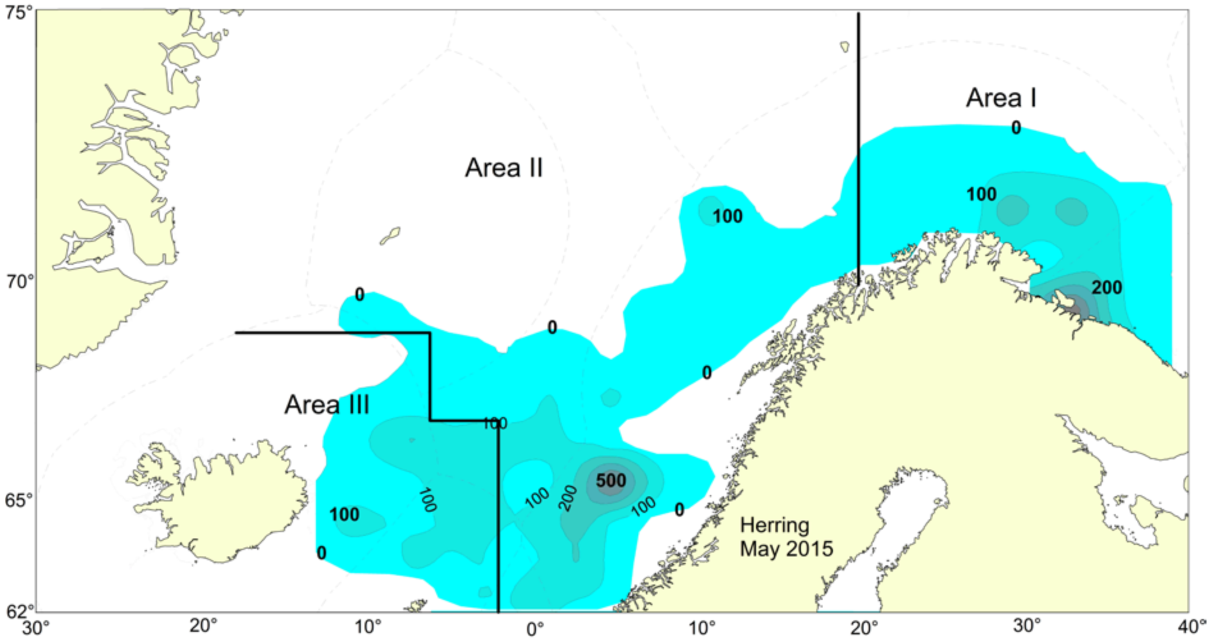

Figure 21. Distribution of Norwegian spring-spawning herring as measured during the International survey in April-June 2015 in terms of sA-values (m^2/nm^2) based on combined 5 nm values.

