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Report of the Working Group of International Pelagic Surveys (WGIPS)

19–23 January 2015

ICES HQ, Copenhagen, Denmark

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Executive summary

The Working Group of International Pelagic Surveys (WGIPS) met at ICES Headquarters, Copenhagen, Denmark from 19–23 January 2015 under the chairmanship of Karl-Johan Stæhr, Denmark and Ciaran O'Donnell, Ireland: to report on herring larvae surveys in 2014 and to coordinate herring larvae survey activities for 2014 in the North Sea, Irish Sea and Western Baltic; to report on acoustic surveys in 2014 and to coordinate acoustic survey activities for 2015 on herring, blue whiting, sprat, mackerel and boarfish in the Northeast Atlantic, North Sea and Western Baltic.

Review of larvae surveys in 2014 and coordination of larvae survey in 2015. The herring larvae sampling was still in progress at the time of the WGIPS meeting, thus sample examination and larvae measurements had not yet been completed. The information necessary for the larvae abundance index calculation will be ready for, and presented at the Herring Assessment Working Group (HAWG) meeting in March 2015.

Reporting on survey results from 2014 and coordination of surveys in 2015 for herring larvae in North Sea, Irish Sea and Western Baltic are given in Section 3 of this report.

Review of acoustic surveys in 2014 and coordination of acoustic surveys in 2015. During the meeting, four internationally coordinated acoustic surveys and five individual acoustic surveys carried out in 2014 were reported on for use by the relevant assessment groups. Furthermore, planning for 2015 surveys was carried out.

North Sea, West of Scotland and Malin Shelf summer acoustic survey (HERAS). For this survey, herring and sprat abundances for the North Sea, West of Scotland, Malin Shelf and ICES Subdivision IIIa in June-July 2014 were reported. Data on herring divided into North Sea autumn spawners and Western Baltic spring spawners as well as sprat can be found in Section 4.1.1 in the report and for more detail in the post-cruise report, Annex 5c.

International blue whiting spawning stock survey (IBWSS). Blue whiting abundances for Porcupine Bank, Hebrides, Faroese/Shetland and Rockall in March-April 2014 were reported. Data on blue whiting abundance, biomass, mean weight and mean length is found in Section 4.1.2 in the report and for more detail in the post-cruise report, Annex 5a.

International Ecosystem survey in Nordic Sea (IESNS). For this survey herring and blue whiting abundances in the Nordic Sea and Barents Sea in May 2014 were reported. Data on Norwegian spring-spawning herring and blue whiting abundance, biomass, mean weight and mean length can be found in Section 4.1.3 in the report and for more detail in the post-cruise report, Annex 5b. Furthermore, hydrographic and zooplankton information collected during the survey have been reported.

Coordinated Nordic Seas ecosystem survey (IESSNS). For this survey mackerel, herring, blue whiting and lumpfish abundances in the Nordic Seas in July 2014 were reported. Data on mackerel Norwegian spring-spawning herring and blue whiting abundance, biomass, mean weight and mean length can be found in Section 4.1.4 in the report and for more detail in the post-cruise report, Annex 5b. Furthermore, information on hydrography, zooplankton and marine mammals collected during the survey was reported.

Western Baltic Acoustic Survey This is a survey conducted by Germany in October 2014 in the Western Baltic (ICES Subdivisions 21–24). The survey is coordinated within the framework of Baltic International Acoustic Survey (BIAS). The survey provides

HAWG with abundance data on Western Baltic spring-spawning herring and sprat. The survey has been reported in Section 4.3.1 of this report and in Annex 6a.

Irish Sea Survey. For this survey herring, abundance for the Irish Sea and North Channel in August 2013 has been reported by Northern Ireland, UK. Data on herring abundance, biomass, mean weight and mean length can be found in Section 4.3.2 in the report and for more detail in the survey report, Annex 6b.

Celtic Sea herring acoustic survey (CHAS). For this survey herring and sprat, abundance for the Celtic Sea in October 2014 was reported by Ireland. Data on herring and sprat abundance, biomass, mean weight and mean length can be found in Section 4.3.3 in the report and for more detail in the survey report, Annex 6c.

Boarfish acoustic survey (BFAS). For this survey boarfish, abundance in July 2014 was reported by Ireland. Data on boarfish abundance, biomass, mean weight and mean length is found in Section 4.3.4 in the report and for more detail in the survey report, Annex 6d.

Pelagic ecosystem survey in Western Channel and eastern Celtic Sea (PELTIC). This is a new survey conducted by Cefas, UK, in the Western Channel and eastern Celtic Sea in October-November 2014. The survey provides abundance data on pelagic species in the area such as herring, sardine, anchovy, mackerel and boarfish. The survey has been reported in Section 4.3.5 of this report and for more detail in the survey report, Annex 6e.

Coordination of acoustic surveys in 2015. Coordination of the four internationally coordinated acoustic surveys and five individual acoustic surveys are given in Section 4.2 and Section 4.3 of this report.

1 Opening of the meeting

The Working Group for International Pelagic Surveys (WGIPS), met in Copenhagen, Denmark from 19–23 January 2015 to:

a) Combine the 2014 survey data to provide indices of abundance for the population of herring, sprat and Blue whiting within the area, using the FishFrameAcoustics database and WGNAPES database;

b) Review the 2014 survey data and provide the following data for the Herring Assessment Working Group (HAWG) and Working Group for Widely Distributed Stocks (WGWIDE):

c) Stock indices of blue whiting, sprat, Norwegian spring-spawning herring, North Sea autumn-spawning herring and Western Baltic spring-spawning herring,

d) Zooplankton biomass to allow the calculation of a short-term projection of Norwegian spring-spawning herring growth,

e) Hydrographic and zooplankton conditions for ecological considerations in the Norwegian sea,

f) Spatial distribution of pelagic species such as mackerel in the Norwegian Sea.

g) Coordinate the timing, area and effort allocation and methodologies for acoustic and larvae surveys on pelagic resources in the North Sea, Malin Shelf, Northeast Atlantic and Nordic sea in 2015 including:

h) The herring larval surveys in the North Sea and the Channel,

i) The international acoustic survey covering the main spawning grounds of blue whiting in March-April 2015 (IBWSS),

j) The international coordinated survey on Norwegian spring-spawning herring in May-June 2015 (IESNS),

k) The international coordinated acoustic survey in the Skagerrak and Kattegat, the North Sea, west of Scotland and the Malin Shelf area in June-July 2015 (HERAS).

l) Coordinated Nordic Seas ecosystem survey (IESSNS) in July-August 2015

m) Review the progress of the acoustic database.

WGIPS will report by 7 March 2015 (via SSGIEOM) for the attention of SCICOM, WGISUR, ACOM, WGWIDE and HAWG.

2 Adoption of the agenda

The agenda was presented and adopted by WGIPS on the first day. Participant's contact details are listed in Annex 1, the agenda is given in Annex 2.

The following persons attended WGIPS:

Name	Function	Country
Karl-Johan Stæhr	Chair	Denmark
Ciaran O'Donnell	Chair	Ireland
Cormac Nolan	common member	Ireland
Norbert Rohlf	common member	Germany
Matthias Schaber	common member	Germany
Susan Mærsk Lusseau	common member	UK
Eric Armstrong	common member	UK
Philip Copland	common member	UK
Kjell Rong Utne	common member	Norway
Are Salthaug	common member	Norway
Sascha Fässler	common member	Netherlands
Ben Scoulding	common member	Netherlands
Pieter-Jan Schon	common member	UK
Jeroen Van der Kooij	common member	UK
Leon Smit	common member	Faroes
Eydna ì Homrum	common member	Faroes
Alexander Krysov	common member	Russia
Teunis Jansen	common member	Denmark
Gudmundur J. Oskarsson	common member	Iceland

3 Herring larvae surveys

3.1 Review of larvae surveys in 2014

3.1.1 Western Baltic

The waters of the Greifswalder Bodden (ICES area 24) are considered a major spawning area of Western Baltic spring-spawning (WBSS) herring. The German Thünen Institute of Baltic Sea Fisheries (TI-OF), Rostock, and its predecessor monitors the density of herring larvae as a vector of recruitment success since 1977 within the framework of the Rügen Herring Larvae Survey (RHLS). It delivers a unique high-resolution dataset on the herring larvae ecology in the Western Baltic, both temporally and spatially. Onboard the research vessel "FFS Clupea" a sampling grid including 35 stations is sampled weekly using ichthyoplankton gear (Bongo net, mesh sizes 335 μm; 780 μm) during the main reproduction period from March to June. The weekly assessment of the entire sampling area is conducted within two days (detailed description of the survey design can be found in Polte 2013, ICES WD08). The data collected provide an important baseline for detailed investigation of spawning and recruitment ecology of WBSS herring stocks.

The recruitment index is incorporated into the assessment of the ICES Herring Assessment Working Group and is the solely 0-group recruitment index for the assessment of Western Baltic Spring-spawning herring.

The rationale for the N20 recruitment index is based on strong correlation found between the amount of larvae reaching a length of 20 mm (TL) in Greifswald Bay and abundance data of juveniles (1wr and 2 wr fish) as determined by acoustic surveys in the Arkona and Belt Seas (GERAS).

Those recurring correlations (N20/GERAS 1992–2013 R^2=0.71) support the underlying hypotheses that i) major variability of natural mortality occurs at early life stages before larvae reach a total length of 20 mm and ii) annual recruitment strength of the WBSS herring stock is not independent of larval production in the particular Greifswald Bay area. The N20 recruitment index is calculated every year based on data obtained from the RHLS. This is done by correcting weekly growth of larvae for seasonal temperature change and taking the sum of larvae reaching 20 mm by every survey week until the end of the investigation period. On the spatial scale, the 35 sampling stations are assigned to 5 strata and mean values of stations for each stratum are extrapolated to the strata area (for details see Oeberst et. al 2009). The sum of N20 larvae caught over the investigation period in the entire area results in the N20 recruitment index for those herring that enter the fishery as adults two to three years later.

With an estimated product of 539 million larvae, the 2014 N20 recruitment index is the lowest value ever observed in the entire time-series (Table 3.1.1.1, Figure 3.1.1.1). It is about 50% lower than the second lowest value, estimated in 1992 (1060 x 10–6).

However, this result reflects our field observations on early life stage mortality in the system. Data analysis of the 2014 ichthyoplankton samples are in progress and may increase our knowledge of ecological cascades affecting herring recruitment as consequences of short cold weather periods combined with high eutrophication in shallow inshore spawning areas.

The conditions in the 2013/2014 spawning season were classified as "weak or extremely weak ice winter for the entire Baltic Sea" http://www.bsh.de/en/Marine_data/Observations/Ice/Ice_Season_201314.pdf).

The ice cover of the Greifswalder Bodden basin was limited this year. Herring spawning activity began early the second week of March (calendar week 11). Field observations include massive spawning on small shoots of aquatic plants before the start of the vegetation period. This resulted on high densities of herring eggs attached to the surrounding sediments ambient to the macrophyte spawning beds (P. Polte and P. Kotterba, pers. observation). In the course of the spawning season increasing temperatures in the shallow waters of the spawning beds (above 2 m isobaths) probably in combination with the high nutrient loads of the system resulted in massive growth of aquatic fungi (unknown species) and filamentous brown algae (Pilayella littoralis). Both contributed to high herring egg mortality during the main spawning period. An additional stressor to larval survival might have occurred by significant storm events in early May when wind induced turbulence in the shallow bay potentially affected foraging of larval fish over a multiple day period. The regular larvae survey was conducted in a 15 weeks period, from March 17th to June 26th.

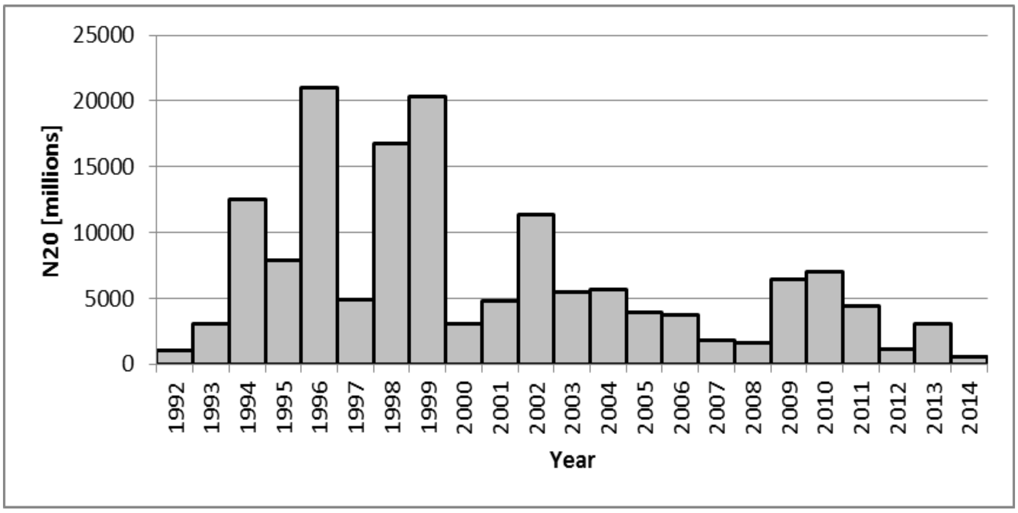

Figure 3.1.1.1. Validated RHLS time-series with N20 index data presented as annual sum of 20 mm larvae (numbers in millions).

An additional herring larvae survey was conducted in early November to control for potential autumn spawning. This is historically documented to represent the formerly dominant spawning season which is, for unknown reasons, of minor relevance today. The one-week survey resulted in only a total of 20 herring larvae (size range 10 to 21 mm). However, as in previous years, ripe herring (maturity stage 5, 6 and 7) was observed in the Greifswald Bay during gillnet sampling conducted simultaneously to ichthyoplankton sampling. This indicates some (minor) autumn herring spawning activity.

Table 3.1.1.1. N20 index of Western Baltic spring-spawning herring (WBSS), generated by RHLS data (Numbers of herring larvae in millions).

YEAR	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
N20	1060	3044	12515	7930	21012	4872	16743	20364	3026	4845	11324

YEAR	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
N20	5507	5640	3887	3774	1829	1622	6464	7037	4444	1140	3021

YEAR	2014
N20	**539**

3.1.2 North Sea

The main spawning grounds of North Sea autumn spawning herring are monitored annually in the International herring larvae surveys. They are treated as four subareas (Orkney/Shetlands, Buchan, Central North Sea and Southern North Sea). The first two subareas should be sampled twice, the last two subareas three times during the spawning season in different half-month intervals (Table 3.1.2.1). The standard gear is a GULF III or GULF VII sampler and stations are approximately 10 nautical miles apart.

The abundance of newly hatched larvae (less than 10 mm total length; 11 mm for the Southern North Sea) is used as the basis for the index calculation. To estimate larval abundance, the mean number of larvae per square meter as obtained from the ichthyoplankton hauls is raised to rectangles of 30x30 nautical miles and the corresponding surface area. These values are summed up within the given subarea and provide the larval abundance per subarea for one interval.

However, since the middle of the 1990s, survey participation and effort is too low to monitor the whole spawning season. In the last two decades, almost only the Netherlands and Germany participated in the herring larvae surveys.

The herring larvae sampling period is still in progress during the WGIPS meeting in January. So far, four units and time periods out of ten were covered in the 2014/15 period, as given below. Due to a number of storms in the North Sea and the English Channel in December and January, two surveys in the Southern North Sea had to be cancelled.

Table 3.1.2.1. Areas and periods covered during the 2014/2015 herring larvae surveys. Two surveys in the Southern North Sea had to be cancelled due to poor weather conditions:

Area / Period	1–15 September	16–30 September	1–15 October
Orkney / Shetland	--	Germany	
Buchan	--	Netherlands + Germany	--
Central North Sea	--	Netherlands	--
	16–31 December	**1–15 January**	**16–31 January**
Southern North Sea	~~Netherlands~~	~~Germany~~	Netherlands

For most of the herring larvae surveys in the North Sea, sample examination and larvae measurements have not yet been completed; therefore, it is not possible to give an overview on the final survey results. Figure 3.1.2.1 shows the herring larvae distribution as obtained by the German survey in the Orkney/Shetlands and the Buchan area in the second half of September 2014. In addition, this survey was affected by strong wind speeds and high waves west of the Orkneys. Thus, no samples from the area west of the Orkneys are available.

As in previous years, the available information will be summarized and presented at the Herring Assessment Working Group (HAWG) meeting in March 2015. However, it is very unlikely that a meaningful herring larvae abundance index can be calculated for the Southern North Sea in 2014.

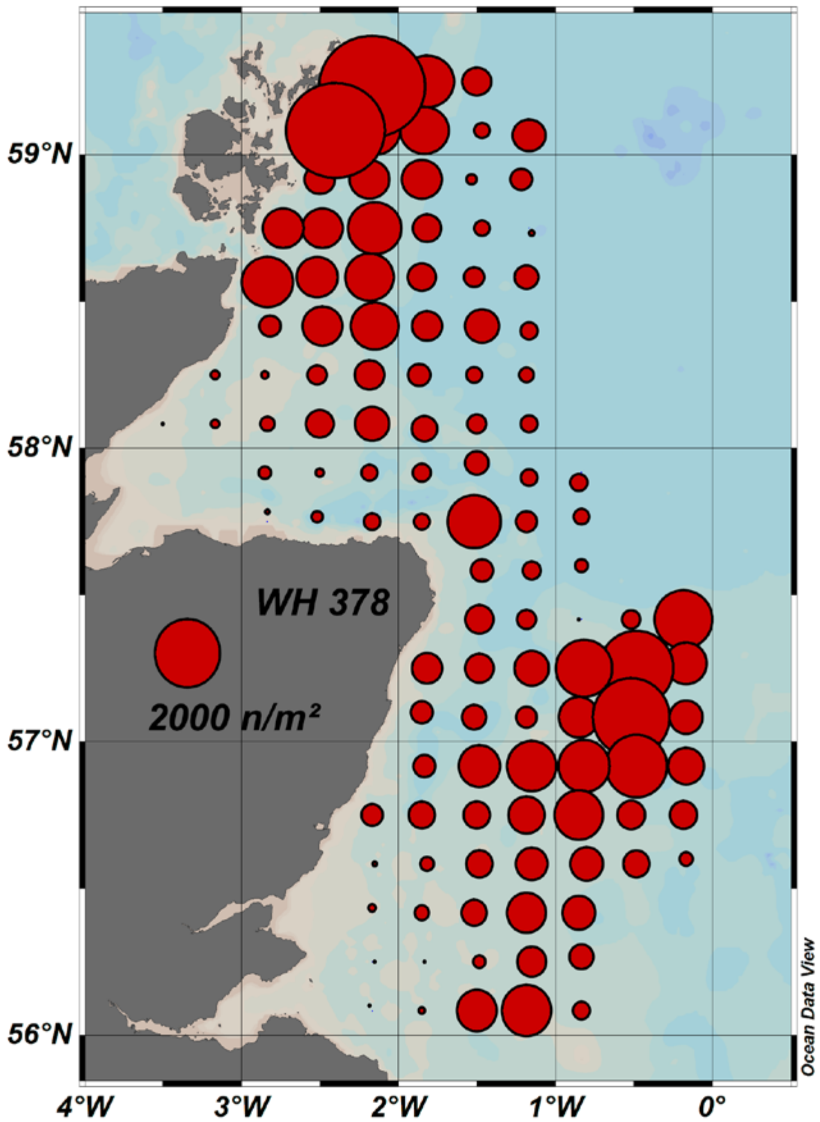

Figure 3.1.2.1. Abundance of herring larvae per square metre (all sizes, n/m²), as obtained by the German survey in the Orkney/Shetlands and Buchan area (second half of September 2014). The symbol size is equal to 2 000 larvae/m². WH 378 refers to the national cruise number.

3.1.3 Irish Sea

Herring larvae surveys of the northern Irish Sea (ICES area VIIaN) have been carried out by the Agri-Food and Biosciences Institute (AFBI), formerly the Department of Agriculture and Rural Development for Northern Ireland (DARD), in November each year since 1993. The surveys have been carried out onboard the RV "Corystes" since 2005, and prior to that on the smaller RV "Lough Foyle".

Sampling is carried out on a systematic grid of stations covering the spawning grounds and surrounding regions in the NE and NW Irish Sea (Figure 3.1.3.1). Larvae are sampled using a Gulf-VII high-speed plankton sampler with 280 µm net. Mean catch-rates (nos.m-2) are calculated over stations to give separate indices of abundance for the NE and NW Irish Sea. Larval production rates (standardized to a larva of 6 mm), and birth-date distributions, are computed based on the mean density of larvae by length class.

A growth-rate of 0.35 mm day-1 and instantaneous mortality of 0.14 day-1 are assumed based on estimates made in 1993–1997.

The 2014 survey was hampered by bad weather and mechanical issues with the research vessel leading to a reduction in survey coverage. Despite this the survey covered the main spawning sites to the east and north of the Isle of Man. Results for the 2014 Irish Sea herring larvae survey indicate a roughly similar distribution pattern to previous years, but with much higher relative abundance to the north of the Isle of Man. There was some evidence of a northwesterly drift pattern from these northern larva patches.

The point estimate of production in the northeastern Irish Sea for 2014 (2.72×10^{11} larvae) was the lowest in the time-series (Figure 3.1.3.2). During the survey very few larvae of all size ranges were encountered with the vast majority >11mmTL. This suggests either the timing of the survey was not optimal or that larvae were experiencing high mortality rates. The index is used as an indicator of spawning-stock biomass in the assessment of Irish Sea herring by the Herring Assessment Working Group (HAWG).

The 2015 survey is scheduled to take place 2–8 November.

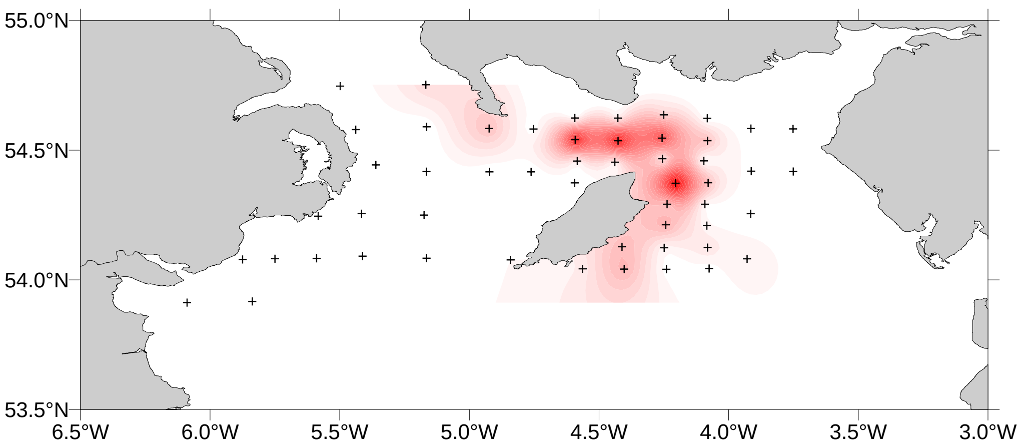

Figure 3.1.3.1. Estimates of larval herring abundance in the Northern Irish Sea in 2014. Crosses indicate sampling stations. Intensity of shading is proportional to larva abundance (maximum = 51.8 per m^2).