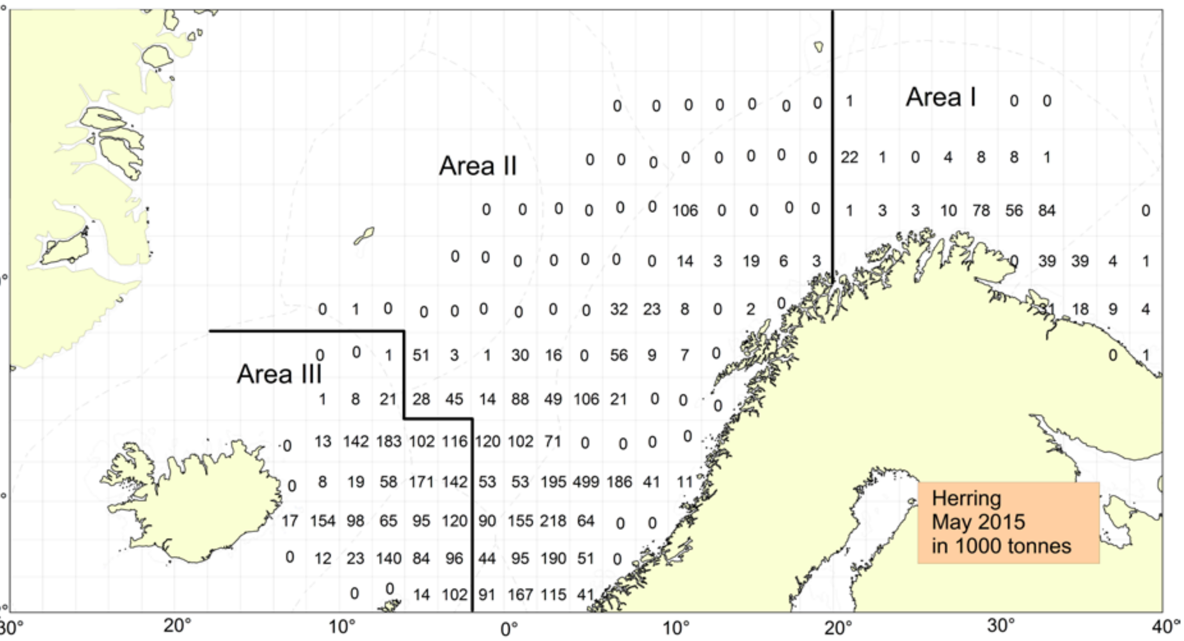

Figure 22. Norwegian spring-spawning herring biomass from IESNS 2015 by sub-area.

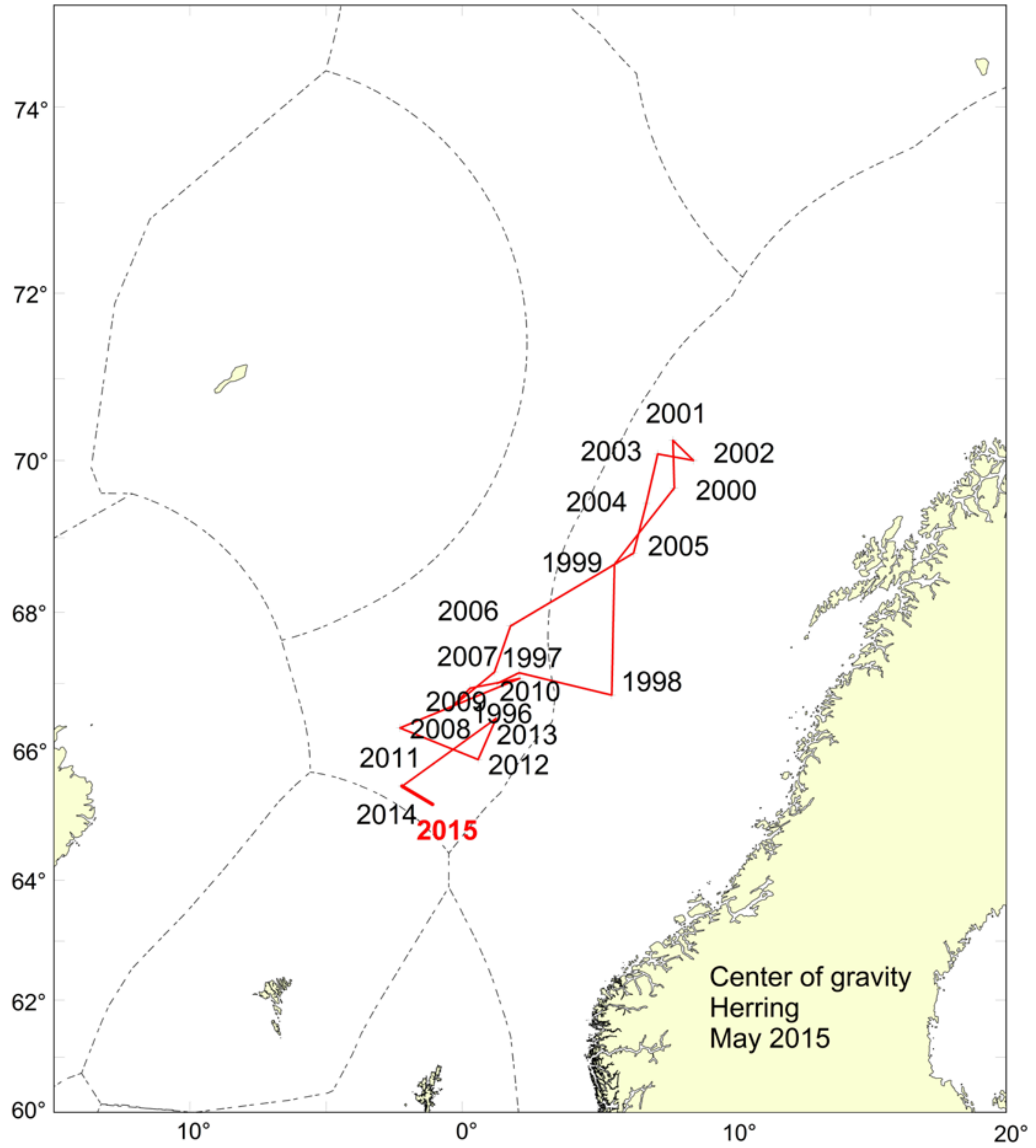

Figure 23. Centre of gravity of herring during the period 1996-2015 derived from acoustic. Acoustic data from area II and III only, i.e. west of 20° E

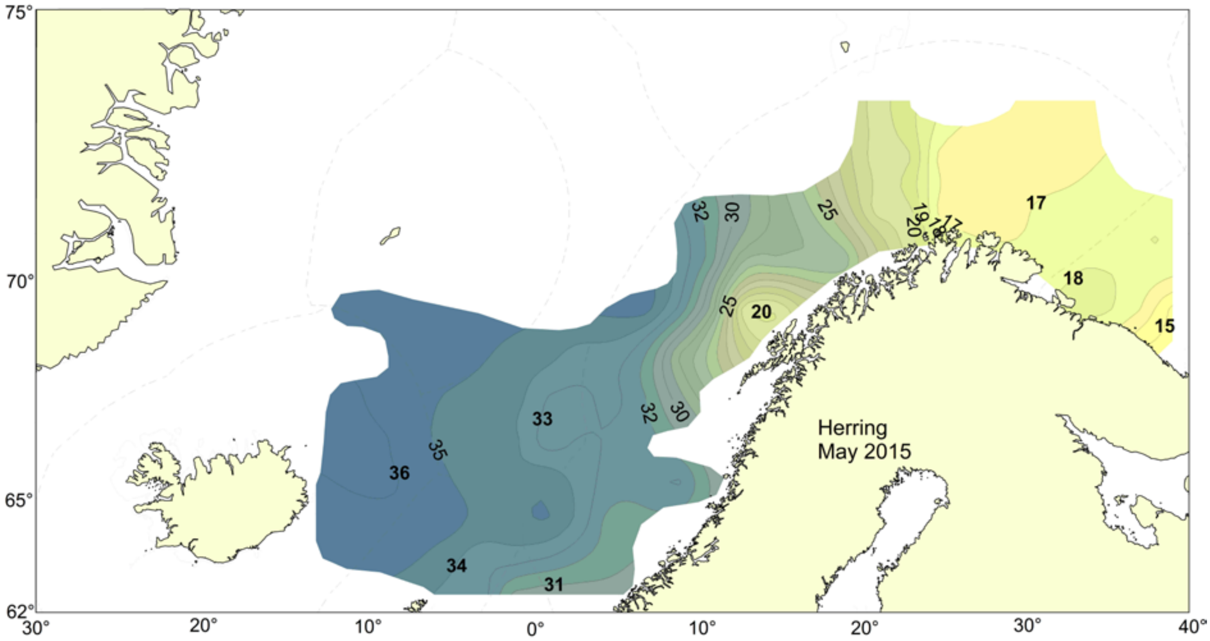

Figure 24. Mean length of Norwegian spring-spawning herring as measured during the International survey in April-June 2015.