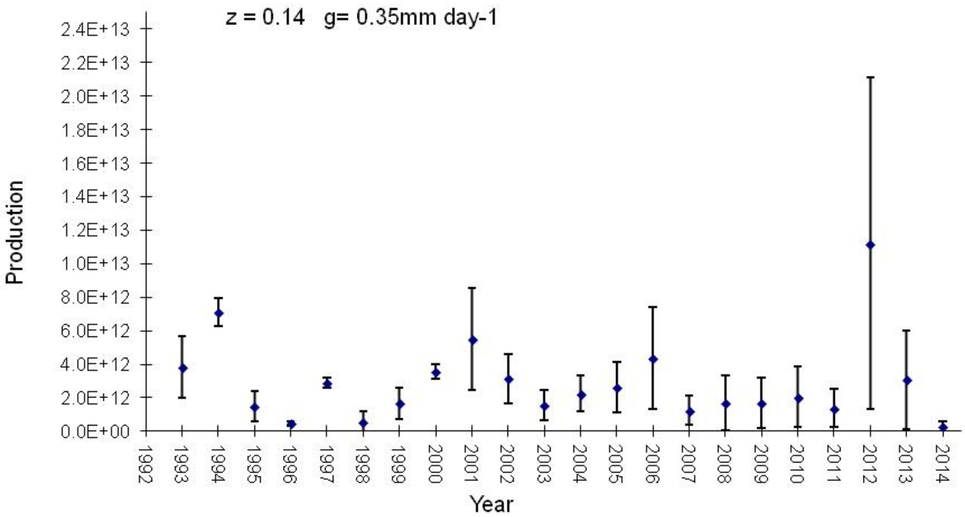

Figure 3.1.3.2. Estimates of larval herring production in the NE Irish Sea from 1993 to 2014. Error bars denote 1 standard error (calculated from coefficients of variation of the estimates of abundance, but not including uncertainty in growth or mortality).

3.2 Coordination of herring larvae surveys in the North Sea in 2015

At the time of the WGIPS meeting, only the participation of the Netherlands and Germany is confirmed for the next herring larvae survey period in the North Sea. Due to limitations in available ship time, none of the areas will be covered neither in the first half of September nor in October. Sampling will be done in the second half of September by Germany in the Orkney/Shetland area and by the Netherlands in the Buchan area and the Central North Sea. The whole spawning activity of Downs herring will be monitored in three surveys from the middle of December 2015 to the end of January 2016. A preliminary timetable for the next sampling period is presented as follows:

Table 3.2.1. Areas and time periods for the 2015 herring larvae surveys:

Area / Period	1-15 September	16-30 September	1-15 October
Orkney / Shetland	--	Germany	
Buchan	--	Netherlands	
Central North Sea	--	Netherlands	--
	16-31 December	**1-15 January**	**16-31 January**
Southern North Sea	Netherlands	Germany	Netherlands

4 Acoustic surveys

4.1 Combined estimates of the acoustic survey

4.1.1 North Sea, West of Scotland and Malin Shelf summer acoustic survey

A combined report has been prepared from the data from all individual surveys, attached as Annex 5c to this report. The combined survey results provide spatial distributions of herring and sprat abundance by number and biomass at age by statistical rectangle and distributions of mean weight and fraction mature at age.

Participants reported that all allocated survey squares apart from 40F5 and 41F5 had been visited. Table 4.1.1.7 lists the survey coverage by country and vessel.

Herring

The estimate of North Sea autumn spawning herring spawning-stock biomass is slightly higher than previous year at 2.6 million tonnes and also comprised of a larger number of fish (2014: 14 392mill. fish, 2013: 11 689mill. fish). Results are shown in Table 4.1.1.1

The 2014 estimate of Western Baltic spring-spawning herring SSB is 128 000 tonnes and 791 million herring. In terms of biomass the SSB increased by 42 000 tonnes, while the amount of fishes is in the same order of magnitude as in 2013. Results are shown in Table 4.1.1.2

The West of Scotland estimate (VIaN) of SSB is 272 000 tonnes and 1 400 million herring, as shown in Table 4.1.1.3. This is a slight increase on the 2013 estimate.

The SSB estimate for the Malin Shelf area (divisions VIaN-S and VIIb,c) is 285 000 tonnes and 1 471 million herring. This is a marginal increase on 2013 and the second lowest SSB estimate in the seven year time-series. Results are shown in Table 4.1.1.4

The Irish Sea survey program is reported separately in the WGIPS report (Section 4.3.2).

Sprat in the North Sea and Division IIIa

The total abundance of North Sea sprat (Subarea IV) in 2014 was estimated at 88 219 million individuals and the biomass at 728 300 tonnes (Table 4.1.1.5). This is the highest estimate ever observed in the time-series, both in terms of abundance and biomass.

In Division IIIa, the abundance is estimated at 913 mill individuals and the biomass at 10 134 tonnes. The stock is dominated by 1-year-old sprat (Table 4.1.1.6).

Table 4.1.1.1. Total numbers (millions) and biomass (thousands of tonnes) of North Sea autumn spawning herring in the area surveyed in the acoustic surveys June - July 2014 with mean weights and mean lengths by age in winter rings.

Age (ring)	Numbers	Biomass	Maturity	Weight(g)	Length (cm)
0	34864	194	0.00	5.6	9.3
1	11634	512	0.03	44.0	17.3
2	4918	639	0.85	129.9	23.9
3	2827	500	1.00	177.0	26.7
4	2939	572	1.00	194.5	27.4
5	1791	403	1.00	225.2	28.7
6	1236	269	1.00	217.8	28.7
7	669	151	1.00	225.1	29.1
8	211	53	1.00	250.3	29.9
9+	250	61	1.00	246.1	29.7
Immature	46947	744		15.8	11.4
Mature	14392	2611		181.4	26.7
Total	61339	3354	0.23	54.7	15.0

Table 4.1.1.2. Total numbers (millions) and biomass (thousands of tonnes) of Western Baltic spring-spawning herring in the area surveyed in the acoustic surveys June-July 2014, with mean weights, mean length and fraction mature by age ring.

Age (ring)	Numbers	Biomass	Maturity	weight(g)	Length (cm)
0	314	1	0.00	4.3	9.1
1	513	26	0.01	51.6	18.2
2	415	48	0.68	114.9	23.0
3	176	21	0.73	122.4	24.2
4	248	43	0.98	175.0	26.6
5	28	6	1.00	210.6	28.5
6	37	8	1.00	220.2	28.8
7	26	6	1.00	213.3	28.9
8+	42	11	1.00	244.1	30.3
Immature	1007	42		41.9	16.0
Mature	791	128		161.7	25.8
Total	1,798	170	0.44	94.6	20.3

Table 4.1.1.3. Total numbers (millions) and biomass (thousands of tonnes) of autumn spawning West of Scotland herring in the area surveyed in the acoustic surveys July 2014, with mean weights, mean lengths and fraction mature by age ring.

Age (ring)	Numbers	Biomass	Maturity	Weight (g)	Length (cm)
0					
1	1031	66	0	64.4	19.5
2	243	26	0.20	108.1	22.9
3	218	34	0.75	157.4	25.8
4	469	85	0.99	180.4	27.3
5	519	107	1.00	206.0	28.5
6	143	31	1.00	213.8	29.2
7	30	7	1.00	231.1	29.4
8	19	5	1.00	244.3	30.2
9+	11	3	1.00	264.4	30.4
Immature	1284	91		71.2	20.1
Mature	1400	272		194.6	27.9
Total	2684	364	0.52	135.5	24.2

Table 4.1.1.4. Total numbers (millions) and biomass (thousands of tonnes) of Malin Shelf herring (VIaN-S, VIIb,c) June-July 2014. Mean weights, mean lengths and fraction mature by age ring.

Age (ring)	Numbers	Biomass	Maturity	Weight (g)	Length (cm)
0					
1	1031	66	0	64.4	19.5
2	281	30	0.18	106.2	22.8
3	243	37	0.73	154.2	25.6
4	502	90	0.99	179.9	27.2
5	534	110	1.00	205.4	28.5
6	148	32	1.00	214.1	29.2
7	33	8	1.00	232.0	29.4
8	19	5	1.00	244.3	30.2
9+	13	3	1.00	259.1	30.1
Immature	1333	96		72.2	20.2
Mature	1471	285		193.6	27.8
Total	2804	381	0.52	135.9	24.2

Table 4.1.1.5. Sprat in the North Sea (Subarea IV): Abundance, biomass, mean weight and mean length by age and maturity (i = immature, m = mature) from summer 2014 North Sea acoustic survey (HERAS).

Age	Abundance (million)	Biomass (1000 t)	Mean weight (g)	Mean length (cm)
0i	5,828.0	8.9	1.5	6.2
1i	23,957.3	134.5	5.6	9.2
1m	34,447.4	294.5	8.6	10.5
2i	1,784.5	14.1	7.9	10.3
2m	18,379.7	214.1	11.6	11.7
3m	3,662.3	59.0	16.1	13.1
4m	155.9	3.1	20.1	14.2
5m	4.4	0.1	28.1	15.9
6m	0.0	0.0	-	-
Immature	31,569.8	157.5	5.0	8.7
Mature	56,649.7	570.9	10.1	11.1
Total	88,219.5	728.3	8.3	10.2

Table 4.1.1.6. Sprat in Division IIIa: Abundance, biomass, mean weight and length by age and maturity from summer 2014 North Sea acoustic survey (HERAS).

Age	Abundance (million)	Biomass (tonnes)	mean weight (g)	mean length (cm)
0i	29.6	118	4.2	8.0
1i	604.9	4 641	7.7	9.8
1m	9.6	117	12.5	11.2
2i	75.6	1 255	16.7	13.2
2m	34.2	564	16.6	13.0
3m+	159.4	3 439	21.7	14.5
Immature	710.1	6 014	8.5	10.1
Mature	203.2	4 120	20.4	14.1
Total	913.3	10 134	11.1	11.0

Table 4.1.1.7. Vessels, areas and cruise dates during the 2014 herring acoustic surveys.

Vessel	Period	Area	Rectangles
Celtic Explorer (IR)	22 June – 12 July	53°30'-58°30'N ,12°-5°W	35D8-D9, 36D8-D9, 37D9-E1, 38D9-E1, 39E0-E2, 40E0-E2,41E0-E3, 42E0-E3, 43E0-E3, 44E0-E3, 45E0-E4
Scotia (SCO)*	28 June – 17 July	58°30'-62°N, 7°W-2°E	46E3-F1, 47E3-F1, 48E4-F1, 49E5-F1, 50E6-F1, 51E8-F1, 52E9-F1
Johan Hjort (NOR)	30 June – 15 July	56°30'-62°N, 2°-6°E	42F2-F5, 43F2-F5, 44F2-F5, 45F2-F5, 46F2-F4, 47F2-F4, 48F2-F4, 49F2-F4, 50F2-F4, 51F2-F4, 52F2-F4
Tridens (NED)	23 June – 18 July	54°25'– 58°24'N, 3° W–5°E	37E9-F1, 38E8-F1, 39E8-F1, 40E8-F4, 41E7-F4, 42E7-F1, 43E7-F1, 44E6-F1, 45E6-F1
Solea (GER) DBFH	25 June – 15 July	52°-56°N, Eng to Den/Ger coasts	33F1-F4, 34F2-F4, 35F2-F4, 36F0-F7, 37F2-F8, 38F2-F7, 39F2-F7, 40F6-F7
Dana (DEN) OXBH	25 June – 8 July	Kattegat and North of 56°N, east of 6°E	41F6-F7, 41G1-G2, 42F6-F7, 42G0-G2, 43F6-G1, 44F6-G1, 45F8-G1, 46F9-G0

***Scottish chartered vessel the MFV *Sunbeam* covered the same area and rectangles as MRV *Scotia* using interlaced transects, the data collected from the chartered vessel has not been used in the combined estimate at this stage , however, due to a technical fault.**

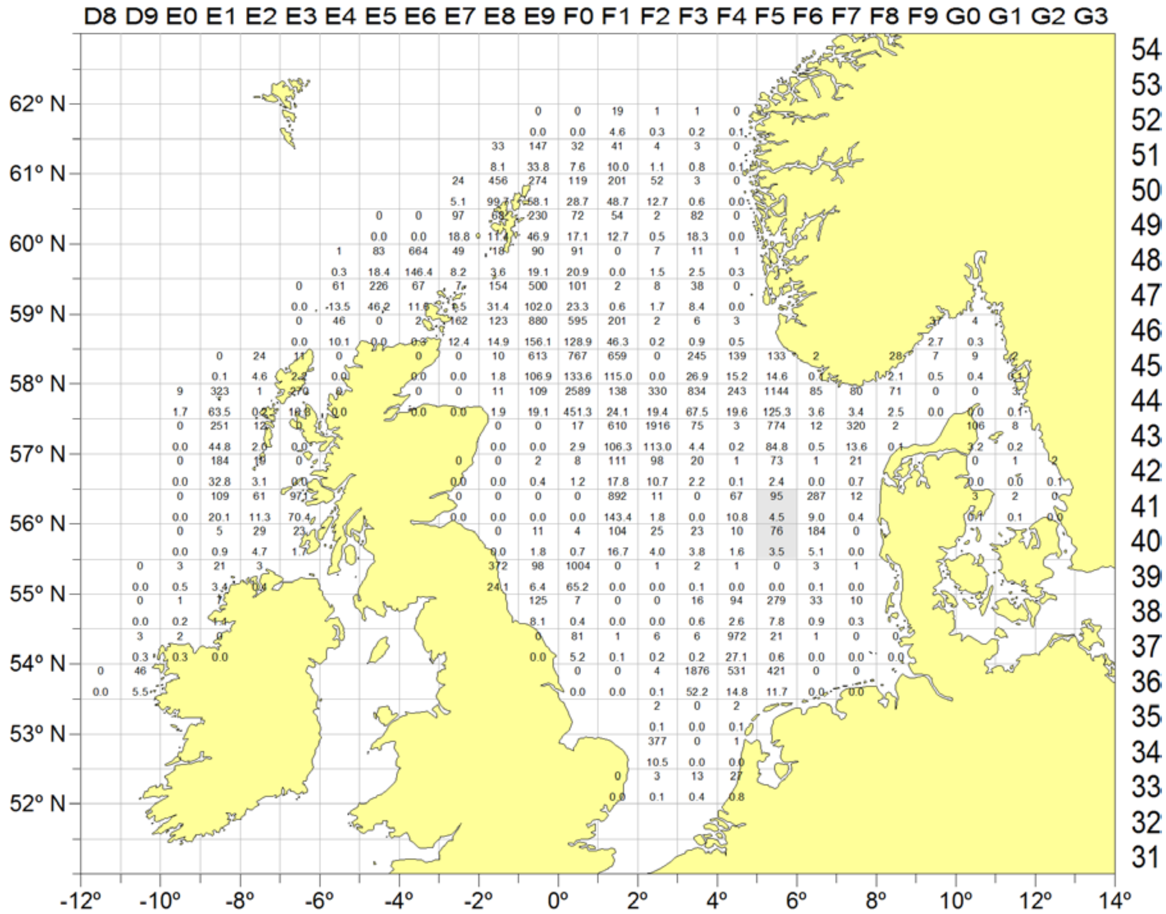

Figure 4.1.1.1. Abundance of autumn spawning herring (winter ring 1–9+) from the combined acoustic survey in June-July 2014. Numbers (millions, upper figure) and biomass (thousands of tonnes, lower figure). Light grey rectangles were not surveyed and values represent interpolations.

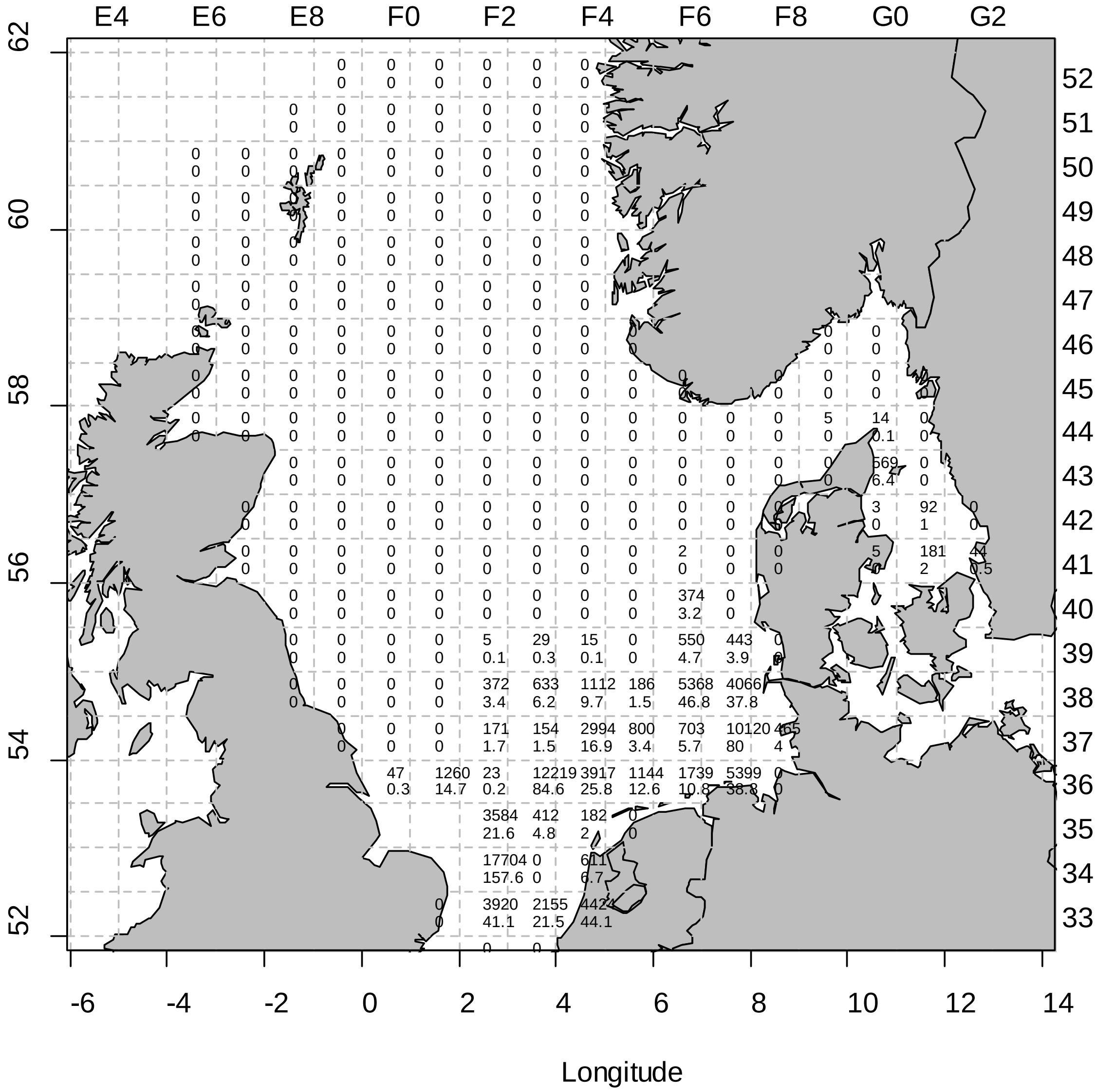

Figure 4.1.1.2. North Sea Sprat. Abundance (upper figure, in millions) and biomass (lower figure, in 1000t) per ICES statistical rectangle in the 2014 survey.

4.1.2 International blue whiting spawning stock survey (IBWSS)

Coordination of the survey was initiated in the meeting of the Working Group on International Pelagic Surveys (WGIPS, ICES, 2014) and continued by correspondence until the start of the survey. The 2014 survey was designed in a way to allocate maximum effort in the area that contained the majority of blue whiting concentrations over the years 2008–2013 (subarea III, Hebrides). At the same time coverage was slightly increased to accommodate the increase in stock size. The design was based on variable transect spacing, ranging from 30 nm in areas containing less dense aggregations (e.g. subarea I, south Porcupine), to 7.5 nm in the core survey area (Subarea III, Hebrides).

During the survey, updates on vessel positions and trawl activities were collated by the survey coordinator and distributed to the participants twice a day. The survey design allowed for a flexible setup of transects and good coverage of the spawning aggregations. Due to acceptable - good weather conditions throughout the survey period, the survey resulted in a high quality coverage of the stock. Transects of all vessels were consistent in spatial coverage and timing, delivering full coverage of the respective distribution areas within 14 days. Regular communication between vessels was maintained during the survey (via e-mail and Internet weblog) exchanging blue whiting distribution data, echograms, fleet activity and biological information.

Combined survey

The estimated total abundance of blue whiting for the 2014 international survey was 3.25 million tonnes, representing an abundance of 31.1x109 individuals (Figure 4.1, Table 4.1). Spawning stock was estimated at 3.2 million tonnes and 24.4x10^9 individuals. Compared with the 2013 survey estimate, there is a decrease (-3%) in the observed stock biomass and a related increase in stock numbers (+15%). (Figure 4.2).

The Hebrides core area was found to contain 48% of the total biomass observed during the survey, which is lower than seen in previous years (73% of the stock found in this area in 2013 and 71% in 2012). The major part of the biomass recorded in the area was found more towards the southern part, while in previous years, the bulk of the aggregation was observed further north. The North Porcupine and Rockall areas ranked second and third highest contributing 27% and 15% to the total biomass respectively. Compared to the previous year, less biomass was observed in the Hebrides and Faroes/Shetland area, but more in the Northern Porcupine area, reflecting again the more southern distribution seen this year. An increase in absolute blue whiting biomass was observed in the Rockall area, both on the bank itself and in the Rockall Trough as compared to 2013. However, this increase can be attributed primarily to a high density area in the eastern Rockall Trough, as compared to the lower density echotraces found on the Rockall Bank itself. The breakdown of survey biomass by subarea is shown in Table 4.3.

Stock distribution

In total 8,231 n.m. (nautical miles) of survey transects were completed and the total area of all the sub-survey areas covered was 125,319 n.m.^{2} (Figure 4.1, Tables 4.1 and 4.3. Covered survey track length was 10% longer and surveyed areas 30% larger than last year as a result of increased and more detailed coverage of the Rockall and Porcupine Bank areas.