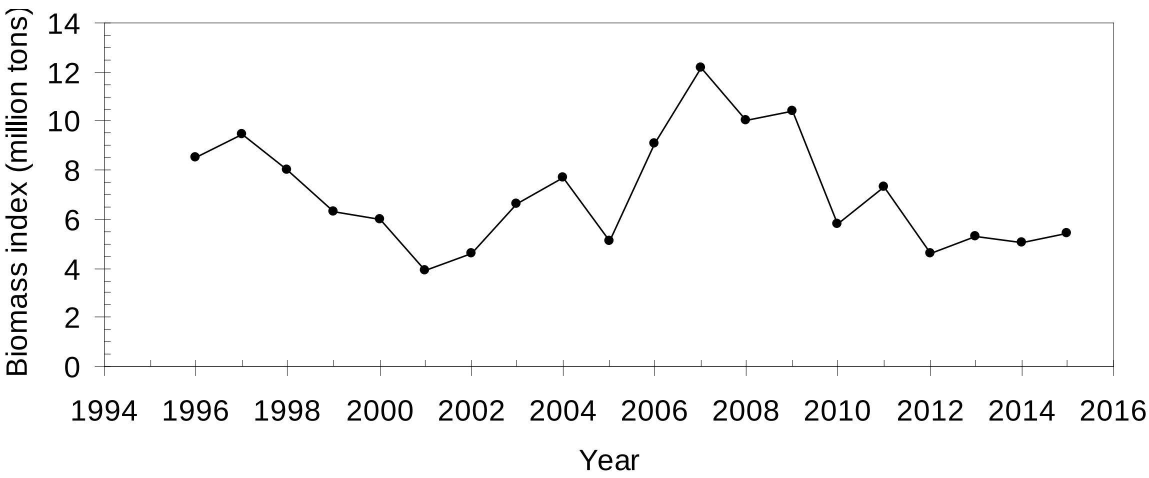

Figure 25. The annual biomass index of Norwegian-spring spawning herring in the May surveys in the Norwegian Sea and adjacent waters from 1996 to 2015.

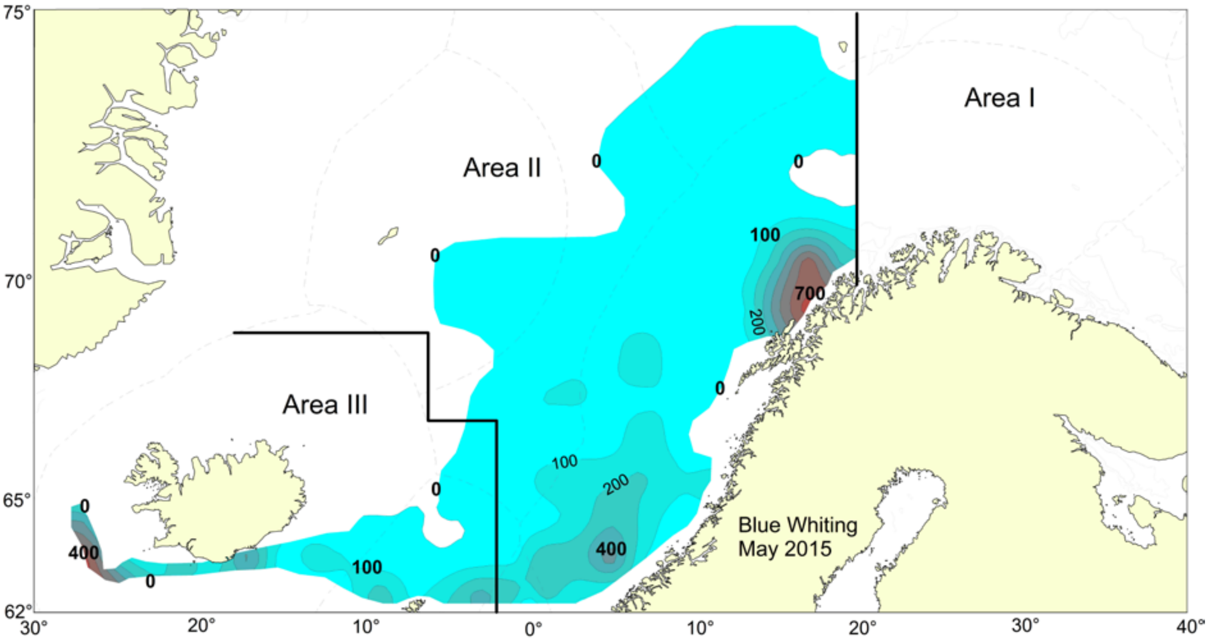

Figure 26. Distribution of blue whiting as measured during the International survey in April-June 2015 in terms of sA-values (m²/nm²) based on combined 5 nm values. The standard area is shown on the map.