The highest concentrations of blue whiting were recorded in the Hebrides area but the observed biomass there was 37% less than in the previous year. (Figure 4.6, Table 4.2). Due to the perceived later northward migration of the stock as compared to 2013 the centre of gravity was located further south within the northern Porcupine Bank area. This area saw an increase in biomass of 310% as compared to 2013. (Figures 4.2 and 4.3). Medium and high density registrations were concentrated along the shelf slope extending up to 15 nm from the shelf edge

Stock composition

Individuals of ages 1 to 15 years were observed during the survey. A comparison of age reading between nations was carried out and the results showed better agreement across participants for especially the younger year classes compared to 2013, with a broad spread of lengths for the youngest and oldest fish in the range. The stock biomass within the survey area is dominated by age-classes 3, 4, and 5 and 1 years of the 2010, 2009, 2008 and 2013 year classes respectively. The main contribution (76%) to the spawning-stock biomass were the age-groups 4, 3, 5 and 6 (Table 4.4).

The Hebrides area has consistently been the most productive in the current time-series with the exception of this year where a slightly lower but still significant proportion of the overall biomass was located in that area. But this year the contribution was 48%

while the Porcupine area contained a significant portion of the spawning stock in 2014. Mean lengths and weights of the fish caught in the Hebrides area were also among the highest within the whole survey area. The Faroe/Shetland subarea was dominated by mainly 1 and 3 year old fish, with some 2 year olds, and Porcupine subareas were dominated by 3–5 year old fish. One year old fishes were mainly observed in subarea IV (Faroes-Shetland). Older fish (8+ years) were predominantly observed in subarea III (Hebrides) and V (Rockall).

From the survey data, the Faroese/Shetland subarea was found to contain significant proportion of young blue whiting (1–3 years), consistent with previous years. This together represents 70% (238,000t) of the total biomass and 85% (4183 million individuals) of the total abundance in this area. This is close to the proportions seen in 2012 (75% and 86% respectively), and larger than last year (Table 4.4).

The largest blue whiting were observed on the Rockall Bank and here most of the fish were mature (97%).

Immature blue whiting were present to various extents in all subareas in 2014. Maturity analysis of survey samples indicate that 14% of 1-year old, 56% of 2-year old and 90% of 3-year old fish were mature as compared to the 2013 estimates, where 18% of 1-year old fish, 54% of 2-year old fish and 82% of 3-year old fish were considered mature. Overall, immature blue whiting from the estimate represented 7.4% (242,000t) of the total biomass and 15% (4667 million) of the total abundance recorded during the survey (Table 4.3).

Table 4.1. Temporal trends in abundance and biomass of blue whiting estimated by the IBWSS.

		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Change from 2013 (%)
Biomass	Total	2.6	3.4	3.6	2.6	2	1.3	1.6	2.2	3.4	3.3	-3%
(mill. t)	Mature	2.4	3.3	3.6	2.6	2	1.3	1.5	2.2	3.2	3	-6%
Numbers	Total	29	34.7	33.5	22.1	15.2	9.3	12.1	18.2	27	31.1	15%
(10^9)	Mature	26.7	33.8	32.9	21.7	15.0	8.9	9.7	16.5	24.4	26.4	8%
Survey area (nm^2)		172,000	170,000	135,000	127,000	133,900	109,320	68,851	88,746	87,895	125,319	43%

Table 4.2. Differences in blue whiting biomass by survey subarea estimated by the IBWSS in 2013 and 2014.

		Biomass (million tonnes)				
		2013		2014		
	Sub-area		% of total		% of total	Change (%)
I	S. Porcupine Bank	-	-	0.03	1	-
II	N. Porcupine Bank	0.21	6	0.86	27	310%
III	Hebrides	2.44	73	1.54	48	-37%
IV	Faroes/Shetland	0.43	13	0.34	10	-21%
V	Rockall	0.27	8	0.47	15	74%

Table 4.3. Assessment factors of blue whiting for different survey subareas covered by the IBWSS in 2014.

Vessel	Effective survey period	Length of cruise track (nmi)	Trawl stations	CTD stations	Plankton sampling	Aged fish	Length-measured fish
Celtic Explorer	26/3-6/4	1451	11	24		550	1650
Magnus Heinason	29/3-6/4	1173	10	21	21	337	721
G.O.Sars	27/3- 7/4	1962	8	41	38	204	625
Tridens	26/3-5/4	1997	11	24		1101	1100
Fritjof Nansen	25/3-5/4	1648	12	57		1100	3632
Total	25/3-7/4	8,231	52	167	59	3,292	7,728

Table 4.4. Blue whiting maturity fraction, mean weight, abundance and biomass by length and age estimated by the IBWSS in 2014

	Age in years (year class)										Numbers	Biomass	Mean	Prop.
Length	1	2	3	4	5	6	7	8	9	10+			weight	mature*
(cm)	2012	2011	2010	2009	2008	2007	2006	2005	2004		($*10^{-6}$)	(10^6 kg)	(g)	(%)
11.0 – 12.0											0			
12.0 – 13.0											0			
13.0 – 14.0											0			
14.0 – 15.0											0			
15.0 – 16.0											0			
16.0 – 17.0	77	0	0	0	0	0	0	0	0		77	1.7	22	0
17.0 – 18.0	388	6	0	0	0	0	0	0	0		394	10.1	26	0
18.0 – 19.0	784	49	6	0	0	0	0	0	0		839	26.1	31	13
19.0 – 20.0	993	150	1	0	0	0	0	0	0		1144	42	37	14
20.0 – 21.0	435	246	1	0	0	0	0	0	0		682	28.8	42	14
21.0 – 22.0	164	164	4	0	0	0	0	0	0		332	16.9	51	52
22.0 – 23.0	35	113	46	0	0	0	0	0	0		194	11.2	58	62
23.0 – 24.0	0	154	226	18	1	0	0	0	0		399	26.2	66	74
24.0 – 25.0	10	299	941	411	74	0	0	0	0		1735	128.8	75	75
25.0 – 26.0	0	229	2244	1376	597	41	11	0	0		4498	366.5	82	85
26.0 – 27.0	0	81	2476	1834	1320	61	19	0	0		5791	517.7	90	94
27.0 – 28.0	0	11	1660	1888	987	94	0	0	0		4640	462.8	100	98
28.0 – 29.0	0	0	527	1188	1039	228	10	0	0		2992	334.4	112	100
29.0 – 30.0	0	0	206	557	759	208	24	0	10		1764	219.4	125	100
30.0 – 31.0	0	0	28	352	568	285	84	23	0	55	1395	197.4	142	100
31.0 – 32.0	0	0	0	68	278	234	90	70	115	158	1013	169.2	168	100
32.0 – 33.0	0	0	20	49	142	124	109	167	116	276	1003	184.7	185	100
33.0 – 34.0	0	0	9	30	108	85	51	176	73	269	801	163.1	205	100
34.0 – 35.0	0	0	1	0	47	33	58	38	113	228	518	115.1	224	100
35.0 – 36.0	0	0	0	0	4	43	41	21	84	212	405	99.3	246	100
36.0 – 37.0	0	0	0	0	0	25	8	27	59	112	231	58.3	254	100
37.0 – 38.0	0	0	0	0	0	6	21	6	19	78	130	35.1	273	100
38.0 – 39.0	0	0	0	0	3	1	6	6	3	32	51	14.9	280	100
39.0 – 40.0	0	0	0	0	0	0	0	0	4	22	26	8.4	321	100
40.0 – 41.0	0	0	0	0	0	0	0	0	0	0	0	0	.	100
41.0 – 42.0	0	0	0	0	0	0	0	2	0	2	4	1.4	407	100
42.0 – 43.0	0	0	0	0	0	0	0	0	0	10	10	3.9	383	100
43.0 – 44.0	0	0	0	0	0	0	0	0	3	12	15	6.9	455	100
44.0 – 45.0	0	0	0	0	0	0	0	0	0	2	2	1.1	519	100
TSN (10^6)	2886	1502	8396	7771	5927	1468	532	536	599	1468	31085	3251		
TSB (10^6 kg)	102.1	96	761.2	767.4	660.7	215.3	93.7	106.7	127.7	320.6	3251			
Mean length (cm)	19.2	22.8	26.3	27.3	28.2	30.4	32.3	33.2	33.9	34.5				
Mean weight (g)	35.4	63.8	90.7	98.7	111.4	146.5	176.4	199	212.8	225				
Condition (g/dm^3)														
% mature*	14	56	90	94	97	99	99	100	100	100				
SSB	14.7	53.5	685.2	721.8	637.6	213.6	93.2	106.7	127.7	320.6	2974.6			

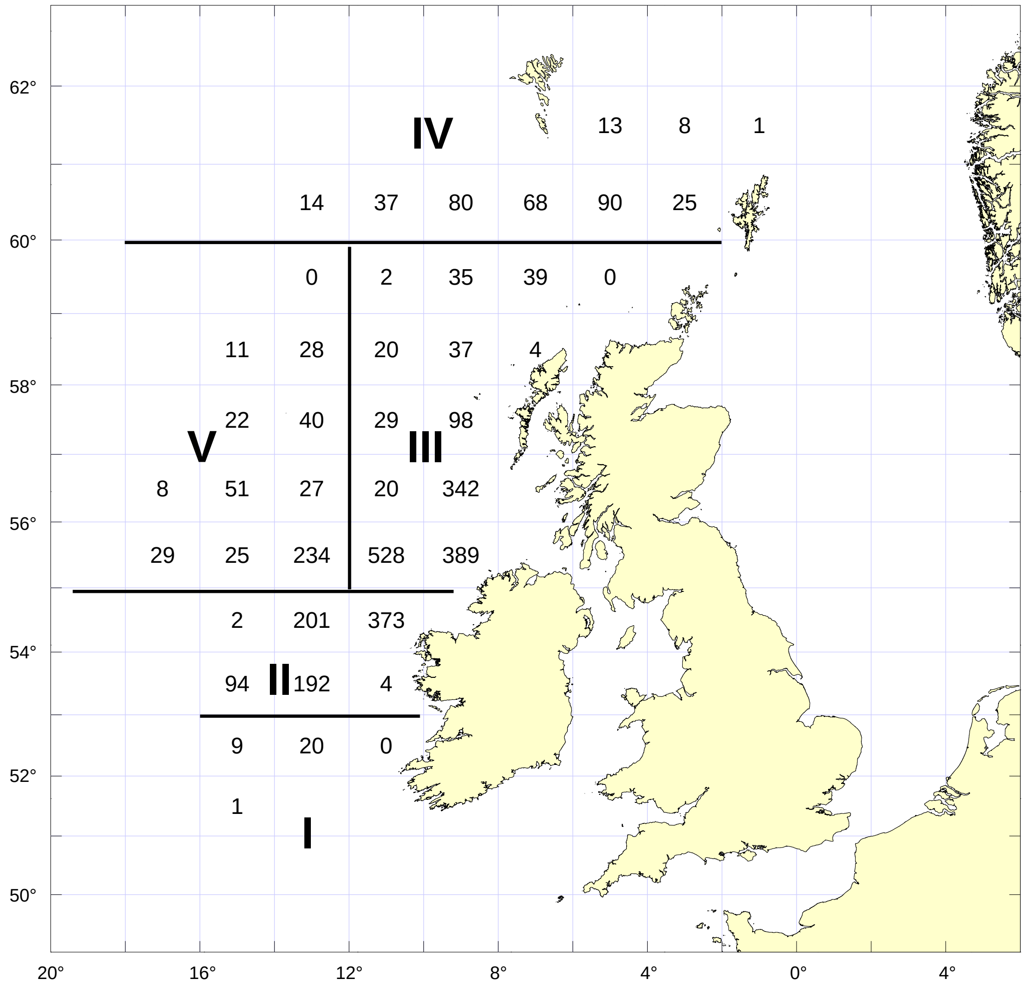

Figure 4.1. Blue whiting biomass (x1000 tonnes) by survey subareas estimated by the IBWSS in 2014

4.1.3 International ecosystem survey in the Nordic Seas (IESNS)

The full post-cruise report from the International ecosystem survey in the Nordic Seas (IESNS) in 2014 is given as Annex 5b in this report.

The IESNS 2014 was conducted April-June 2014 by 5 research vessels from EU (Danish vessel), Faroe Islands, Iceland, Norway and Russia. The main objective of the IESNS cruise is obtaining age-disaggregated biomass estimates of Norwegian Spring-spawning (NSS) herring, which are used as tuning series in the analytical assessment. Acoustical data were sampled for NSS herring and blue whiting, as well as biological samples (such as length, weight, age) from all species caught in opportunistic trawl samples. In addition hydrographical and zooplankton data were collected.

Hydrography

The temperatures close to the surface, at 10 m depth, ranged between 2°C in the Iceland Sea and 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 to 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 70°N in the surface layers and to 68°N at 200 m depth. Relative to a 19 years long term mean, from 1995 to 2013, the temperature at 20 m depth northeast of Iceland was considerable higher in 2014 compared to the long-term mean (Figure 11 Annex 5b) – at greater depths the difference was smaller (Figures 12–14 Annex 5b). In the eastern part of the Norwegian Sea the temperature was lower than the mean, particularly in the upper layer. In the central Norwegian Basin the temperature was lower than the long-term mean, especially at 400 m depth.

Zooplankton

The zooplankton biomass was relatively uniform over the whole survey area, except for higher concentrations off the Norwegian coast. The upwards trend in biomass continues since the lowest recorded value in the time-series in 2009 (Figure 20 Annex 5b). Recorded zooplankton density was 9.7 g dry weight m^{-2} (for the whole survey area, excluding the Barents Sea). In the Barents Sea, the mean density was 1.6 g dry weight m^{-2}. However, 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 density 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

NSS herring was measured acoustically during the survey and the total biomass was estimated to be 5.1 million tonnes in 2014. This is a 6% decrease as compared to 2013, and approximately 50% decrease as compared to 2007–2009, when stock size was at the highest (10.0–12.2 million tonnes (ICES, 2014)). Thus, the downward trend in biomass is apparent.

The herring distribution in 2014 was similar to the 2013 distribution. The highest concentrations were found in the central to southwestern part of the Norwegian Sea (Figures 21 and 22 in Annex 5b), and consisted mainly of older part of the stock (age 8 and older; Table 2 in Annex 5b). A dense concentration was also found in the northeast (around 69°N and 5°E) and consisted of a mixture of all age classes from age 2–14. Overall the herring density was relatively low and herring was never observed in big schools. In 2014, like in previous three years, almost no herring were observed north of 70°N.

The herring stock is now dominated by 10 year old herring (2004 year class) in numbers but the 2009, 2006, 2005, 2003 and 2002 year classes are also numerous (Table 2 Annex 5b), which is similar to previous years. The 2009 year class appears to be the largest of the younger age groups, although, it appears to be only around 50% of average size of five year olds in the time-series since 1997.

The investigations of herring in the Barents Sea covered the area from 44°E to the 20°30′ E. The total abundance estimate was higher than in the last two years, with 5876 million individuals of age 1 (mean length of 11.5 cm and weight of 8.7 g), 2185 million individuals of age 2 (mean length of 17.8 cm and mean weight of 32.4 g), 2156 million individuals of age 3 herring (mean length of 23.8 cm and mean weight of 76.3 g) and 242 million individuals of age 4 herring (mean length of 25.7 cm and mean weight of 95.9 g). Only very few older herring were observed.

Work is currently being conducted to obtain an estimate of uncertainty in the survey. The new approach of dividing the survey area into stratum 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 future.

There were concerns regarding age-reading of NSS herring, as in the last years, because the age distribution from the different participants have showed differences. In addition, this year, there were also concerns regarding the acoustic estimates from one of the participants. It was recommended to establish workshops to resolve these concerns. The scrutinizing workshop will take place in March 2015, or prior to the 2015 survey. A workshop on ageing of herring has not yet been planned.

Blue whiting

The total biomass of blue whiting registered in the IESNS survey 2014 was 0.63 million tons, which is somewhat less than the biomass estimates in 2012 and 2013. The stock estimate in number for 2014 is 8.9 billion, which is a slight increase as compared to 2013, but a 40% reduction compared to the 2011 estimate. Age one is dominating the estimate, whereas in 2013, the 1-group was more or less absent. The estimate of 1-group in 2014 is 3.7 billion compared to only 0.6 billion in 2013. The number of 2 year olds was lower than in 2013, 2.5 billion compared to 6.3 billion. These results confirm the weak 2012 year class and suggest that the 2013 year class is stronger. The 2013 year class constituted 41% of the total number and 26% of the total biomass. A positive sign in development of the stock size was first observed in the 2011 survey, when blue whiting at age 1 and 2 were observed in larger numbers than the previous years.

The main concentrations were observed both in connection with the continental slopes off Norway and south and southwest of Iceland and in the open sea in the southern part of the Norwegian Sea (Figures 25 and 26 Annex 5b).

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

4.1.4 Coordinated Nordic Seas ecosystem survey (IESSNS) in July–August

The full post-cruise report from the International ecosystem survey in the Norwegian Sea and adjacent areas (IESSNS) in 2014 is given as Annex 5d in this report.

IESSNS was performed during 2 July to 12 August 2014 with four vessels from Norway (2), Iceland (1) and Faroes (1). Greenland leased the Icelandic vessel for 12 days to cover the East Greenland area. In addition to collect acoustical data, hydrographical and zooplankton data, a standardized pelagic trawl swept-area method was used to estimate abundance of NEA mackerel in the survey area (Figure 1 in Annex 5d) as in recent years. One of the main objectives of the IESSNS is to provide reliable and consistent age-disaggregated abundance indices of NEA mackerel. The WKPELA meeting held at ICES in Copenhagen in February 2014 benchmarked the assessment of mackerel in the Northeast Atlantic (ICES 2014). It was agreed during the meeting to include age-disaggregated indices for age group 6+ scaled by the coverage each year from the IESSNS into the assessment.

All vessels that participated in the IESSNS 2014 used the same pelagic sampling trawl design (Multpelt 832) and followed the protocol agreed upon in Hirtshals in February 2013 for both rigging and operation (ICES, 2013). Systematic underwater video recordings of mackerel swimming behaviour in relation to the catching process were also conducted. Results from those exercises are not available yet.

Hydrography

The surface temperatures in the Nordic Seas in July-August 2014 were generally higher in all areas compared to July-August 2013. The SST anomaly map showed considerably higher average surface temperatures in July 2014 or 1–3°C higher compared to the average temperature in July during the last 20 years (Figure 3 in Annex 5d). This is thought to be due to the unusual calm weather conditions this summer.

Zooplankton

The average concentration of zooplankton in the Nordic Seas in July-August 2014 was at the same level as in 2013, 8.3 g/m^2 and 8.6 g/m^2, respectively (Figure 11 in Annex 5d). However, in the western areas, i.e. west of 14 degrees west (Iceland and East Greenland areas), the zooplankton biomass was markedly lower in 2014.

Mackerel

The total swept-area estimate of NEA mackerel in summer 2014 was 9.0 million tonnes distributed in the Nordic Seas. Mackerel was found up to 76°10'N and from 22°E outside the Norwegian coast to 43°W in the Irminger Sea south of Cape Farewell in Greenland waters (Figures 17–18 in Annex 5d). The 2011-year class contributed with 32.0% in number followed by the 2010-year class with 21.1% (Figure 19 and Table 8 in Annex 5d). The 2007, 2008 and 2009 year classes contributed then to around 11% each. Altogether 66.2% of the estimated number of mackerel was less than 6 years old. The internal consistency plot for age-disaggregated year classes has greatly improved since 2013 especially for younger year classes. There is now good internal consistency between year classes 1–10 years old, except between the less abundant 5 and 6 year old (Figure 20 in Annex 5d). Mackerel was observed in most of the surveyed area, and the zero boundaries were found in most areas, except in the southwestern border of the East Greenland zone (Figure 16 in Annex 5d). There are also mackerel in the North Sea and probably also west of the British Isles. These areas are not covered by the survey. Approximately 8% of the mature mackerel sampled during the survey had not yet spawned at the time of the survey. This was determined based on maturity determination performed on all vessels. The geographical coverage and survey effort was 2.45 million km^2 in 2014 which was very similar to 2013 (2.41 million km^2). The area coverage in 2013 and 2014 is larger than previous years mapping from 2007 to 2012.

Norwegian spring-spawning herring

Norwegian spring-spawning (NSS) herring was measured acoustically during the survey and the total biomass came to 4.6 million tonnes. The 2004 and 2005 year classes were most abundant in the survey. The NSS herring was mainly found in the southwestern and western part of the Norwegian Sea; i.e. from north of the Faroe Islands and to the east and north off Iceland (Figure 21 in Annex 5d) . Small concentrations were found in the northern and eastern areas, while herring was mostly absent in the mid Norwegian Sea. The biomass estimate is considerably lower than from the 2013 survey (8.6 million tonnes). This is partly due to insufficient coverage north of Iceland and west of Jan Mayen, and partly due to the very shallow distribution in the Jan Mayen area, with apparently large proportions of NSS herring being in the acoustic dead zone above the transducers. The spatio-temporal overlap between NEA mackerel and NSS herring in July-August 2014 was highest in the southern and southwestern part of the Norwegian Sea (Figure 15 in Annex 5d). Herring was most densely aggregated in areas where zooplankton concentrations where high. Mackerel, on the other hand, was found in most of the surveyed area, and in areas with varying zooplankton concentrations.

Blue whiting

No deep trawl hauls were taken on acoustic registrations of blue whiting, and acoustic registrations deeper than 200 m were not scrutinized in part of the survey area in 2014. Thus the results of the survey can neither be used to quantify nor map the distribution of blue whiting in the Nordic Seas in summer 2014.

Marine mammals

Whale observations were done by the two Norwegian vessels during the survey. The number of marine mammal sightings was generally very low in the central and eastern part of the Norwegian Sea but considerably larger numbers, especially of fin whales, were observed in the northern Norwegian Sea and into the Barents Sea. Many groups of killer whales were observed in central and northern Norwegian Sea feeding on mackerel, whereas fin whales where mainly observed near Jan Mayen, Bear Island and the southwestern part of the Barents Sea and off the coast of Finnmark.

4.2 Coordination of international acoustic surveys in 2014

4.2.1 International acoustic survey coverage North Sea, West of Scotland and Malin Shelf (HERAS)

Acoustic surveys in the North Sea, West of Scotland, Malin Shelf, Irish and Celtic Sea in 2015 will be carried out in the periods and areas given in Table 4.2.1.1 and Figure 4.2.1.1. In general, participants are asked to ensure that coverage of the agreed survey areas is completed as far as possible. Sampling effort within those general areas should be directed as indicated from results of recent surveys, to ensure adequate, detailed coverage reflecting the likely stock distribution. Interlacing of adjacent surveys is encouraged where considered appropriate, but only when it can be achieved without reducing the effectiveness of each individual survey.

The survey effort, e.g. transect spacing, should be the same as in most recent years. Thus participants should be encouraged to adapt their survey effort, avoiding an imbalance between transect spacing and the occurrence of fish schools.

A review is underway to ascertain whether the transect spacing in different areas is still appropriate given recent trends in the distribution of the stock.

Survey effort should be allocated to also ensure adequate coverage of the North Sea sprat stock, which requires that the southern boundary of the survey area be kept at 52°N.

Table 4.2.1.1. Time periods, areas and rectangles to be covered in the 2015 acoustic surveys.

Vessel	Period	Area	Rectangles
Celtic Explorer (IRE)	24 June – 14 July	53°30′-58°30′N ,12°-5°W	35D8-D9, 36D8-D9, 37D9-E1, 38D9-E1, 39E0-E2, 40E0-E2,41E0-E3, 42E0-E3, 43E0-E3, 44E0-E3, 45E0-E4
Scotia (SCO)	25 June – 14 July	58°30′-62°N, 8°W-2°E	46E2-F1, 47E3-F1, 48E4-F1, 49E5-F1, 50E7-F1, 51E8-F1
Johan Hjort (NOR)	25 June – 15 July	56°30′-62°N, 2°-5°E	42F2-F5, 43F2-F5, 44F2-F5, 45F2-F5, 46F2-F4, 47F2-F4, 48F2-F4, 49F2-F4, 50F2-F4, 51F2-F4, 52F2-F4.
Dana (DEN)	25 June – 8 July	Kattegat and North of 56°N, east of 6°E	41F6-F7, 41G1-G2, 42F6-F7, 42G0-G2, 43F6-G1, 44F6-G1, 45F8-G1, 46F9-G0

Tridens (NED)	29 June – 17 July	54°25′– 58°24′N, 3° W–5°E	37E9-F1, 38E8-F1, 39E8-F1, 40E8-F4, 41E7-F4, 42E7-F1, 43E7-F1, 44E6-F1, 45E6-F1
Solea (GER)	25 June – 15 July	52°-56°N, Eng to Den/Ger coasts	33F1-F4, 34F2-F4, 35F2-F4, 36F0-F7, 37F2-F8, 38F2-F7, 39F2-F7, 40F5-F7, 41F5

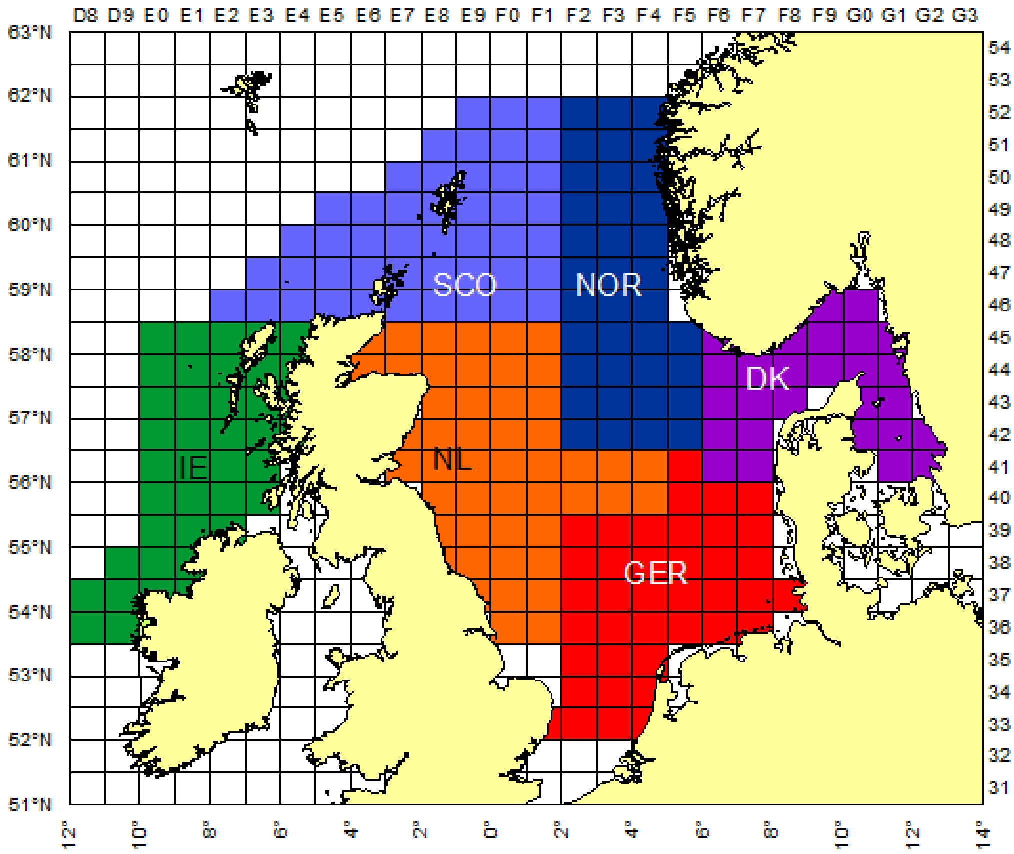

Figure 4.2.1.1. Survey area layouts for all participating vessel in the 2015 acoustic survey of the North Sea and adjacent areas. (IE = Celtic Explorer; SCO = Scotia; NOR = Johan Hjort; DK = Dana; NL = Tridens; GER = Solea).

North Sea surveys

Susan Mærsk Lusseau will be coordinator for the acoustic surveys in June-July 2015. Participants in 2015 should exchange tentative cruise tracks prior to the survey, for further consideration. **Copies of all cruise tracks should also be sent to** Susan Mærsk Lusseau**, not later than 30 May 2015**; she will then contact individual cruise leaders to discuss possible amendments.

Daily communication between vessels should be conducted by e-mail during the cruises, to exchange position and cruise track information as well as survey results (catch depth, species composition, mean length). Deviations from the original submitted cruise track should be communicated immediately, to enable the coordinator to adapt other nations cruise tracks and to avoid gaps. Cruise leaders should circulate their e-mail addresses for the duration of the cruise, **particularly** if it is not their normal contact address.

WGIPS has had a request from HAWG previously for splits between spawning components within the North Sea. The HAWG wants to be able to distinguish between the

Downs winter spawning component and autumn spawning components in the acoustic indices.

WG members responsible for acoustic surveys in the North Sea have previously agreed, as part of their sampling regime, to try to photograph otoliths for use during the surveys for otolith structure and provide subsamples of these otoliths for microstructure calibration. This project was further delayed in 2014 due to staffing constraints in some of the participating nations, but it is hoped this can be solved for the 2015 survey. So far Norway, Germany and Denmark has managed to photograph otoliths with Scotland and Netherlands hoping to achieve this in 2015.

As WGIPS has to deal with a large number of surveys and has limited time available to achieve this, it is recommended that the two day post cruise meeting should be maintained, just before the WGIPS meeting in January 2016, to collate combined survey data and report on the combined result. The meeting will allow WGIPS members to evaluate survey data and discuss issues arising from the surveys and conclude on recommendations to improve survey precision.

Malin Shelf surveys

The synoptic survey of the Malin Shelf metapopulation of herring has been carried out since 2008, with participating vessels from Scotland (chartered fishing vessel), Northern Ireland (RV "Corystes") and Ireland (RV "Celtic Explorer"). From 2011, due to financial restraints, the effort level has changed across participating countries.

The survey plan presented here does not provide survey coverage for the Clyde and North Channel area. The Scottish acoustic survey traditionally carried out in the northern North Sea by RV Scotia will continue to cover the northern area west of Scotland (north of 58°30'N) in 2015. Ireland has agreed to continue coverage south of 58°30'N to maintain the integrity of the Malin Shelf area, and the existing VIaN time-series. Transect spacing will be adjusted to account for areas of tradionally high and low density and will be confirmed during the planning phase.

WGIPS strongly recommends that survey effort and intensity should be maintained in its present form.

RV Celtic Explorer and RV Scotia has been collecting photographs and otoliths to prepare for splitting the acoustic index into VIaN and VIaS stock components since 2010. WGIPS anticipates that HAWG will provide guidance whether this project should continue in 2015 based on results from the planned benchmark of these herring stocks in February 2015.

The results from the national acoustic surveys in June-July 2015 will be collated, and the results from the entire survey combined, prior to the next WGIPS in January 2016.

The survey group is preparing to change to a new database structure which is being developed by ICES. In the interim the group anticipates to make use of the PGNAPES data format for delivery of disaggregated data and to be able to collate the combined survey results from this format pending the outcome of the planned workshop WKEVAL in August 2015. Additionally, the survey data should be delivered in the usual FishFrame format to allow a comparison with the new method and also provide a fall back to a recognized methodology in case of unanticipated delays in developing the new calculation methods. Individual national survey results for sprat and herring should be uploaded to FishFrame and delivered in PGNAPES format no later than **30 November 2015**.

4.2.2 International blue whiting spawning stock survey (IBWSS)

Five vessels representing the Faroe Islands, the Netherlands (EU), Ireland (EU) Norway and Russia are scheduled to participate in the 2015 blue whiting spawning stock survey.

Survey timing and design were discussed during the 2014 IBWSS post-cruise and 2015 WGIPS meetings. The group decided that in 2015, the survey design should follow the principle of the one used during the three previous surveys. The focus will still be on a good coverage of the shelf slope in areas II and III. However, given the increasing stock biomass observed over recent years, it can be expected that the distribution will be more extended over the whole survey area as well, as was observed in the 2014 survey. In previous years when larger stock sizes were observed (2004–2007), blue whiting aggregations were distributed more evenly over the whole survey area, including on the Rockall Bank and Rockall Trough. Therefore, the survey design in 2015 will again allocate more effort in these areas as well.

The design is based on variable transect spacing, ranging from 30 nm in areas containing less dense aggregation (e.g. subarea I, south Porcupine), to 10 nm in the core survey area (subarea III, Hebrides; Figure 4.1). The western borders of the transects in subarea III are set to 12°W in order to cover potential blue whiting aggregations extending further from the continental slope into the Rockall Trough. Transects will be drawn systematically with a random start location.

The aim is to have three vessels start surveying on their transects just north of subarea II (North Porcupine) at the same time (25.03.2015; Table 4.1). That way, the core survey subarea III can be covered synoptically by several vessels with similar temporal progression.

It was decided that the Russian and Irish vessels would start the survey in the southern subareas I and II (Porcupine). 2–4 days after beginning their individual surveys, these vessels will be joint by 'G.O. Sars' and continue surveying the north of subarea II and afterwards area III from the south progressing northwards. Once G.O. Sars has finished surveying subarea III, she will continue northwards into the Faroese-Shetland channel and continue coverage in a northeastern direction until time allows. The Faroese vessel will primarily survey subarea V (Faroese/Shetland) and join the other vessels in the north of area III once they are present there towards the end of the survey period. The Rockall area will be covered by 'Tridens', starting in the south on 25.03.2015, progressing northward. Survey extension in terms of coverage (51–61ºN) will be in line with the previous year to ensure containment of the stock and survey timing will also remain fixed as in previous years.

Key will be to achieve coverage of area III in a consistent temporal progression between vessels. It is therefore very important that all vessels covering the core Hebrides area are present on station in the north of subarea II (just north of Porcupine Bank) on 25 March 2015 (Table 4.1). Nonetheless, if some vessels are found to lag behind others, the tight 10 n.m. transect spacing will allow for adaptation of the survey design without great loss of coverage. For instance, this may mean either skipping or extending some of the horizontal transects to catch up or keep pace with the other vessels. Biological sampling should be carried out following methods normally applied to sampling acoustic registrations.

In most recent years, adherence to the set survey speed of 10 kts has in some instances been difficult for some of the survey participants. As a result, the synoptic progression between vessels has been hampered. Therefore, the **common survey speed is set to 9.5**

kts for the 2015 survey in the expectation that all vessels can maintain it and consequently facilitate coordination.

If registrations of blue whiting marks are continuing at the end of any planned transects, the length of these transects should be extended until no more marks are registered for a distance of 3 n.m. (or 20 minutes at normal survey speed).

Preliminary cruise tracks for the 2015 survey are presented in Figure 4.1. As new survey coordinator in 2015, Ebba Mortensen (Faroe Islands) 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 by the end of January 2015.

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.

Participants are also required to use the logbook system for recording course changes, CTD stations and fishing operations. An example format can be circulated to participants at the 2015 WGIPS meeting. The survey will be carried out according to survey procedures described in the ICES WGIPS Manual for Acoustic Surveys.

Table 4.1. Individual vessel dates for the active surveying period in the 2015 International Blue Whiting Spawning stock Survey (IBWSS).

ship	nation	active surveying time (days)	definitive surveying dates
Fridjof Nansen	Russia	19	23.3.2015 – 10.4.2015
Celtic Explorer	Ireland (EU)	19	23.3.2015 – 10.4.2015
G.O. Sars	Norway	14	25.3.2015 – 7.4.2015
Tridens	Netherlands (EU)	17	23.3.2015 – 8.4.2015
Magnus Heinason	Faroes	11	25.3.2015 – 8.4.2015

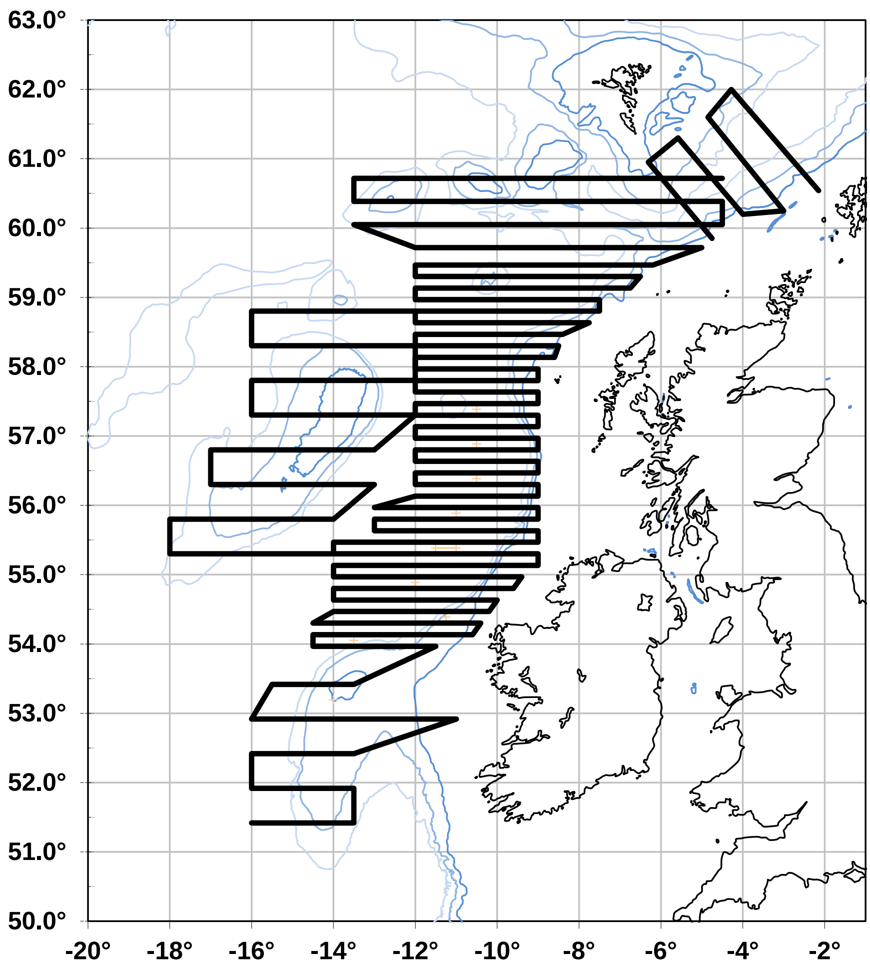

Figure 4.1. Planned survey tracks for the combined 2015 International Blue Whiting Spawning stock Survey (IBWSS).

4.2.3 International ecosystem survey in the Nordic Seas (IESNS)

Denmark (EU-coordinator), Faroe Islands, Iceland, Russia and Norway will participate in the IESNS survey in April-June 2015. Ships and preliminary dates are given in the table below. Survey days exclude time for: hydrographic cross sections, coverage outside the IESNS area and crew change.

Ship	Nation	Survey days*	Preliminary dates
Dana	Denmark (EU)	20	1 May – 23 May
Magnus Heinason	Faroes	12	29 April-12 May
Árni Friðriksson	Iceland	17	29April – 22 May
G.O. Sars	Norway	30	28 April – 3 June
Fridtjof Nansen	Russia	27	15 Mai – 12 June

***estimated effective survey days in the IESNS area**

Following last year's agreed approach, the plan is to use a stratified systematic transect design with random starting points. The strata are shown in Figure 4.2.3.1 and a preliminary suggestion for transects is shown in figure 4.2.3.1. Compared with last year, more survey effort is put into stratum 1, 3 and 4. In addition, Norway will cower two rows of transects across the Norwegian Sea (between Iceland and Norway) in order to collect plankton data from this "cross section". Norway will be the survey coordinator during the cruise. A post-cruise meeting is suggested to be held 16–18 June 2014 in Murmansk (the final decision regarding location will be taken at a later stage).

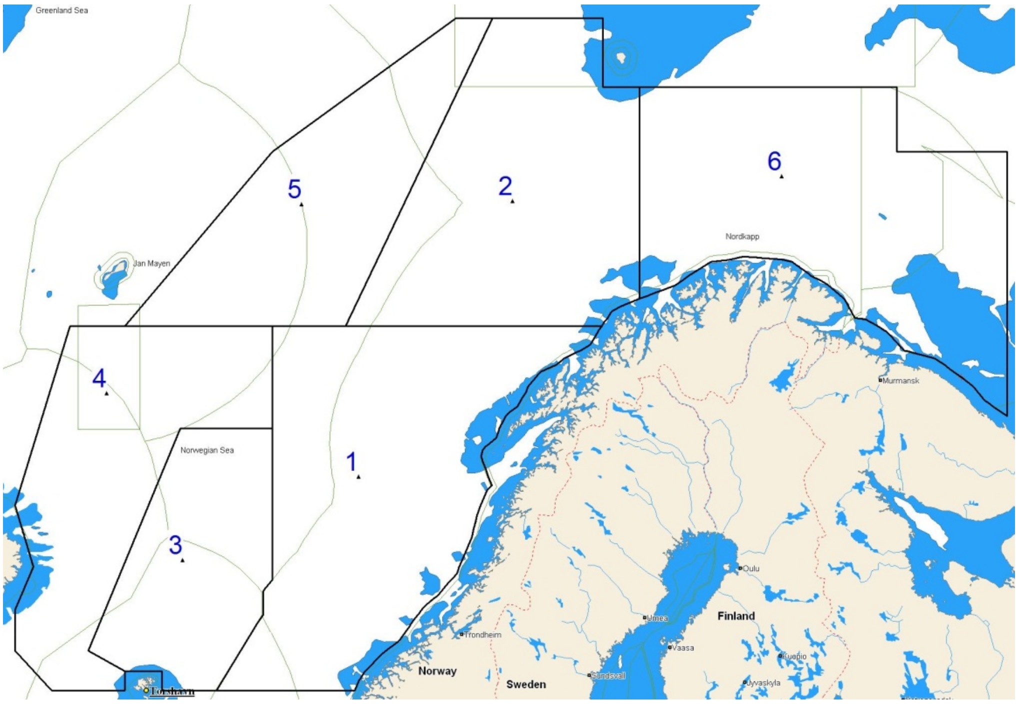

Figure 4.2.3.1. The IESNS strata in the Norwegian Sea and the Barents Sea.

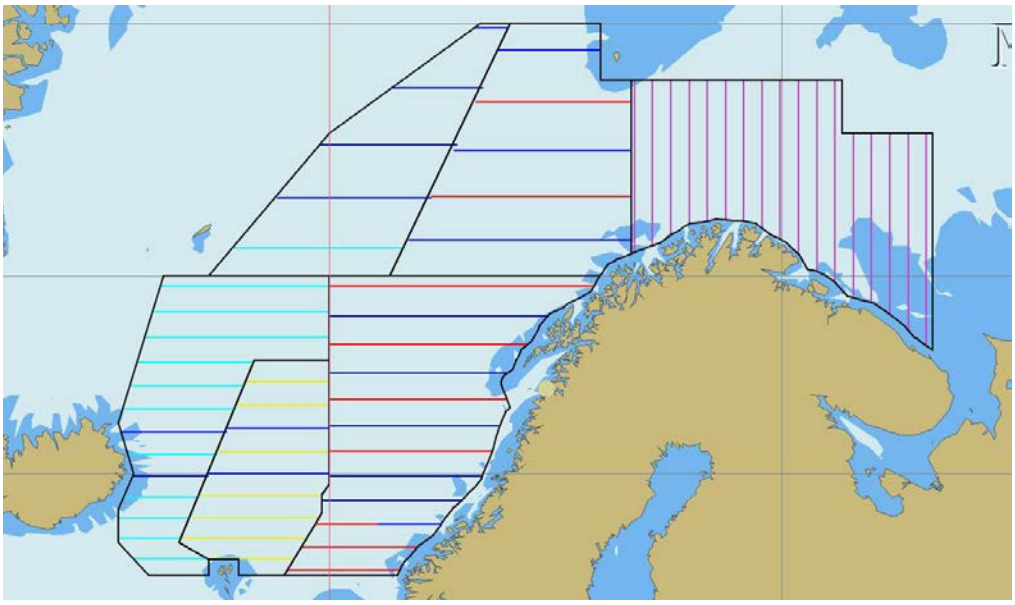

Figure 4.2.3.2. Suggested transects for the IESNS survey in 2015. Colors represent the different vessels/nations (yellow: FO, light blue: IS, dark blue: NO, red: EU, purple: RU).

4.2.4 Coordinated Nordic Seas ecosystem survey (IESSNS) in July–August

The survey in 2015 will be conducted according to the standardized procedures (a specific survey manual will be finished this spring). The preliminary plan is an effort similar to 2014, with two vessels from Norway, one from the Faroese Islands, one from Iceland and one vessel covering Greenland waters. To have an extra vessel surveying Greenland EEZ is under consideration. No survey details have been settled yet but a change in the survey design has been made since 2014 and is discussed below.

The main focus of IESSNS has been to allocate cpue from pelagic trawling to geographical rectangles of 1° lat x 2° lon. This approach has several weaknesses. The most important ones are related to optimal sampling and uncertainty estimates. With the present survey design there is a need for increased sampling in northern regions as the geographical rectangles decrease in area with increasing latitude. In addition is it problematic to provide accurate uncertainty estimates with the present survey design. During the mackerel benchmark in February 2014 a clear recommendation from the group and reviewers was that it should be possible to calculate variance from the swept-area method estimating age-disaggregated abundance of NEA mackerel.