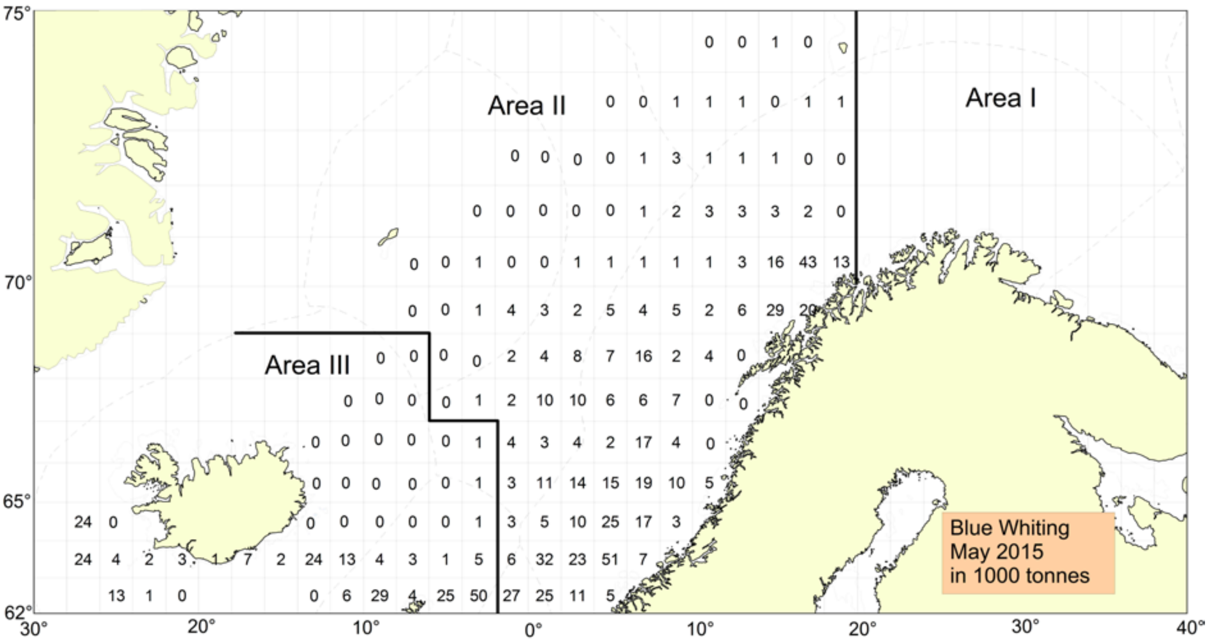

Figure 27. Blue whiting biomass from IESNS 2015 by sub-area.