Arguments for using a stratified systematic transect design with random starting points:

- Efficient use of vessel time (area-proportional allocation of effort within each stratum with most effort in strata with highest densities of mackerel)
- Possible to calculate variance for both estimated biomass and number-at-age
- Straightforward to calculate acoustic estimates for herring in each stratum using "text book approach"
- Robust survey design. In cases of unforeseen problems like ship failure or bad weather leading to reduced survey time, expected estimated abundance of mackerel will not be affected. However, estimated variance will probably increase.
- Successful implementation in the 2014 May (IESNS) survey.

A preliminary suggestion of stratified systematic transect design (see Figure 4.2.4.1) consist of altogether eight strata (might evolve during the final planning):

1) Southern and central part of the Norwegian Sea north to 68°N
2) Faroe Islands EEZ
3) Icelandic EEZ south from 62°N to 66°N in the west and limited to east of 16°W east of Iceland
4) Icelandic EEZ north
5) Greenland EEZ north to 68°N, south to 58°N and west to 48°W
6) Jan Mayen and Spitsbergen EEZ north of a line from (70°N, 10°W) to 74°N, 006°E and north of 74°N from 4°E to 20°E.
7) Northern part of the Norwegian Sea north from 68°N to 74°N, from 10°W to 20°E
8) Coastal parts of Norway extending out to 12 nmi.

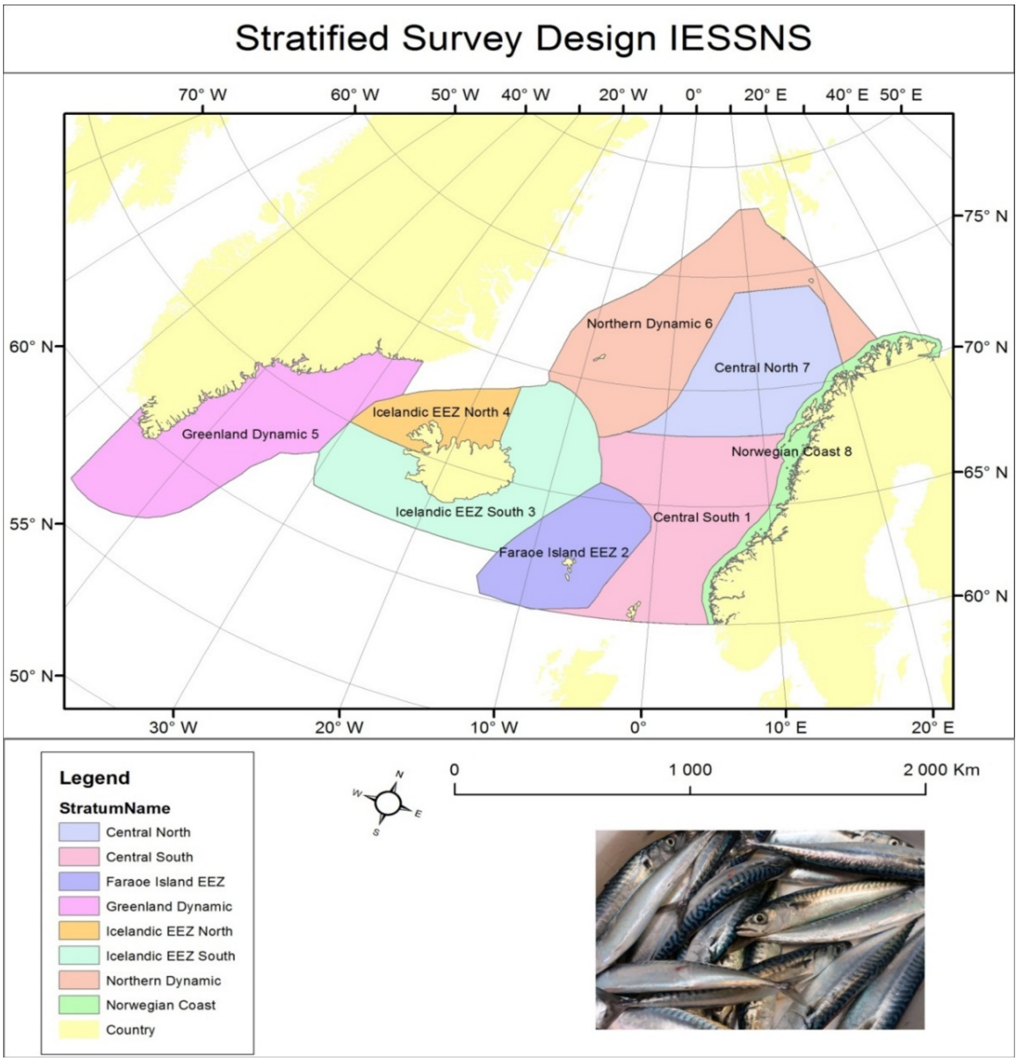

Figure 4.2.4.1. Suggested stratified systematic survey design of the IESSNS.

The optimal survey design would be horizontal random sampling within each strata and allocation of survey time within each stratum according to expected abundance of mackerel in the respective strata. As the survey also estimate herring acoustically the sampling cannot be completely random. Hence, the survey must follow transects within each strata. The position of the first (southernmost) transect within each strata is random and the other transects are then positioned to obtain a fixed distance between transects. In addition, the first trawling station on each transect is randomly placed within the first 60 nmi. The following stations along the transect will be spaced with a fixed distance apart identically as the distance between transects. The transects should either follow an east-west or a north–south gradient within each strata. This doesn’t have to be the same in all strata as they are treated independently of each other, but the two gradients cannot be combined in the same strata. We recommend an east-west gradient for most strata. We also recommend transects going in north–south direction, both in the stratum north and in the stratum south off Iceland (as these will be more perpendicular to the coast than east-west transects). Designing the survey in this way in the south and north within the two Icelandic strata will also ensure proper acoustic data sampling on herring and other pelagic species during the IESSNS survey.

It will also be easier to find and define the zero lines for NEA mackerel when performing north–south transects in these areas. Biological and hydrographic sampling at each station will be identical with the procedure applied in previous IESSNS surveys.

The main idea is to have 5 static strata (number 1, 2, 3 and 7). These will be prioritized and are expected to include the main bulk of mackerel the next years. The other four are dynamic strata with area that changes between years as the horizontal distribution of mackerel changes. Each year before the survey starts the area of the dynamic strata are predetermined based on previous observations and expected horizontal distribution. The dynamic strata should be large enough to include the whole distribution range in these boundary areas, but not include large areas without mackerel. A reasonable approach is to set the dynamic strata slightly larger than the expected horizontal distribution and then to skip sampling in the outermost region if the initial sampling indicates a distribution range as expected. During the IESSNS survey this will typically occur as the trawl catches decrease when moving into colder water masses. Sampling in northern and western regions with water masses too cold for mackerel can then be skipped. Sampling in areas without mackerel will not affect the biomass estimates but is a waste survey time. However, areas with expected distribution of herring need to be covered even if no mackerel is observed. The Norwegian coast is set as a separate stratum as the length distribution and school behaviour in coastal areas deviate from the open ocean. In addition there is a demand for increased focus on mackerel in coastal areas with precise abundance estimates and increased knowledge of ecological interactions.

As figure 4.2.4.1 shows, the initial plan was to divide the Icelandic EEZ into two strata, a northern and a southern part as the areas far to the north were the northeast Icelandic current dominate have low densities of mackerel. As noted above, herring might be located in the cooler water masses north off Iceland, and should therefore be covered. It can be reasonable to spend less time in the northern part and prioritize the southern part. However, following discussions at WGIPS 2015, it is proposed to divided the Icelandic EEZ into four instead of two strata's and to divided the Greenland strata into two. The reason for this splitting is more efficient use of vessel time as the transects should be parallel within each transect.

As a starting point for the final plan for the 2015 survey, the zero line for NEA mackerel is defined as mackerel caught in the Multpelt 832 sampling trawl being less than 10 kg. Other biomass thresholds for defining the zero line can also be possible. If a zero catch is defined by 0 kg catch of mackerel, too much time may be spent during the survey on very limited concentrations of mackerel only to reach the absolute zero-line, which may compromise our overall geographical coverage or sufficient time spent in more high density areas. Transects can be reduced if zero catches are obtained and the water temperature is lower than a pre agreed temperature threshold.

The proposed plan is to apply this strata based survey design for IESSNS in 2015 and onwards. Adjustments of the stratum layouts are possible if considered to be improvements.

4.3 Individual acoustic surveys summary results 2014 and planning for 2015

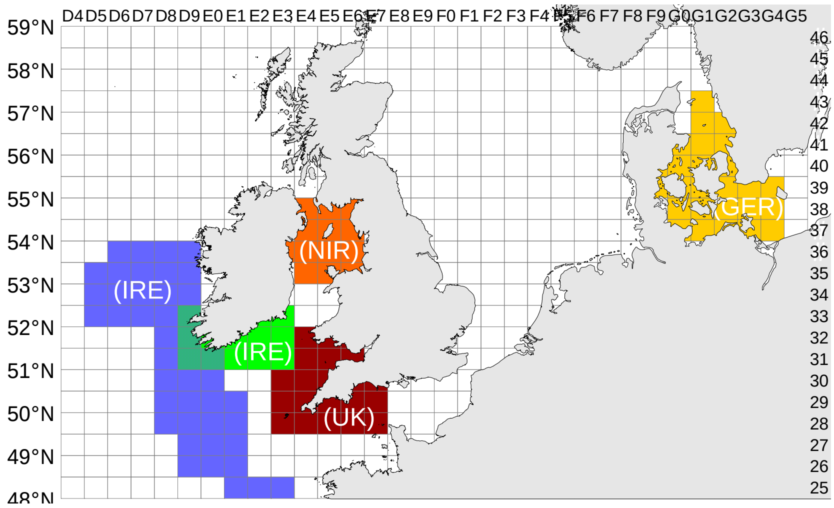

Figure 4.3.1.1. Survey coverage of acoustic surveys planned in 2015 (blue = Boarfish survey BFAS [Ireland]; green = Celtic Sea Herring Acoustic Survey CSHAS [Ireland]; orange = Irish Sea survey [Northern Ireland]; golden = Western Baltic Acoustic Surveys [Germany]; brickred = PELTIC [UK]).

Western Baltic Acoustic survey

This joint German-Danish acoustic autumn survey (GERAS) in the Western Baltic (Subdivisions 21–24) is part of the Baltic International Acoustic Survey (BIAS), conducted within the scope of ICES WGIPS, and traditionally co-coordinated by the Baltic International Fish Survey Working Group (WGBIFS). The survey supplies the ICES Herring Assessment Working Group for the Area South of 62°N (HAWG) and Baltic Fisheries Assessment Working Group (WGBFAS) with an index value for the stock size of herring (Western Baltic Spring Spawners, WBSS) and sprat in the Western Baltic area. The survey was carried out with FRV "SOLEA" during 30 September – 19 October 2014 and is reported in full in Annex 6a. Main results are summarized below.

The 2014 GERAS survey was the 27th survey in the time-series. Calibrated acoustic data were recorded with a hull-mounted EK60 Simrad scientific echosounder operated on two frequencies (38 and 120 kHz). Pulse duration was set to 1.024 µs and ping interval was set to 0.3 s-1 for all frequencies. Target species abundance was determined using data from the 38 kHz transducer. Data on species composition and biological data for the target species were collected from trawl hauls conducted with a PSN388 pelagic trawl. Vertical profiles of temperature, salinity and oxygen concentration were measured with a CTD-probe on 80 stations.

Results

Survey operations were carried out during night-time to take account of the more pelagic distribution and better catchability of target species during that time. However, to compensate for a loss of survey time due to medical issues, acoustic recordings were also conducted during daytime in SD 21 at the end of the survey in order to accomplish survey work in the designated survey area. Weather conditions were generally favourable allowing collection of high quality acoustic data. Altogether, 1,217 nm of acoustic transects were sampled covering a survey area of 13,206 nm^2. A total of 59 trawl hauls were made (Figure 4.3.1.1), of which 58 contained herring and 56 contained sprat.

Fish distribution patterns were similar to previous years. In the majority of rectangles surveyed, mean NASC values per nautical mile were above the long-time survey average. In SD 24 however, the average NASC measured was distinctly lower than in the previous year and also lower than the long-time mean. In SD 23 (Sound), the usual large aggregations of big herring were also present during the 2014 survey. Mean NASC values in the area however significantly exceeded previous year measurements and the long-time survey average. Resulting fish abundance and biomass was estimated as follows: The herring stock in Subdivisions 21–24 (inc. Central Baltic Herring, CBH) was estimated to be 12.3 x 109 fish with a biomass of 397.6 x 103 tonnes. For the included area of Subdivisions 22–24 the number of herring was calculated to be 4.5 x 109 fish with a biomass of 312.1 x 103 tonnes. Altogether, compared to previous results the present estimates of herring (incl. CBH) show a significant increase in abundance (-62% in SD 22–24, -6% in SD 21–24) and biomass (+22% in SD 22–24, +36% in SD 21–24) respectively. Removal of the CBH fraction from herring survey indices in 2014 resulted in total biomass reductions of ca. 0.8% with a corresponding reductions of 0.7% in numbers as compared to the estimates including CBH. As in former years, young herring dominated the stock, but in 2014 a significant increase in larger and older fish (≥4 wr) was also evident. The sprat stock in Subdivisions 21–24 was estimated at 18.8 x 109 fish or 128.9 x 103 tonnes. For the included area of Subdivisions 22–24 the number of sprat was calculated to be 18.7 x 109 fish or 118.5 x 103 tonnes. The overall abundance estimate was dominated by the incoming year class.

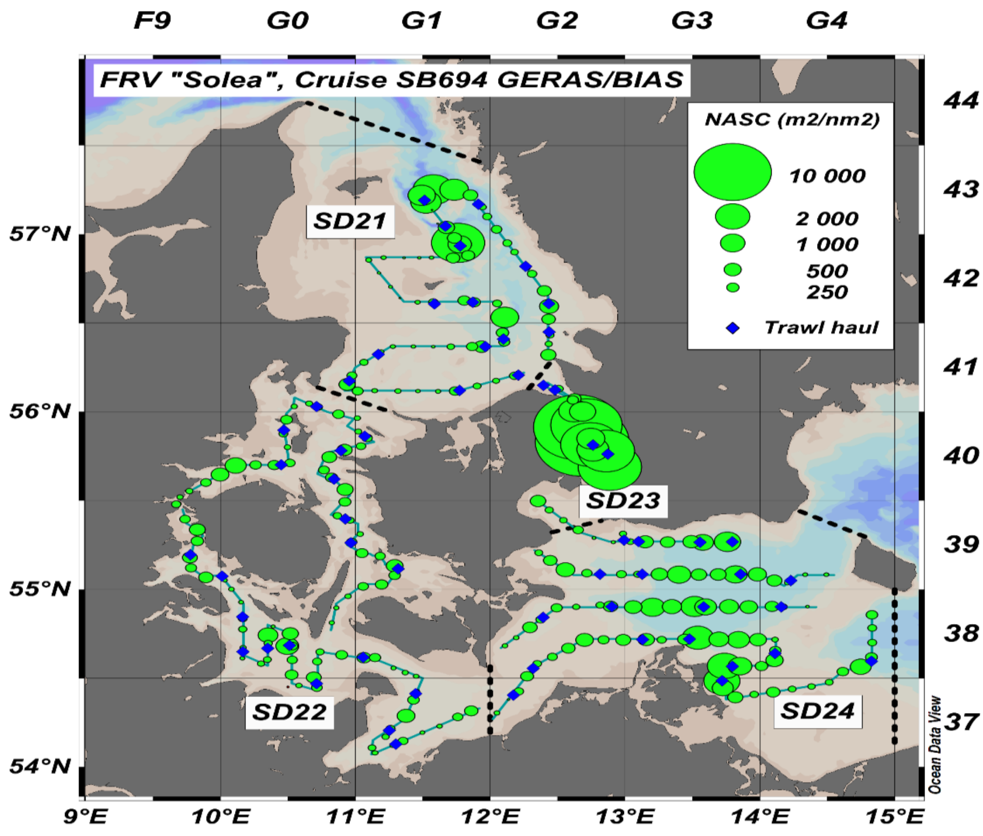

Figure 4.3.1.1. FRV "Solea" cruise SB694, GERAS/BIAS. Cruise track (blue line), trawl hauls (blue diamonds) and mean NASC (m^2 nm^{-2}) per 5nm EDSU (bubbles).

4.3.1 Irish Sea acoustic survey

Acoustic surveys of the northern Irish Sea (ICES Area VIIaN) have been carried by the Agri-Food and Biosciences Institute (AFBI), formerly the Department of Agriculture and Rural Development for Northern Ireland (DARD), since 1991. The survey reported here, coordinated by WGIPS, was carried out during 28 August 2013 to 13 September 2013. The main results of the survey are summarized below and reported in full in Annex 6b. The survey was repeated in 2014; at present analysis of these data are ongoing.

Results

Sampling intensity was high during the 2013 survey with 41 successful trawls completed. In total forty hauls contained herring, but only 20 hauls contained large numbers/proportions of herring. The resulting weight-length relationship for herring was calculated from the sampling information as W = 0.00273*L3.343 (length measured in cm). The age length key used indicated that the population is composed of juveniles and adult fish (age 0–11). The estimated biomass and number of herring was 123,407 t and sprat 197,510 t. A full breakdown of biomass by strata is given in Annex 6b.4. The total number estimate comprises of ~94% age 0, ~1% age 1, ~3% age 2, ~1% age 3, ~1% age 4 and <1% age 5+.

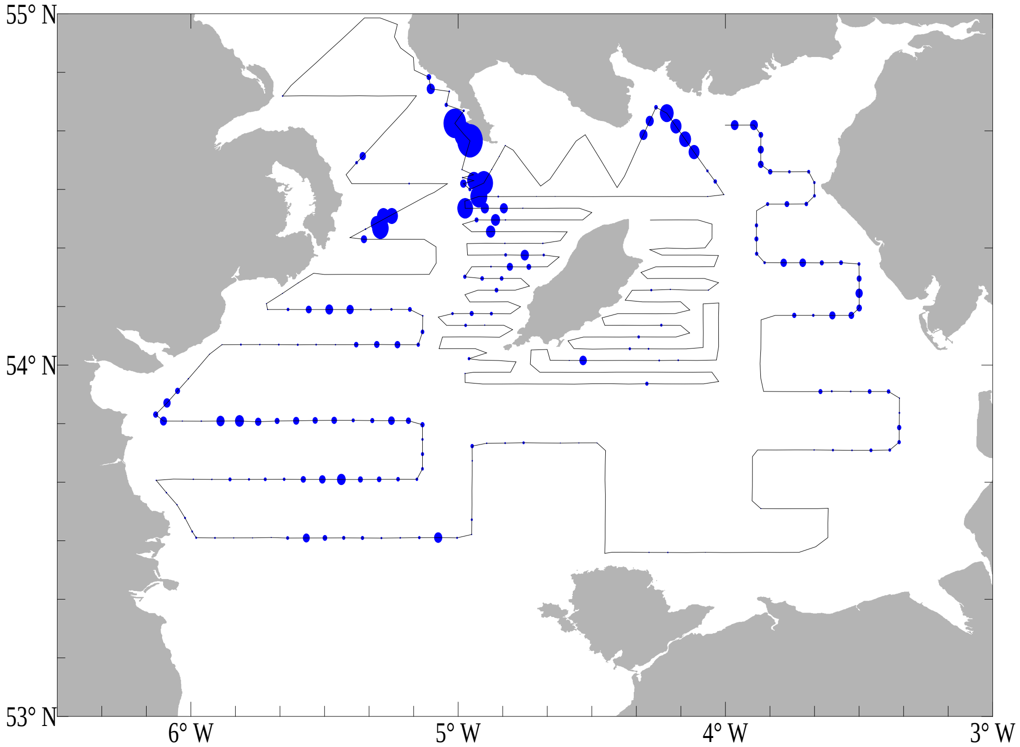

Figure 4.3.2.1. Map of the Irish Sea and North Channel with a post plot showing the distribution of NASC values for assigned herring only (size of ellipses is proportional to square root of the NASC value per 15-minute interval) obtained during the 2013 acoustic survey on RV "Corystes" (maximum value was 6500).

The major contribution of ages to the total estimates is from ages 0 fish by number and weight. The estimated total herring stock (123,407 t or 1.0 x 1010 individuals). The herring were fairly widely distributed within mixed schools at low abundance, with a few distinct high abundance areas. The largest herring aggregations were found northwest of the Isle of Man and off the Northern Ireland coast. Sprat and 0-group herring were distributed around the periphery of the Irish Sea, with the most abundance of 0-group herring in the northeast. The bulk of 1+ herring targets in 2013 were observed north of the Isle of Man and off the Mull of Galloway, with a fairly scattered lesser abundance observed throughout the Irish Sea (Figure 4.3.2.1). The length frequencies generated from these trawls highlight the spatial heterogeneous nature of herring age groups in the Irish Sea.

The estimate of herring SSB of 55 350 t for 2013 is similar to the 2012 estimate. The biomass estimate of 65 649 t for 1+ ringers is, however, lower than the 2012 estimate and a significant reduction from the 2010 and 2011 estimates, which were the highest in the time-series. More than a third of the 1+biomass estimate was to the north of the Isle of Man. This is an area of mixed size fish and the survey was mismatched with the migration of the main spawning biomass, as indicated by the high abundance of herring observed by the fishery on the Douglas Bank post survey. Results of a successive acoustic survey conducted later in September confirmed this. The evidence of higher abundance of spawning herring suggests poor reflection of the current age structure and abundance of the herring population in the Irish Sea.

4.3.2 Celtic Sea herring acoustic survey (CSHAS)

The survey was carried out from the 6–26 October 2014 and is reported in full in Annex 6c. The main results of the survey are summarized below.

Results

The survey covered all core strata using approximately 2,623 nmi of transects for acoustic integration. The experimental strata conducted in 2013 to the east of the core area could not be repeated due to slow progress in rough weather during the second half of the survey.

In stark contrast to previous years, 99% of observed herring biomass was recorded offshore in the southeast corner of the survey area (Figure 4.3.3.1). Within this area, clusters of large, high density herring echotraces dominated. They were located both in midwater and in contact with the seabed. To the northwest, near Cork Harbour, a number of medium and low density echotraces were attributed to herring in a mixture but the proportion was very low and the stratum contributed very little to the overall biomass estimate.

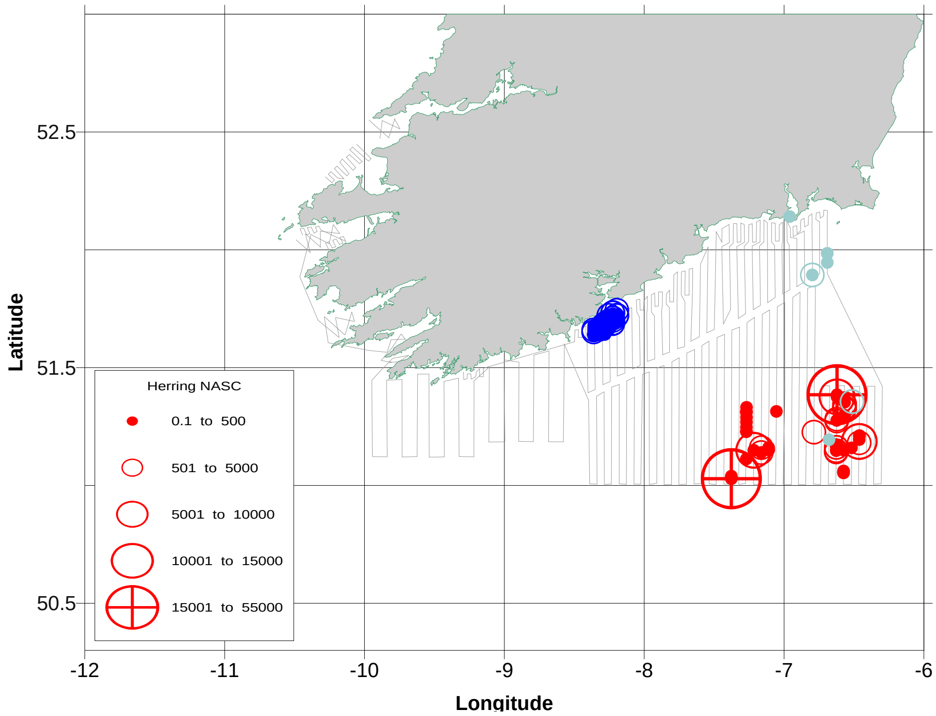

Figure 4.3.3.1. NASC plot of herring distribution in the Celtic Sea, 2014. Weighted herring NASC (Nautical area scattering coefficient) plot of the distribution of "definitely" and "probably" categories (red circles), "mixed herring" (blue) and "possibly herring" (teal).

Herring TSB (total-stock biomass) and abundance (TSN) estimates were 46,952t (CV 60.2%) and 408 million individuals (CV 59.1%) respectively. The overall SSB (spawning-stock biomass) observed during the survey was 47,496t (CV 60.2%), composed of a spawning abundance (SSN) of 372 million individuals. The high CVs can be attributed to the clustering of the large schools. The average CV of this survey over the previous decade is 29%.

A total of 19 trawl hauls were carried out during the survey with 6 hauls containing herring, 3 of which contained >50% herring by weight of catch. A total of 206 herring were aged from survey samples in addition to 1,455 length measurements and 310 length-weights recorded. Herring age samples ranged from 0–9 winter-rings.

The 2 and 3 winter-ring age groups dominated the 2014 estimate, representing 23% and 28% of TSB respectively (29% and 28% of TSN). The 4 winter-ring age group was ranked third, representing 21% of TSB and 17% of TSN. No 0 winter-ring herring were encountered and the 1 winter-ring group contributing just 6% to the TSB and 10% to TSN. Age ranking for 2013 estimate: 1, 2 and 3 winter rings respectively. The proportion of older fish (5–9 winter rings) represented in the total biomass was 23% as compared to 8.5% in 2013.

Maturity analysis indicated over 95% of the TSB as sexually mature. The vast majority of herring sampled during the survey were in a prespawning state, stages 3–4. No spent fish were observed, which is consistent with the dominant winter spawning stock component.

It is clear that at the time of the 2014 survey the herring had not yet reached the spawning grounds and were still migrating northwards from the summer feeding grounds (Figure 4.3.3.1). It is also likely, judging by the low biomass estimate compared to recent years (Table 4.3.3.1), that an unknown portion of the stock still lay outside the survey boundary. These bounds could not be extended during the survey without compromising coverage in core spawning areas. This has resulted in the lowest biomass estimate since 2007 (with a coefficient of variation over twice the average) that is not directly comparable to previous years. The lack of stock containment due to the late arrival of spawning fish and the low precision associated with the biomass estimate means the utility of the 2014 CSHAS data are highly questionable.

Three pieces of anecdotal evidence complement the above views. It is hypothesized that 1 winter ringed herring move from the southern Irish Sea and join the older age groups in the spawning areas on the south coast of Ireland. This is usually apparent in the age profile of the herring sampled during the CSHAS but very few 1 winter ringed herring were observed in 2014, when 99% of the surveyed stock was still offshore. However, catches of very small herring were reported from a handful of commercial vessels fishing to the northeast of the CSHAS grid, near the southern extreme of the Irish Sea. Finally, echograms of extremely large fish schools, almost definitely herring, were also relayed by a commercial vessel from an area where only one week earlier no herring had been registered by the Celtic Explorer. These fish most likely travelled from south of the survey grid in the intervening time.

Table 4.3.3.1. Celtic Sea herring acoustic survey time-series. (Abundance (millions), TSN and SSB (000's tonnes).

Season	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Age (Rings)	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
0	202	3	-	0	-	25	40	0	24	-	2	-	1	2	239	5	0.1	31	3.8	0
1	25	164	-	30	-	102	28	42	13	-	65	21	106	63	381	346	342	270	698	41
2	157	795	-	186	-	112	187	185	62	-	137	211	70	295	112	549	479	856	291	117
3	38	262	-	133	-	13	213	151	60	-	28	48	220	111	210	156	299	615	197	112
4	34	53	-	165	-	2	42	30	17	-	54	14	31	162	57	193	47	330	43.7	69
5	5	43	-	87	-	1	47	7	5	-	22	11	9	27	125	65	71	49	37.9	20
6	3	1	-	25	-	0	33	7	1	-	5	1	13	6	12	91	24	121	9.8	24
7	1	15	-	24	-	0	24	3	0	-	1	-	4	5	4	7	33	25	4.7	7
8	2	0	-	4	-	0	15	0	0	-	0	-	1	-	6	3	4	23	0	17
9	2	2	-	2	-	0	52	0	0	-	0	-	0	-	1	-	2	3	0.2	1
Abundance	469	1338	-	656	-	256	681	423	183	-	312	305	454	671	1,147	1,414	1,300	2,322	1,286	408
SSB	36	151	-	100	-	20	95	41	20	-	33	36	46	93	91	122	122	246	71	48
CV	53	26	-	36	-	100	88	49	34	-	48	35	25	20	24	20	28	25	28	59.1

Planning for 2015

The 2015 CSHAS survey will take place from the 2 – 22 October and will be undertaken on-board the RV *Celtic Explorer* following principle historic strata.

4.3.3 Boarfish acoustic survey (BFAS)

A two vessel acoustic survey (RV *Celtic Explorer* and MFV *Felucca*) was undertaken in June/July 2014 covering the shelf seas from 58′30°N to 47°′30N to estimate the abundance and distribution of boarfish spawning aggregations. Surveys were timed to ensure a continuous, quasi-synoptic, coverage of the combined area from north to south. This survey is the third (excluding 2011- 24hr coverage) survey in the time-series.

The survey cruise report, including biomass and abundance is presented in Annex 6d and summarized below.

Results

The survey was carried out from 04:00–00:00 each day in line with the RV *C. Explorer* to coincide with the hours of daylight when boarfish are most often observed in homogenous schools. In total 3,552nmi (nautical miles) of cruise track was undertaken by both vessels using 130 transects relating to a total area coverage of 56,202nmi^2. Transect spacing was set at 15nmi for the FV *Felucca* and 7.5nmi for the *C. Explorer* component.

No inter-vessel acoustic inter-calibration exercise was carried out this year due to time constraints.

Twenty one hauls (*Felucca:* 18; C. *Explorer*: 3) were carried out during the survey 12 of which contained boarfish. In total, 3,160 lengths and 1,102 length/weight measurements were taken for boarfish in addition to 397 individual boarfish otoliths collected for aging.

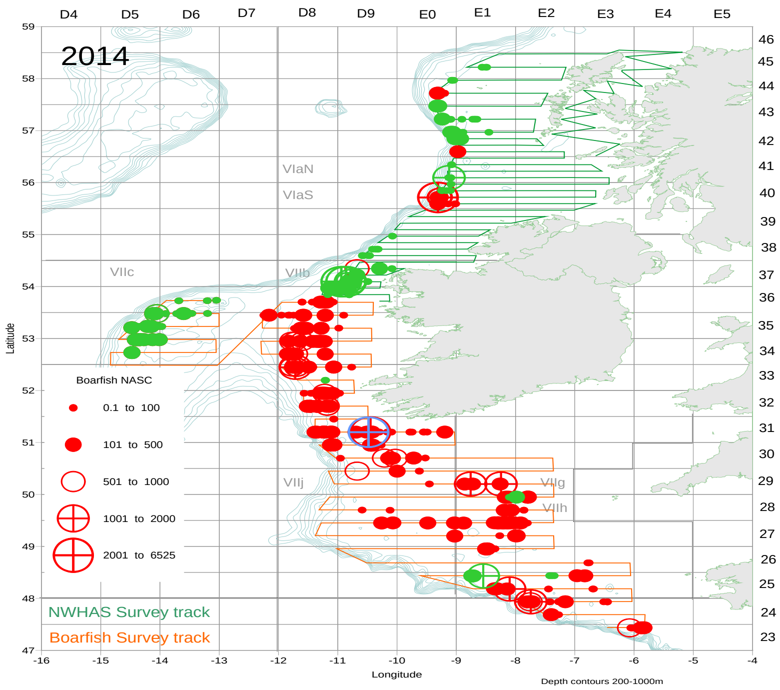

Figure 4.3.4.1. NASC plot of boarfish distribution 2014. Red: 'definitely', blue: 'probably', green: 'mixed boarfish echotraces'

A total of 611 boarfish echotraces were identified during the survey (Figure 4.3.4.1). Of this 71% were categorized as 'definitely' boarfish, 27% as 'probably' and 1% 'boarfish in a mixture'. A total of 66 ICES rectangles were covered by the survey representing combined area coverage of 56,202nmi², a decrease of 1% from 2013.

Of the biomass observed in 2014 the southern area contained the largest proportion of stock biomass (over 39%), ranking second was the western area where 36% of biomass was recorded. The northern area and Porcupine Bank contributed 17% and 8% respectively.

Age distribution as determined from survey samples indicate that the stock is dominated by the following age classes in terms of biomass: 15+, 7, 10 and 9 year old fish representing over 66% of the total biomass and 15+, 7, 8 and 9 years in terms of abundance.

Immature fish were observed in all survey regions albeit in small numbers. Immature boarfish (< 9.7 cm TL) were observed in the highest abundance in the southern (0.1% of biomass and 0.16% of abundance) in line with previous observations. Some of the largest fish were again observed in the northern and western survey areas with more mixed length cohorts further south.

Overall, the total-stock biomass was 57% lower than at the same time in 2013 while survey effort, geographical coverage and timing remained unchanged. Observed biomass was lower in all areas with the exception of the northern area and this was due to the more northward distribution of the stock than in previous years. The most pronounced change in biomass was noted in the southern area (down by c.200,000t from 2013) which is the largest geographically and has previously contained upwards of 60% of the stock.

The stock was considered to be well contained within the survey area, the northward distribution was bounded by the surveys northern limits and a relatively small amount of biomass was observed along the southern most transect. Information from the Ifremer PELGAS acoustic survey in the Bay of Biscay (May-June) confirms that low abundances of boarfish were observed overall and particularly in northern Biscay (overlap area), supporting the boarfish distribution observed.

Table 4.3.4.1. Boarfish acoustic survey time-series. Note: 2011 pilot survey was conducted over 24hrs, from 2012 onwards the survey was conducted during daylight hours.

Age (Yrs)	2011	2012	2013	2014
0	-	-	-	-
1	4.9	21.5	-	-
2	11.3	10.8	78.0	-
3	54.2	174.1	1,842.9	15.0
4	176.0	64.8	696.4	98.2
5	404.7	95.0	381.6	102.3
6	1,068.0	736.1	253.8	104.9
7	1,052.0	973.8	1,056.6	414.6
8	632.5	758.9	879.4	343.8
9	946.1	848.6	800.9	341.9
10	831.8	955.9	703.8	332.3
11	259.7	650.9	263.7	129.9
12	457.2	1,099.7	202.9	104.9
13	281.7	857.2	296.6	166.4
14	257.2	655.8	169.8	88.5
15+	1,746.0	6,353.7	1,464.3	855.1
TSN (mil)	8,183	14,257	9,091	3,098
TSB ('000t)	456,115	863,446	439,890	187,779
SSB ('000t)	455,375	861,544	423,158	187,654
CV	17.5	10.6	17.5	15.1

Planning for 2014

The 2015 BFAS survey will take place from the 10 – 31 July (TBC) and will be undertaken onboard a charter vessel. The northern component (Malin Shelf survey) will run from the 22–12 July. Both surveys will use the same dates as in 2014 and covering the same geographical area.

4.3.4 Pelagic ecosystem survey in the Western Channel and eastern Celtic Sea (PELTIC)

A 20 day multidisciplinary pelagic survey was undertaken in the western English Channel and Eastern Celtic Sea between the 30 September and 19 October 2014 to acoustically asses the biomass of the small pelagic fish community within this area (Divisions VII e-g). This survey, conducted from the RV Cefas Endeavour, is the third of a series of five annual acoustic surveys studying the small pelagic fish guild, its habitat, dynamics and the pelagic ecosystem in autumn as part of project POSEIDON, funded by the UK government. The survey is divided into three geographically separated strata: the western English Channel, the Isles of Scilly and the Bristol Channel (Figure 4.3.5.1). The pelagic fish community is surveyed using a combination on fisheries acoustics and pelagic trawling. Comprehensive sampling of the plankton community was conducted at 70 stations, using 2 ringnets, different mesh. A mini CTD was mounted on the ringnet rig providing vertical profiles of temperature and salinity and a further 40 dedicated casts with a Rosette/CTD were taken to provide high resolution oceanographic data on the water column.

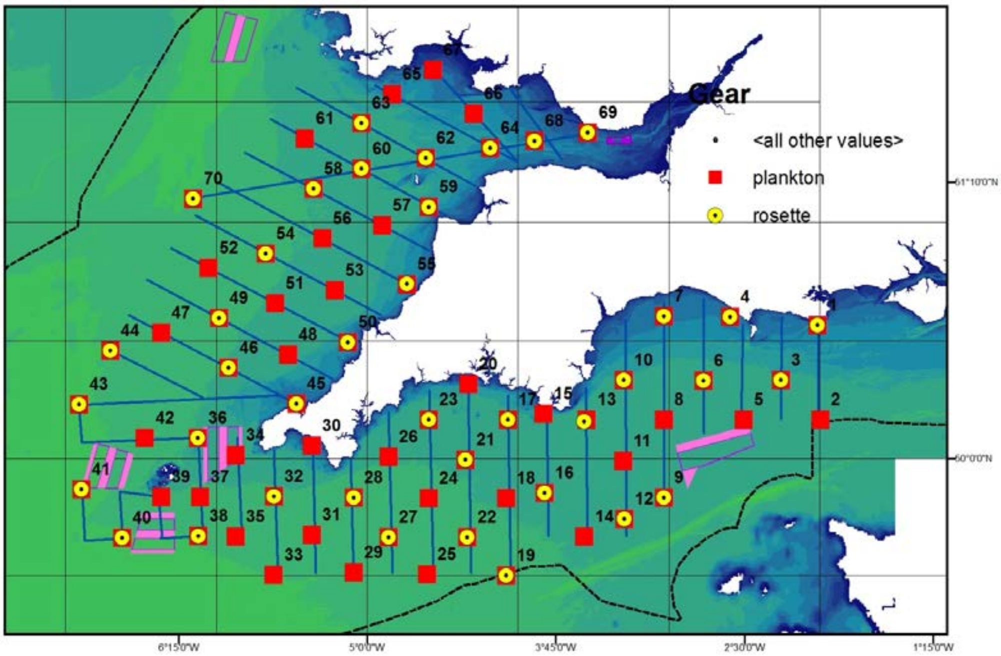

Figure 4.3.5.1. Survey design with acoustic transects (blue lines), zooplankton stations (red squares) and oceanographic stations (yellow circles).

A parallel transect design was used with transects running perpendicular to the coastline and bathymetry within each strata. Offshore extension reached up to 60 nmi (nautical miles) offshore. Inter-transect distance was set at 10nmi for the entire survey. Calibrated acoustic data were collected during daylight hours only (unlike the 24 hour sampling regime in 2012 and 2013) over three frequencies (38, 120, 200 kHz) from transducers mounted on a lowered drop keel at 8.2m below the surface. Pulse duration was set to 0.516 ms for all three frequencies and the ping rate was set to 0.6 s^{-1} as the depth did not exceed 100 m. Data from 38 kHz was used to determine target species abundance for all swimbladder fish and from the 200 kHz for mackerel.

Preliminary Results

As the survey was only recently completed acoustically derived abundance estimates for the various species are not yet available. A general description is provided here (more details in Annex 6e). Acoustic data were generally of very high standard given the generally favourable weather conditions. For the few days where adverse weather negatively impacted the data quality, an algorithm was used in post-processing to filter out empty pings due to surface aeration. After removing the off-transect data a total of ~1400 nautical miles of acoustic sampling units were collected for further analysis. To distinguish between organisms with different acoustic properties (echotypes) a multifrequency algorithm was developed, principally based on a threshold applied to the summed backscatter of the three frequencies, eventually resulting in separate echograms for each of the echotypes. For mackerel a separate dedicated algorithm was used.

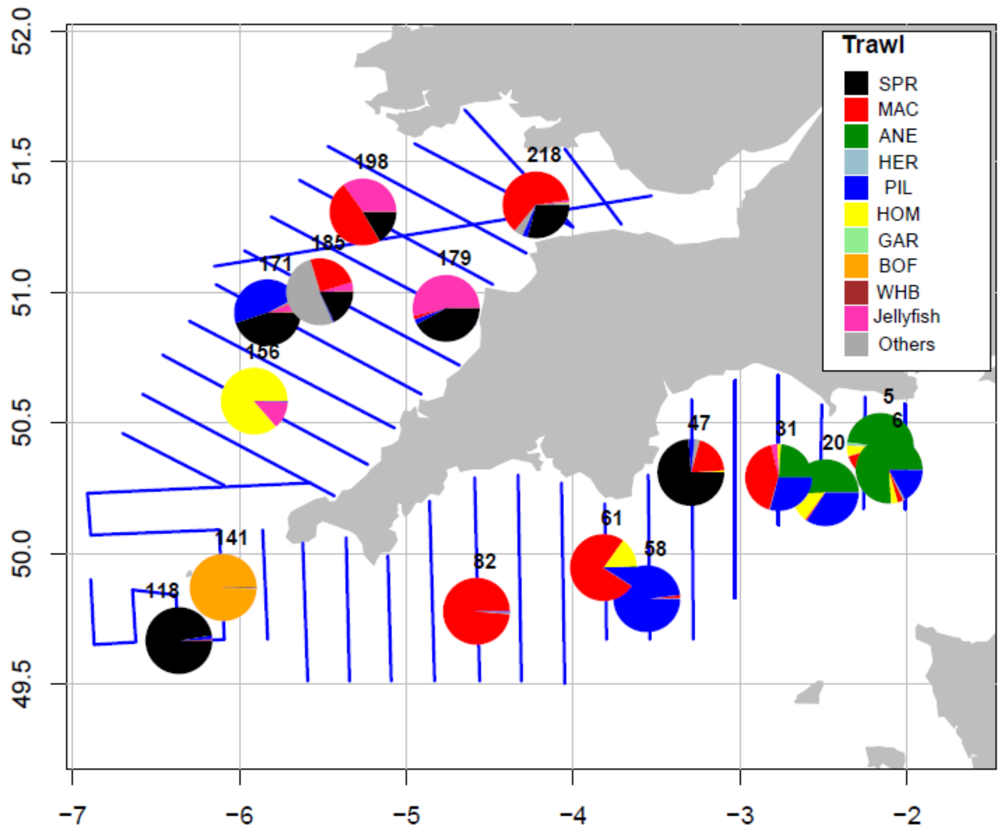

Figure 4.3.5.2. Overview map and detail of the survey area. Acoustic transects (blue lines) and trawl catches (pies) with relative catch composition by key species. Three letter codes: SPR=sprat, MAC=mackerel, ANE=anchovy, HER=herring, PIL=sardine, HOM= horse mackerel, GAR=garfish, BOF=Boarfish, WHB=Blue whiting.

A total of 16 trawls were made (Figure 4.3.5.2). Geographically they were evenly spread, providing a suitable source of species and length data to adequately partition the acoustic data. At times there was no opportunity to trawl for various reasons: presence of large amounts of static gear, target schools tight to the seabed, and adverse weather conditions. Sprat (*Sprattus sprattus*) was the dominant small pelagic species, with highest densities in the eastern parts of the western Channel and the Bristol Channel. As in previous two years, large schools in the Bristol Channel appeared to consist mainly of juvenile sprat, whereas those in the English Channel also included larger size classes. For the first time sprat were found in deeper waters around the Isles of Scilly and large offshore aggregations mixed with sardine in the Bristol Channel. Sardines (*Sardina pilchardus*) were much more widespread than in previous years according to the trawl stations, with predominantly juvenile specimens found in most hauls, including around the Isles of Scilly and offshore in the Bristol Channel. For the first time large spawning aggregations were observed in the acoustic data of the western channel. Mackerel (*Scomber scombrus*) observations appeared to be in line with those in 2012 when only small numbers of juvenile mackerel were found. None of the very large mackerel schools as seen in 2013 were observed in the western channel this year despite the large overlap in timing of the surveys. Anchovy appeared in larger numbers than in previous years and geographically specimens were found more widespread than solely in Lyme Bay. However three length classes could be identified in the catches with good numbers of large fish. Horse mackerel (*Trachurus trachurus*) and herring (*Clupea harengus*) were found in the study area although not in dense schools, but mixed in with other small pelagic species. Herring typically displayed a more coastal distribution whereas horse mackerel were found pretty much across the entire study. Boarfish (*Capros aper*) was found in the in the deeper waters (>75m) around the Isles of Scilly. Good numbers of sardine eggs and larvae were observed further highlighting the importance of the area as a spawning ground. Physical oceanographic conditions were different again from previous year with warm conditions and strong frontal systems present.