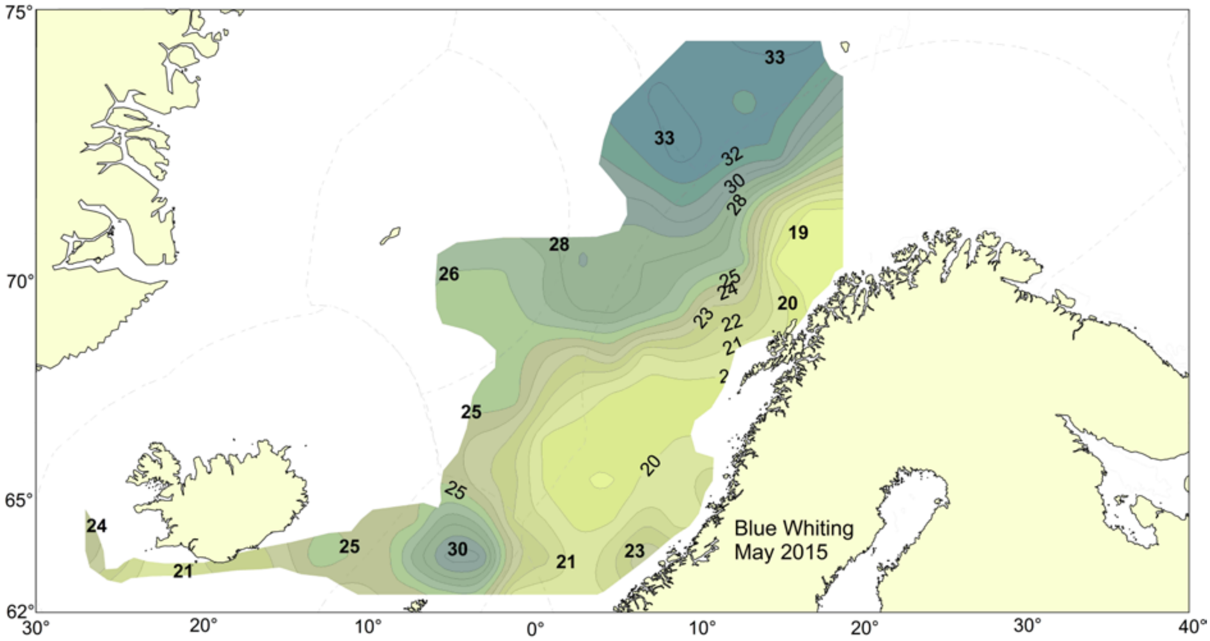

Figure 28. Mean length (cm) of blue whiting recorded in the North-east Atlantic Ecosystem Survey in April–June 2015.