Table 4.3.1.1. Preliminary planning table for individual surveys in 2015.

Survey	Vessel	Timing 2015	Area	Rectangles
GERAS/BIAS (GER)	Solea	01 – 21 October	SD 21–24	43G1-G2, 42G1-G2, 41G0-G2, 40F9-G2, 39F9-G4, 38G0-G4, 37G0-G4
BFAS (IRE)	Commercial charter	10 – 31 July	53°30′-58°30'N ,12°-5°W	36D6, 8-D9, 35D5–9, 34D5–9, 33D5–9, 32D8–9, 31D8–9, 31E0, 30D8-E0, 29D8-E1, 28D8-E1, 27D8-E1, 26D9-E1, 25E1–3, 24 E2–3
ISAS (NIR)	Corystes	27 August - 13 September	53°-55°N, 6°-3°W	35E4-E6, 36E3-E6, 37E4-E6, 38E4-E6
CSHAS (IRE)	Celtic Explorer (IRE)	02 – 22 October	51°-52°30'N ,11°-6°30W	33D9, 33E2-E3, 32D9-E3, 31D9-E2
PELTIC (UK)	Cefas Endeavour	03–20 October	49° 30–51° 45'N 7° - 2° W	28E3-E7, 29E3-E7, 30E3-E7, 31E4-E6, 32E4-E6

4.4 Delivery of and addressing recommendations from other groups

Recommendations directed for the attention of WGIPS coordinated surveys through ICES and also from outside groups have been investigated and are replied to below:

4.4.1 Request from Spain to join the IBWSS program in 2015

In response to the request from Spain to accommodate the RV 'Vizconde de Eza' into the IBWSS program discussions were undertaken during planning for the 2015 International survey. It was agreed by the group that the utility of an additional vessel within the established survey program, north of the 52ºN line of latitude, would not be of benefit to the existing program. However, in light of the recent research on blue whiting stock structure (Pointin and Payne, 2014, Keating *et al.*, 2014, Was *et al.*, 2008, Brophy and King, 2007) in support of the existence of a second blue whiting population spawning south of the 52ºN line of latitude, then the group agreed that an additional new survey focusing specifically on this southern population would be of benefit in expanding the knowledge of blue whiting in the Northeast Atlantic. It is suggested that current acoustic observations (IBWSS) are not capable of resolving both populations, as they occur too late in the year and do not extend sufficiently far south to cover the southern population (Pointin and Payne, 2014). Due to the temporal mis-match with the current IBWSS survey program it is suggested that a new survey program is established targeting spawning aggregations south of the 52ºN line of latitude. Expertise within the IBWSS survey group would be readily shared with the new survey in terms of survey design, planning and data analysis.

4.4.2 HAWG, Quality considerations for HERAS

HAWG recommends that acoustic and larval surveys used for the stock assessments should go through an annual evaluation to better advise on the particular aspects of surveys that may influence the assessment model fitting process. The quality of surveys in terms of fulfilling the objectives of providing an independent abundance index for stock assessment purposes should be evaluated and commented on. This should include consideration on the internal consistency and the interannual variability of the survey abundance index; highlight issues that might result in year effects that are independent of changes in stock abundance. Clear advice should be given on any issues that could potentially invalidate the use of the survey information for stock assessment. This also applies to the evaluation of the quality of biological parameter estimates.

A section on quality considerations on survey results will be included in this years combined HERAS survey report (Annex 5c) addressing issues possibly affecting survey results.

A workshop on evaluating current national acoustic abundance estimation methods for HERAS surveys (WKEVAL), chaired by Ciaran O'Donnell, Ireland, will be established for a single meeting and will meet in ICES, Copenhagen, 24–28 August 2015. The detailed aims of the workshop are presented in Chapter 8 of this report.

The new database and standardized common analysis tool to be implemented across all coordinated survey will in future allow for the calculation of uncertainty estimates around annual survey estimates

4.4.3 HAWG, Stock identification

HAWG recommends that the sprat stock structure around the British Isles, Kattegat and Skagerrak plus the surrounding fjords are examined for stock structure. The request is for an identification of the number distinct stocks and their boundaries so that adequate assessment and management of this species within the ICES area can be undertaken. The lack of information on stock boundaries is well known, has been highlighted in the past and was raised as a major issue at the 2013 bench mark (WKSPRAT). Without this information assessment, management and advice of these stocks will remain imprecise. Stock identification falls outside the remit of this group but WGIPS will provide support to deliver metrics to aid stock identification where possible.

4.4.4 WKPELA, Solar elevation angle in IESSNS

Mackerel - The International Ecosystem Survey in the Nordic Seas (IESSNS). For next benchmark: Look at impact of solar elevation angle as measure of daytime and weather conditions etc. instead of a simple two state parameter. Look at the method for calculating CVs – There is doubt about the current estimates as these were all similar.

The survey design will change from 2015 and follow the same setup as IESNS with the survey area divided into a set of strata. The approach for calculating age separated indices used in the assessment will change from rectangle based calculations in R to strata based calculations using the newly developed software StoX. By doing the calculations in StoX, age specific CVs can be obtained.

Since 2014 light intensity measurements have been sampled continuously on all vessels during IESSNS. Data on wave height have been recorded for several years. Data on both light intensity and wave height will be sampled during IESSNS in 2015.

4.4.5 WKPELA, Abundance of 6+ mackerel in HERAS

Mackerel - The International Ecosystem Survey in the Nordic Seas (IESSNS): In order to quantify the abundance of 6+ fish in the North Sea (using IBTS and HERAS acoustic information as presented in the report) trawl samples are needed. Calculate true swept-area (Use average trawl width measures for every single haul) – Recalculate the index and compare with the current index. Pre- IBP (explore the effective tow time during fishing – fish may enter the net at hauling etc.

IMARES to collect these data for future HERAS surveys when the necessary trawl monitoring sensor suite becomes available nationally. Additionally, EU participation in future IESSNS survey is being tabled.

4.4.6 WKPELA, Calculation of swept-area in IESSNS

Mackerel - The International Ecosystem Survey in the Nordic Seas (IESSNS). Before a possible Inter benchmark: Calculate true swept-area (Use average trawl width measures for every single haul) – Recalculate the index and compare with the current index. Pre- IBP (explore the effective tow time during fishing – fish may enter the net at hauling etc.)

It is not realistic to measure the actual trawl width for each haul preformed during the IESSNS. Optimal measurements of trawl geometry would require employing a trawl sensor requiring a cable connection to the ship, which is not possible to use during surface trawling. Instead of measuring trawl width for every haul the focus will be on following the trawl protocol to every detail. If the trawl procedure is fully standardized the trawl width should be fairly constant for all tows.

Personnel at IMR are working on calculating the efficient towing time. Preliminary results indicate that the efficient trawl time is no longer the actually employed trawl time.

4.4.7 WKIDCLUP, Clupoid larval identification

WKIDCLUP recommends to investigate the effect of the low agreement in clupeoid larval identification on the herring assessment.

WGIPS recommends forwarding this recommendation to the IBTS Working Group for further investigation.

WKIDCLUP, Collection of clupoid larvae

WKIDCLUP recommends to use validated larvae for future clupeoid larvae identification workshops, collected from incubation of eggs. WKIDCLUP also recommends to collect and preserve separately clupeoid larvae from survey samples for use in future identification workshops.

Preserved clupeoid larvae samples are available from the North Sea (more than 30 years, (Germany) and from the Irish Sea (ca. 20 years, Northern Ireland).

WKIDCLUP, Staff for larval identification

Experienced persons showed a much higher agreement in species identification compared to less experienced. WKIDCLUP recommends that institutes ensure the continuity of staff for fish larvae identification to increase the quality of larval identification in survey samples.

WGIPS encourages institutes involved to ensure staff continuity for fish larvae identification from survey samples.

5 Status of the WGIPS survey manual

The WGIPS manual for acoustic surveys is now available on the ICES repository (SISP 9: Manual for International Pelagic Surveys)

It is recommended by the group that the manual be periodically reviewed and updated with the latest research and recommendations.

6 WGIPS database

WGIPS survey data are currently stored in two databases. The Fish Frame acoustic database for North Sea herring and sprat data (HERAS surveys), and the PGNAPES database for surveys including blue whiting and mackerel. Since merging the two groups (WGIPS and WGNAPES) into WGIPS in 2011 (ICES, 2011) the working group has recommended that a database be established to store disaggregated biological and acoustic survey data from HERAS surveys.

In 2014 ICES decided to initiate the work for a ICES hosted database for all acoustic surveys reported by ices EG's. During the meeting ICES data centre informed on the work going on concerning the establishment of the new acoustic DB. The work on specifying the acoustic database is nearly linked to the EU funded project AtlantOS 2.4, se below. ICES data centre expect to be ready with the setup for the new acoustic database by the end of 2015.

A Workshop is scheduled to take place in ICES, Copenhagen 24–28 August 2015 (WKEVAL) to discuss current calculation methodologies employed at national level and to initiate the use of new software application, StoX for calculation of global estimates based on disaggregated data. One of the outcomes of this workshop will be requirements from the HERAS survey to the content in the new ICES acoustic DB. For more details on WKEVAL, see Section 9.

AtlantOS 2.4:

A EU funded project AtlantOS 2.4 started on 14 January 2015. Main topic of the project is to develop an acoustic database with disaggregated data, based on the template of the PGNAPES database. The participants of the project are people from:

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There are 3 milestones/deliverables in the project

1) Milestone: Database definition due December 2015
2) Deliverables: Database implementation due March 2016
3) Internal milestone: Different software appliances (StoX, EchoR, Client etc.).

6.1 FishFrame acoustic database, coordinated acoustic surveys in the North Sea, West of Scotland and Malin Shelf

Since 2007 WGIPS has had FishFrame as its only platform for producing 'global' abundance estimates for the surveys in the North Sea, West of Scotland and Malin Shelf, HERAS. The database currently contains national aggregated survey data and global estimates since 2003 for all herring and sprat stocks in the area. Global estimates of abundance are provided to the Herring Assessment Working Group annually.

Depending of the outcome of the WKEVAL FishFrame should be used in 2016 for producing the global estimate for the HERAS survey based on the national aggregated survey data. Furthermore should it be possible to compare survey estimates from FishFrame to a new software application, StoX, for calculation of global estimates based on disaggregated data.

Therefore FishFrame has to be running at least throughout 2016. As DTU-Aqua has no longer the resources to maintain the acoustic part of FishFrame, it was discussed with ICES data centre to host the DB. ICES data centre were reluctant to do this as they were of the opinion that the DB would not survive the physical transfer into ICES. A solution with DTU-Aqua therefore has to be found.

6.2 PGNAPES database, coordinated surveys in the Northeast Atlantic

WGIPS use the PGNAPES database for disaggregated survey data from the international coordinated surveys in the Northeast Atlantic, BWSS, IESNS and IESSNS.

At the PGSPFN meeting in Bergen 2001 the group agreed to set up a common database for the data collected in Norwegian Sea since 1996 by the different nations. This was due to the fact that the data handling was becoming more and more difficult, as the amount of data collected is huge. Already then a draft database design was made. In 2007 a database webserver (Oracle 10g express edition) was set up at "Faroe Marine Research Institute." The participants of the IBWSS, IESNS and IESSNS coordinated surveys have committed to submit all relevant cruise data to this central database, to achieve easy access to the complete time-series.

The database was developed on a Microsoft Access platform, and the Access-version is very useful during a survey, facilitating the collection and organization of data and ensuring the quality and integrity of the dataset. Another great benefit is that the table exports fits right into the central database on the Internet.

Software supporting the PGNAPES format is constantly evolving. Apart from the various national systems developed to export survey data in PGNAPES format useful applications are being developed to exploit the potential of the PGNAPES database.

The LSSS application (Large Scale Survey System) is now able to export data in PGNAPES format. This facility is a major step forward for the LSSS users participating in the surveys.

PGNAPES client 1.0 developed by IMR: The client gives the users an excellent overview over the cruises in the database, and is able to perform basic queries developed in the estimate calculations.

The most awaited StoX abundance calculation application from IMR will be able to connect online to the PGNAPES database and extract data on cruise level and perform estimate calculations on top of the data.

Recent developments:

The PGNAPES database was updated to 11g XE version of the Oracle database, and migrated into the Virtual server environment at Havstovan (FAMRI) .

Pre 2007 data in database:

During the Costal State meeting on Norwegian spring-spawning herring in London, October 2013, it was agreed to establish a scientific working group to collect and collate information on the spatial distribution of all life stages of the Norwegian spring-spawning herring stock in the years 1995–2012.

Starting up the work in the scientific work group the group meet the challenge that data from the International Ecosystem Survey in the Nordic Seas (IESNS) before 2007 were not available in a database. In the first years the survey data, like acoustic values and biological information, were brought to the planning/evaluation groups on excel sheets, combined there and results published. It soon became clear that it would be feasible to establish a common database, but it was not until 2007 that the PGNAPES database was established. Since 2007 all data from these IESNS surveys have been uploaded to the database. The PGNAPES database is hosted at Havstovan, The Faroe Marine Research Institute, and administrated by Leon Smith, leonsmit@hav.fo.

The scientific group has decided to make an effort in loading older data into the database. This means that data from approx. 60 surveys in the period 1995 to 2007 have to be uploaded. WGIPS recognize the data problem, and have urged participating nations to submit data.

Also as WGIPS is preparing the transition to new databases and assessment tools, it is important to have datasets back in time to recalculate and evaluate the new tools provided.

In the tables below the progress so far is displayed:

EU IESNS data in the database:

COUNTRY	YEAR	CRUISE	LOG	CATCH	BIO	HYDR	ACOUSTIC	ACOUSTICVAL	PL
DK	2008	308	191	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
DK	2011	201103	122	118	1051	2759	587	1174	32
DK	2012	201205	70	44	1192	2753	2936	3676	35
DK	2013	201305	105	107	3554	3409	2263	15458	43
DK	2014	201405	100	147	6040	2899	3350	68185	35

EU Surveys to upload

Year	Vessel	Cruise leader	Status for data
1997	Walter Herwig	Not known	Not known
1997	Argos	Dave Reid - Poul Fernandes	Not known
1998	Argos	Not known	Not known
1999	Walther Herwig	Not known	Not known
2000	Tridens	Not known	Not known
2001	Walther Herwig	Not known	Not known
2004	Dana	Jørgen Dalskov, DK/Aril Slotte,N	Not known
2005	Dana	Bram Couperus,NL/Aril Slotte, N	Avaliable
2006	Dana	Bram Couperus,NL	Avaliable
2007	Dana	Karl-Johan Stæhr, DK/Bram Couperus,NL	Avaliable

WGIPS chair has made an effort to identify responsible cruise leaders and institutes to explore the status for the data from the above mentioned surveys and ask them to enter the data for the surveys into the PGNAPES database.

So far the chair has confirmed that the data from DK and SE surveys are available, but still needs compilation into the PGNAPES format.

FO IESNS data:

COUNTRY	YEAR	CRUISE	LOG	CATCH	BIO	HYDR	ACOUSTIC	ACOUSTICVAL	PL
FO	1996	9632	39	57	9037	-	487	1342	-
FO	1997	9736	27	47	8006	-	445	842	-
FO	1998	9832	43	66	8681	-	482	856	-
FO	1999	9932	36	58	7557	-	644	1441	-
FO	2004	0428	283	119	5341	-	660	6745	-
FO	2005	0532	86	-	-	-	378	4675	-
FO	2007	0732	76	29	1109	2994	359	4925	31
FO	2008	0824	77	43	2656	2619	1670	19172	27
FO	2009	0932	90	30	1234	3239	1404	7037	23
FO	2010	1014	77	30	1417	3708	1589	12067	23
FO	2011	1116	86	36	2716	3250	1382	9045	22
FO	2012	1218	73	35	1062	2539	1588	10903	25
FO	2013	1320	68	58	2227	2415	1517	12107	26
FO	2014	1416	63	33	1691	1715	1218	9494	20

FO has been working up old data from 1996 to 1999, and for the period 2004–2007. Surveys from 2000 to 2003 will be added during 2015.

IS IESNS data

COUNTRY	YEAR	CRUISE	LOG	CATCH	BIO	HYDR	ACOUSTIC	ACOUSTICVAL	PL
IS	1995	A8–95	3	-	300	-	413	442	-
IS	1995	B6–95	3	-	300	-	214	224	-
IS	1996	A6–96	50	-	9459	-	624	865	-
IS	1997	A7–97	193	-	8956	-	522	1103	-
IS	1998	A5–98	192	-	8208	-	673	3314	-
IS	1999	A5–99	141	-	2380	-	445	845	-
IS	2000	A3–2000	125	-	3654	-	3052	3287	-
IS	2001	A6–2001	96	-	4303	-	2197	2114	-
IS	2002	B6–2002	5	-	483	-	2164	4492	-
IS	2003	A9–2003	113	-	-	-	1715	9144	-
IS	2003	B1–2003	9	-	3056	-	-	-	-
IS	2004	A7–2004	34	-	6571	-	3490	20127	-
IS	2005	A4–2005	116	7	9217	-	2886	16909	-
IS	2006	A7–2006	206	70	3559	-	3950	20019	-
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	A7–2010	217	48	4006	5608	4031	9966	144
IS	2011	A5–2011	191	76	4932	4491	3621	23471	113
IS	2012	A5–2012	188	52	5397	5139	3867	17577	122
IS	2013	A5–2013	145	100	5222	4099	3506	16009	100
IS	2013	B3–2013	16	-	-	1509	-	-	-
IS	2014	A5–2014	128	63	4727	3165	4365	13597	68
IS	2014	B4–2014	32	-	-	2313	-	-	-

Iceland has delivered all data back to 1996.

RU IESNS data

COUNTRY	YEAR	CRUISE	LOG	CATCH	BIO	HYDR	ACOUSTIC	ACOUSTICVAL	PL
RU	2008	2008068	186	64	669	602	456	2844	64
RU	2009	2009073	142	70	960	648	354	378	61
RU	2010	201078	239	68	2449	2771	569	620	96
RU	2011	2011083	207	140	2264	2400	493	815	72
RU	2012	2012087	201	58	881	2544	511	208	85
RU	2013	2013091	138	42	712	1862	337	281	61
RU	2014	2014095	257	132	1709	2166	705	801	106

Due to heavy workload data prior to 2008 will not be delivered in 2015.

NO IESNS data

COUNTRY	YEAR	CRUISE	LOG	CATCH	BIO	HYDR	ACOUSTIC	ACOUSTICVAL	PL
NO	2007	2007106	238	409	8871	5749	4478	111484	-
NO	2008	2008103	118	39	551	3735	686	24537	24
NO	2008	2008834	107	117	2712	2319	2235	43796	29
NO	2009	2009206	211	119	2265	5278	664	2556	59
NO	2010	2010107	179	93	1903	5802	3150	7803	61
NO	2011	2011106	151	90	2816	5202	651	2188	48
NO	2012	2012205	229	134	3620	8192	3819	108551	80
NO	2013	2013107	46	5	445	1712	-	-	-
NO	2013	2013204	245	105	4645	6792	3933	96089	76
NO	2014	2014107	201	135	3873	5545	3332	90756	57

So far acoustic values for 1996 and 1999 are available in the database. NO is committed to submit remaining data in 2015.

PGNAPES database status:

Data in the PGNAPES database by January 2015

	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
DK	2011	201103	122	118	1051	2759	587	1174	32
DK	2012	201205	81	44	1192	2753	2936	3676	35
DK	2013	201305	105	107	3554	3409	2263	15458	43
DK	2014	201405	103	147	6040	2899	3350	68185	35
FO	1995	9540	22	38	1155	-	487	640	-
FO	1996	9632	39	57	9037	-	487	1342	-
FO	1997	9736	27	47	8006	-	445	842	-
FO	1998	9832	43	66	8681	-	482	856	-
FO	1999	9932	36	58	7557	-	644	1441	-
FO	2004	0428	296	119	5341	-	660	6745	-
FO	2005	0520	19	66	2107	-	322	4404	-
FO	2005	0532	86	-	-	-	378	4675	-
FO	2006	0624	36	58	1598	1359	260	4196	-
FO	2007	0724	27	42	1948	729	337	5222	-
FO	2007	0732	76	29	1109	2994	359	4925	31
FO	2008	0816	51	32	1199	1890	1249	16954	13
FO	2008	0824	77	43	2656	2619	1670	19172	27
FO	2009	0920	67	44	1521	2229	1359	22664	-
FO	2009	0932	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	98	83	4165	1297	2363	30073	30
FO	2011	1111	41	23	1016	1359	843	13989	-
FO	2011	1116	86	36	2716	3250	1382	9045	22
FO	2011	1152	67	49	3114	1007	1819	20179	23
FO	2012	1210	50	40	1463	1561	1237	18203	-
FO	2012	1218	73	35	1062	2539	1588	10903	25
FO	2012	1252	85	67	4464	1204	1847	16973	27
FO	2012	1253	8	17	1105	-	-	-	-
FO	2013	1314	50	29	878	1673	1212	17664	-
FO	2013	1320	68	58	2227	2415	1517	12107	26
FO	2013	1352	119	71	5588	1690	2646	20222	35
FO	2013	1353	8	16	1088	-	-	-	-
FO	2014	1410	53	30	1138	1668	1173	15726	21