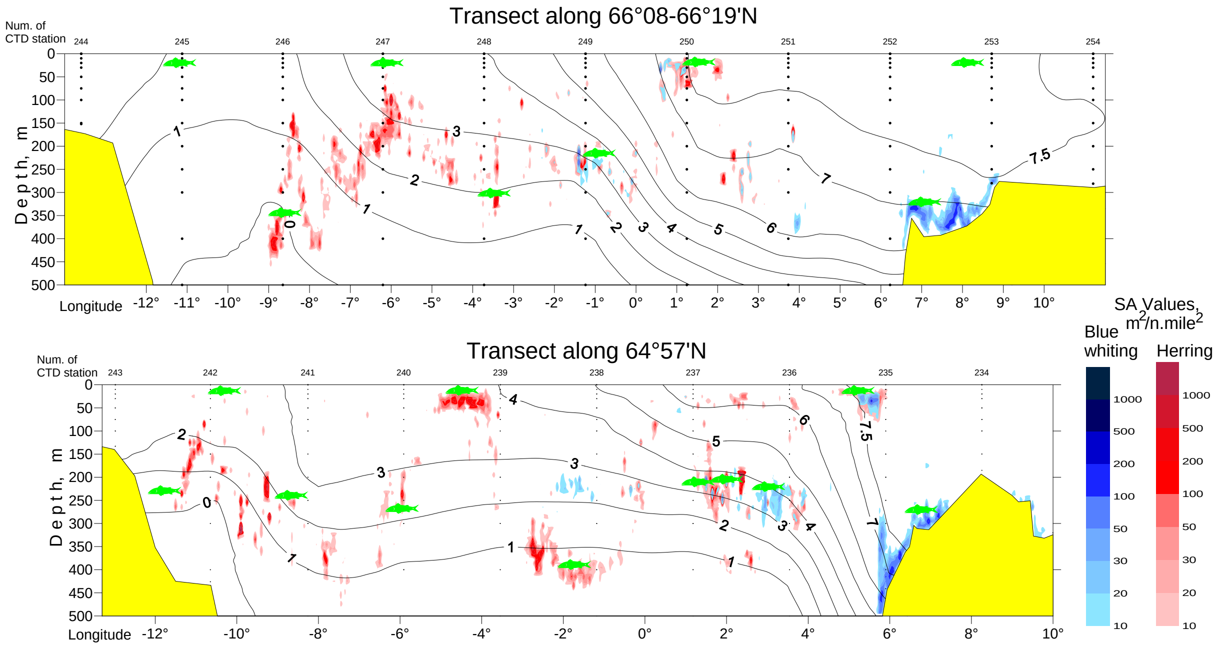

Figure 29. Acoustic values of blue whiting (blue) and NSS-herring (red), location of trawl stations (green fish), and temperature profile (lines) along two transects across the whole Norwegian Sea in May 2015 taken by G.O Sars (Figures produced by Evgeny Sentyabov, PINRO).

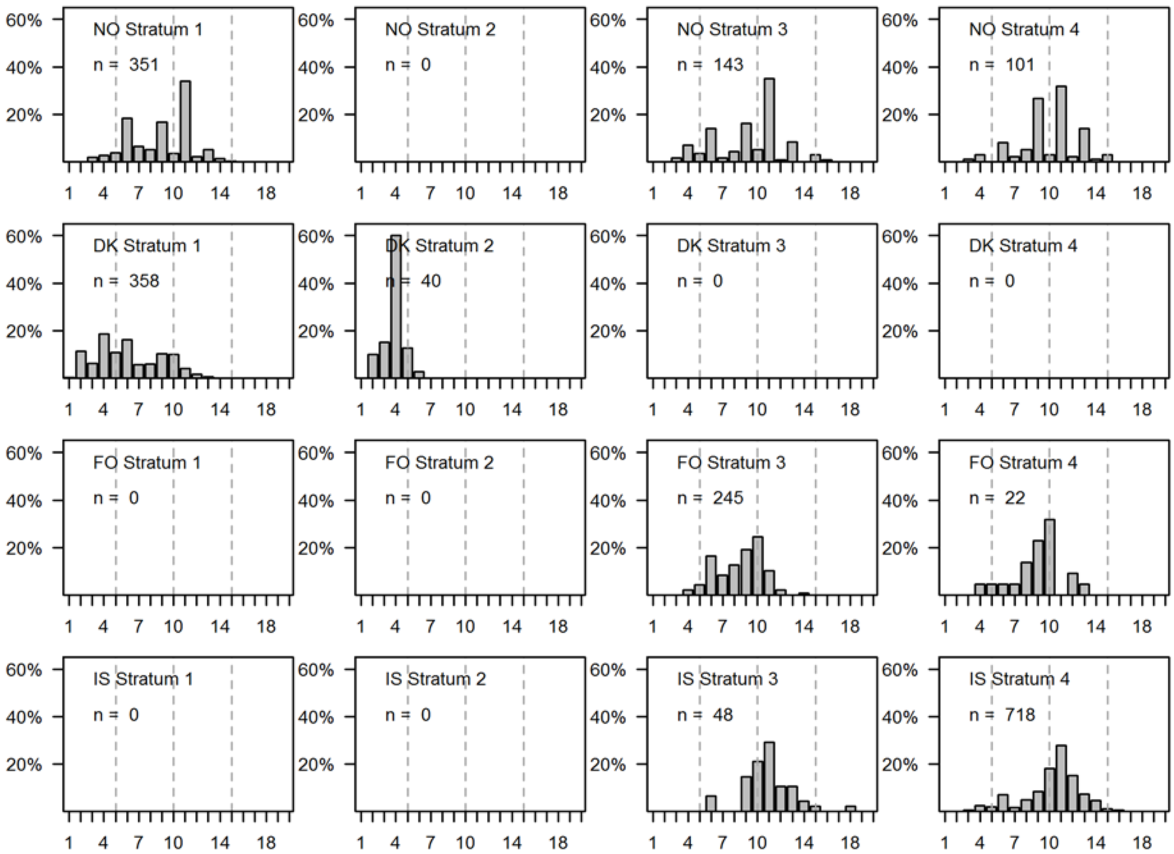

Figure 30. Comparison of the age distributions of NSS-herring by stratum and vessel in IESNS 2015.