FO	2014	1416	63	33	1691	1715	1218	9494	20
FO	2014	1452	99	68	4601	1418	2257	13683	32
IE	2004	2004-Mar	10	-	1000	-	360	2341	-
IE	2005	2005-Mar	16	-	1409	-	583	1206	-
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	-
IE	2011	BWAS11	33	21	1050	794	850	1308	-
IE	2011	BWAS11_2	29	10	600	844	795	1079	-
IE	2012	CE12005	70	37	2049	1251	1816	4037	-
IE	2013	CE13006	71	31	1850	2349	1954	7560	-
IE	2014	CE14005	56	24	1650	2082	1241	4089	-
IS	1995	A8–95	3	-	300	-	413	442	-
IS	1995	B6–95	3	-	300	-	214	224	-
IS	1996	A6–96	50	-	9459	-	624	865	-
IS	1997	A7–97	193	-	8956	-	522	1103	-
IS	1998	A5–98	192	-	8208	-	673	3314	-
IS	1999	A5–99	141	-	2380	-	445	845	-
IS	2000	A3–2000	125	-	3654	-	3052	3287	-
IS	2001	A6–2001	96	-	4303	-	2197	2114	-
IS	2002	B6–2002	5	-	483	-	2164	4492	-
IS	2003	A9–2003	113	-	-	-	1715	9144	-
IS	2003	B1–2003	40	-	3056	-	-	-	-
IS	2004	A7–2004	34	-	6571	-	3490	20127	-
IS	2005	A4–2005	116	7	9217	-	2886	16909	-
IS	2006	A7–2006	206	70	3559	-	3950	20019	-
IS	2007	A08–2007	130	39	9873	336	4005	26405	68
IS	2007	B08–2007	50	-	-	-	-	-	50
IS	2007	B8–2007	90	-	-	-	-	-	-
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	2009	A9–2009	133	116	7495	22343	2598	8504	-
IS	2009	B10–2009	90	-	-	49182	-	-	-
IS	2009	NYT2–2009	33	35	3743	-	-	-	-
IS	2010	A10–2010	205	255	6357	14420	4615	7322	-
IS	2010	A7–2010	217	48	4006	5608	4031	9966	144
IS	2011	A5–2011	191	76	4932	4491	3621	23471	113
IS	2011	A8–2011	370	302	21544	4447	4025	39602	189
IS	2012	A5–2012	188	52	5397	5139	3867	17577	122
IS	2012	A8–2012	319	246	16971	3476	5632	9287	177
IS	2013	A5–2013	145	100	5222	4099	3506	16009	100
IS	2013	A7–2013	316	323	19214	3884	5522	22983	93
IS	2013	B3–2013	16	-	-	1509	-	-	-
IS	2014	A5–2014	128	63	4727	3165	4365	13597	68
IS	2014	A6–2014	350	290	21035	4970	6080	6937	216
IS	2014	B4–2014	32	-	-	2313	-	-	-
NL	2005	BWHTS2005	8	-	300	-	1405	509	-
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	-
NL	2010	BWHTS2010	30	67	250	400	1294	204	-
NL	2011	BWHTS2011_1	28	17	100	898	616	616	-
NL	2011	BWHTS2011_2	43	36	350	3157	798	798	-
NL	2012	BWHTS2012	102	87	950	18212	1727	747	-
NL	2013	BWHTS2013	172	79	1000	1909	1899	3139	-
NL	2014	BWHTS2014	92	-	1101	1557	1805	1529	-
NO	2004	2004204	212	80	3600	-	692	1911	-
NO	2005	2005105	165	66	3898	-	634	1724	-
NO	2006	2006104	131	53	2576	57741	3515	7582	-
NO	2007	2007106	274	409	8871	5749	4478	111484	-
NO	2007	2007830	186	220	7353	2657	-	-	-
NO	2007	2007831	225	252	8494	2915	665	4068	-
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	2008823	102	115	2005	1554	397	2009	-
NO	2008	2008834	107	117	2712	2319	2235	43796	29
NO	2009	2009206	217	119	2265	5278	664	2556	59
NO	2009	2009818	217	178	4334	1974	4338	26160	39
NO	2009	2009820	177	162	2946	2283	3174	21554	41
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
NO	2010	2010807	202	247	9273	2804	3642	104115	62
NO	2010	2010810	318	310	9870	4321	1316	24681	88

NO	2011	2011103a	36	25	707	17541	820	15638	-
NO	2011	2011103b	20	10	182	637	584	2176	-
NO	2011	2011106	164	90	2816	5202	651	2188	48
NO	2011	2011826	223	196	2079	1405	4333	162807	60
NO	2012	2012118	170	193	9526	1968	2754	17890	44
NO	2012	2012205	229	134	3620	8192	3819	108551	80
NO	2012	2012825	151	169	8225	1738	3722	28473	40
NO	2012	2012838	92	22	1676	1687	1900	16339	-
NO	2013	2013107	46	5	445	1712	-	-	-
NO	2013	2013204	245	105	4645	6792	3933	96089	76
NO	2013	2013826	236	281	11907	3194	3953	113182	74
NO	2013	2013827	200	225	8634	2564	4081	87478	66
NO	2014	2014105	94	32	940	3299	1962	21196	-
NO	2014	2014107	201	135	3873	5545	3332	90756	57
NO	2014	2014812	235	280	9766	2953	4283	2334	77
NO	2014	2014813	168	207	8103	2422	3462	5149	54
RU	2005	2005060	175	32	6340	-	4644	2686	-
RU	2005	5	1	-	-	-	1967	1005	-
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
RU	2011	2011082	38	7	462	2053	855	11249	-
RU	2011	2011083	207	140	2264	2400	493	815	72
RU	2012	2012086	75	16	3549	792	1939	2453	-
RU	2012	2012087	201	58	881	2544	511	208	85
RU	2013	2013090	53	16	3507	3281	1630	2138	-
RU	2013	2013091	138	42	712	1862	337	281	61
RU	2014	2014094	69	15	3632	4284	1648	2360	-
RU	2014	2014095	257	132	1709	2166	705	801	106

7 StoX – an open source approach to acoustic and swept-area survey calculations

E. Johnsen, A. Totland, Å. Skålevik, S. Lid and N.O. Handegard

StoX is open source software developed at IMR, Norway to calculate survey estimates from acoustic and swept-area surveys. 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. Various statistical survey design models can be implemented in the R-library, however, in the current version of StoX the stratified transect design model developed by Jolly and Hampton (1990) is implemented. StoX has been tested on the 2014 IESNS survey and Norwegian acoustic sandeel and cod surveys. When new statistical methods are implemented it is regarded essential that expert specification demands, documentation and statistical rigorousness is available. According to the plan, a test version of the software will be available for people outside IMR by the end of March 2014.

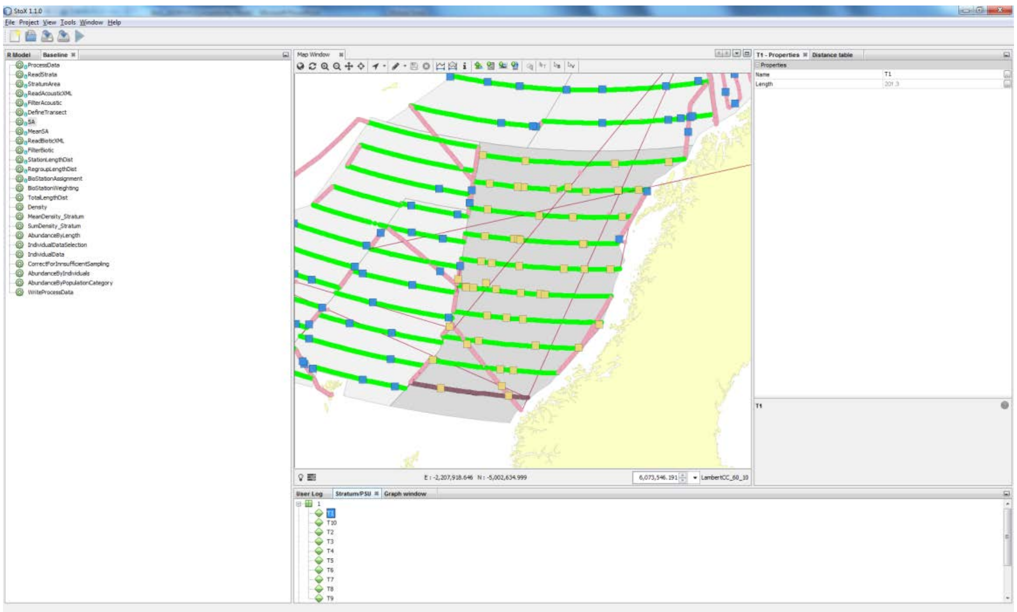


Figure 7.1. The graphical user interface of StoX with baseline functions (left), GIS-window (center), parameter setting window (right) and transects by stratum (bottom).

It is the goal of WGIPS to aid in the development of StoX through feedback with the developers with the end goal of adopting StoX as the standardized abundance estimation tool for all WGIPS coordinated surveys.

8 WKSCRUT – Workshop on Scrutinisation Procedures for Pelagic Ecosystem Surveys

A Workshop on Scrutinisation Procedures for Pelagic Ecosystem Surveys (WKSCRUT), chaired by Matthias Schaber, Germany, will be held for a single meeting in Hamburg, 7–11 September 2015.

The scrutinisation of echograms (allocating quantities of acoustic energy to fish species) is to a large extent subjective. However, it largely determines the outcome and abundance estimation from acoustic survey data. Therefore it is very important that all scientists responsible for the scrutinisation are following the same general procedures. It was found by WGIPS that there is a need to compare, evaluate and harmonize echogram scrutinisation and post-processing procedures currently applied by participants of the 29 pelagic surveys coordinated by WGIPS. Furthermore, there is a need to document recommended methods to be followed by survey participants to produce acoustic density values by species and sampling units from raw (multifrequency) acoustic energy data, and to implement data requirements needed for a move to a new database for storage of disaggregated survey data. The WK will provide updates on agreed and recommended methods in the corresponding SISP.

Pre-workshop tasks

It is requested that participants from WGIPS coordinated pelagic ecosystem surveys provide detailed information on echosounder settings, post-processing software, scrutinisation protocols and further methods employed during their corresponding surveys. Furthermore, the survey coordinators are encouraged to collect training datasets (acoustic raw data) from participating national surveys that are considered representative for the echosignatures encountered during the survey. These datasets will be scrutinised and post-processed by participants with their corresponding protocols and results will be compared in order to elaborate common procedures for each survey where applicable.

A scrutinising workshop in relation to the International Ecosystem Survey in Nordic Seas (IESNS) will take place 3–5 March 2015 in Reykjavik. The IESNS group considered it urgent to deal with a potential discrepancy in scrutinising procedures among the different vessels in the 2014 survey (see Section 4.1.3.) before the 2015 survey takes place. Thus, it has to be held prior to the WKSCRUT workshop in September 2015. The results of this workshop in March will be made available to all participants prior to the survey in April-May 2015 and will be presented and reported formally in the WKSCRUT report in September 2015.

A SharePoint site has been set up specifically for the WK: WKSCRUT SharePoint

9 WKEVAL – Workshop on evaluating current national acoustic abundance estimation methods for HERAS surveys

A workshop on evaluating current national acoustic abundance estimation methods for HERAS surveys (WKEVAL), chaired by Ciaran O'Donnell, Ireland, will be established for a single meeting and will meet in ICES, Copenhagen, 24–28 August 2015.

The aims of the workshop are highlighted below:

a) To evaluate existing national acoustic abundance estimation tools used to calculate the biomass of herring and sprat from HERAS surveys (North Sea, West of Scotland and the Malin Shelf).

b) Test run StoX estimation software using existing data to back calculate 'global' herring abundance (2012–2014) as a sensitively exercise with FishFrame.

c) Establish baseline parameters within StoX for use during future HERAS surveys.

d) Provide feedback to the ICES data centre in the development of the new database.

e) Provide feedback to StoX developers to address outstanding issues.

Background

The group currently uses FishFrame to store aggregated survey data and as a computational tool to estimate 'global' abundance for HERAS surveys. From 2015, the group working in harmony with the ICES data centre and as part of the larger AtlantOS project will develop a new acoustic database to store survey data from all WGIPS coordinated surveys. The IMR developed StoX computational software will be used and developed through user input by the group as the standardized calculation tool for acoustically derived abundance estimates.

Pre-workshop tasks

Methods review

It is requested that each HERAS participant provide a detailed description of calculation methods employed at national level in advance of the coming WKEVAL workshop. Participants are requested to detail all steps involved in the calculation of acoustic abundance from species allocated NASC data. Echogram scrutinisation will be discussed but a detailed review will be left for consideration at the dedicated workshop (EKSCRUT). Participants should also include details on the stratifying of survey areas, track design, trawl haul allocation and estimates of precision, where applicable. Calculation tools (Excel spreadsheets, R-scripts etc.) and working examples of recent survey datasets should be made available during the meeting.

A SharePoint site has been set up specifically for the WK: WKEVAL SharePoint

The deadline for submissions of methods is the ***Friday the 31st July, 2015.***

Data

As the group is preparing to migrate to a new ICES DB format, based on the existing WGNAPES, a number of tasks are required to initiate the process. The StoX program will be adopted as the new computational tool for 'global' estimates of acoustic abundance across WGIPS coordinated surveys.

As an internal sensitivity exercise, a comparative run of historic estimates produced using StoX and FishFrame will be carried out. To that end participants are asked to reformat current HERAS data for the years 2012–2014 into WGNAPES format for upload to the trial ICES database. Log in details and portal address will be circulated by the ICES data centre as soon as they are ready.

Acoustic data allocated by species should be submitted in 1nmi EDSU and as a single depth channel covering the entire water column. Stock identifiers should be added as an additional column using a pre-agreed naming convention. Additional confirmation is required on the missing meta-data (ICES meta data standards) currently not included as part of the WGNAPES format. This will be provided by Leon Smith in advance of the exercise.

Data format examples, process detail and instructions are available in the WGIPS acoustic survey manual. Support has been volunteered by Leon Smith to help aid the process and this is gratefully appreciated.

The deadline for converted data is the ***Friday the 31st July, 2015.***

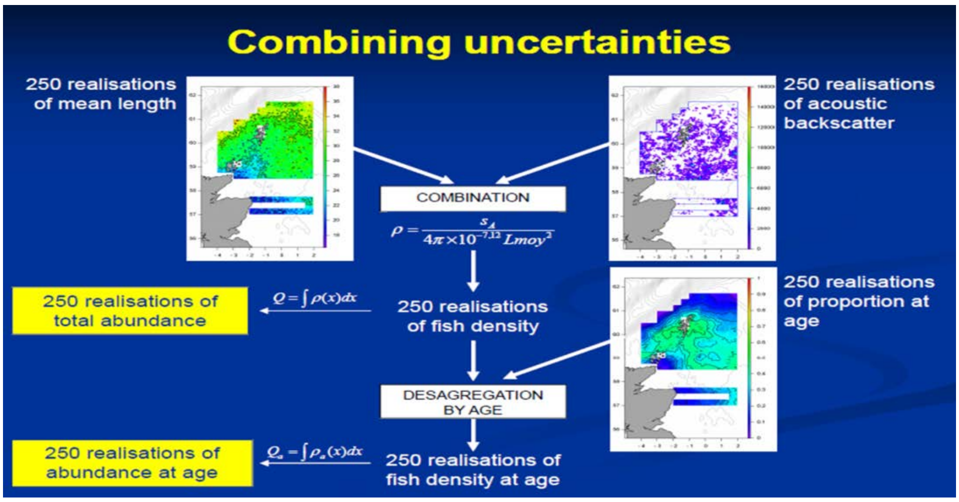
10 Geostatistical tools for acoustic surveys

10.1 Geostatistical simulations to estimate uncertainty in acoustic surveys

Woillez *et al.* (2009) proposed a methodology to evaluate uncertainty of abundance estimates from acoustic surveys using geostatistical simulations. Most of the biomass or abundance estimates generated within WGIPS surveys are based on a combination of acoustic and biological data (length, weight, age). As the corresponding surveys regularly cover a vast area, it is important to evaluate uncertainty due to sampling in space. The main benefit of using geostatistical simulations lies in its capabilities to combine different sources of uncertainty.

Although the benefits of applying the proposed methodology appear obvious, it has not been used on a regular basis yet. With the new ICES course on geostatistics and the recognition that there is an urgent need for improved variance estimates as a standard input into or survey reports, the promotion of this tool becomes eminent.

A detailed description of how to apply the methods can be found in Woillez *et al.* (2009). The major steps will be quickly described in the following. In a first step a geostatistical conditional model has to be developed (geostatistical = Reproducing spatial variability, conditional = respecting data values at given points). This is a relatively simple task for the biological data (mean length, cumulated proportions, age, etc.), as a multivariate gaussian model can be applied directly (e.g. relation between bottom depth and herring length). Unfortunately, acoustic data generally includes a substantial amount of 0 values (dissymmetric distribution). Hence it is necessary to transform the acoustic data into a gaussian form (Gaussian anamorphosis), which will then allow fitting the new curve to a variogram. The next step will be the Gibbs sampler, where values for mean length, acoustic backscatter and proportions at age will be generated iteratively. Following the sampling process, uncertainties for each of the simulated groups can be computed and combined to estimate combined and separated CVs respectively. Generally, CVs for abundance at age are found to be ~12% and 10% for abundance estimates, based on the example of herring around Western Scotland.



10.2 Geostatistical indices for PGNAPES datasets

A webtool entirely developed in R allowing a direct analysis of acoustic data in combination with biological information has been presented. The tool was developed in RStudio (http://www.rstudio.com/) using the RGeoS package (http://rgoes.free.fr), developed by Ifremer and the shiny (http://www.rstudio.com/shiny/) package, allowing an easy creation of a user interface. It has to be noted that the work presented was in an absolute preliminary state and further development is needed for this tool to be useful for the group. The main strength of the tool lies in its flexibility and its potential implementation of a vast number of tools and modules, as it is completely open-source and entirely written in R, the most commonly used data analysis tool among the present group.

The first part of the tool consists of a number of geostatistical indices which, besides presenting a summary of the acoustic and biological data, allow the detection of differences in the spatial distribution due to changes occurring in the environment:

- Capture spatial patterns
- Characterize properties of spatial distributions.

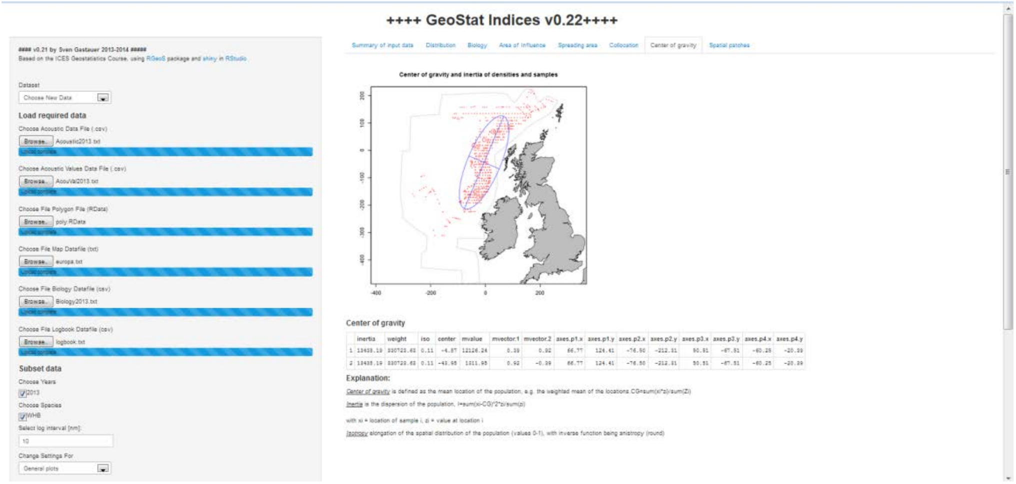
Indices related to the location of the stock that are currently implemented in the tool are the

- centre of gravity (Mean location of the population)
- Dispersion (mean dispersion of the population with Isotropy (elongation of the spatial distribution)/Anistropy (Inverse of Isotropy)
- number of spatial patches (fish aggregations at a scale larger than a fish school)
- Occupation (Positive/ Equivalent and Spreading area)
- global and local index collocation (GIC: how 2 populations are geographically melted, LIC: collocated occurrence of 2 populations at sampling scale)

The second part of the tool provides a quick overview of the loaded acoustic data, presenting a summary, and generating mean values for each covered ICES rectangle, with the possibility of applying different transformations to the data such as square-root, log, or normal.

In a next step, the tool will be directly connected to the PGNAPES database, allowing the user to directly interact with the database instead of having to upload data.

With the upcoming Norwegian tool for standardized analysis of acoustic data, this should not be seen as a competitor, but is rather intended to provide quick and easy overviews, as addition to the tools that will be provided by stocks.


++++ GeoStat Indices v0.22++++
v0.21 by Sven Gastauer 2013-2014
Based on the ICES Geostatistics Course, using RGeoS package and shiny in RStudio
Dataset
Choose New Data
Load required data
Choose Acoustic Data File (.csv)
Browse... Acoustic2013.txt
Choose Acoustic Values Data File (.csv)
Browse... AcouVal2013.txt
Choose File Polygon File (RData)
Browse... poly.RData
Choose File Map Datafile (txt)
Browse... europa.txt
Choose File Biology Datafile (csv)
Browse... Biology2013.txt
Choose File Logbook Datafile (csv)
Browse... logbook.txt
Subset data
Choose Years
2013
Choose Species
WHB
Select log interval [nm]:
10
Change Settings For
General plots
Summary of input data
Distribution
Biology
Area of Influence
Spreading area
Collocation
Center of gravity
Spatial patches
Center of gravity and inertia of densities and samples
Center of gravity
inertia weight iso center mvalue mvector.1 mvector.2 axes.p1.x axes.p1.y axes.p2.x axes.p2.y axes.p3.x axes.p3.y axes.p4.x axes.p4.y
Explanation:
Center of gravity is defined as the mean location of the population, e.g. the weighted mean of the locations.CG=sum(xi*zi)/sum(Zi)
Inertia is the dispersion of the population. I=sum(xi-CG)^2*zi/sum(zi)
with xi = location of sample i, zi = value at location i
Isotropy elongation of the spatial distribution of the population (values 0-1), with inverse function being anistropy (round)

11 References

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Annex 1: List of participants of the Working Group of International Pelagic Surveys (WGIPS) – North Sea Room, ICES Headquarters, 19–23 January 2015

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Annex 2: Agenda WGIPS Meeting January 2015

Agenda for ICES WGIPS, ICES headquarters, 19–23 January 2015

Monday

09:00

- Meeting opens
- Review of TOR for this year.
- Review of recommendations for WGIPS from other expert groups and acoustic manual update
- First discussion on new format for coming TOR

14:00

- Meeting report tasks
- Discussion of contents of this year's report, reporting structure and review of post cruise meeting format.
- Review of herring Larval survey in 2014 and plan for 2015
    - Western Baltic
    - North Sea
    - Irish Sea

Tuesday

09:00

- Report status
- Review of coordinated Acoustic surveys in 2014 and plan for 2015
    - International acoustic survey in North Sea, West of Scotland and Malin Shelf (HERAS; including Sprat in the North Sea and IIIa)
    - Malin Shelf (MSHAS)
    - Western Baltic

14:00

- International blue whiting spawning stock survey(IBWSS)
- International ecosystem survey in the Nordic Seas (IESNS)
- Coordinated Nordic Seas ecosystem survey and Greenlandic survey plans (IESSNS)
- Celtic Sea herring (CSHAS)
- Celtic Sea, English Channel (PELTIC)
- Irish Sea (ISAS)
- Boarfish acoustic survey (BFAS)

Wednesday

09:00

- Report status
- Open discussion on the New ICES Acoustic DB and what it means for the group

  - Presentation: ICES Data Centre, current status
  - Presentation: StocX (Norway) software update

14:00

- Review of answers to recommendations for WGIPS from other expert groups
- Update on new data requests and existing projects
  - sampling of data for maturity study on herring in the North Sea
  - sampling of otoliths for discrimination of Downs herring in the North Sea
  - Update report on continuation of SGHERWAY sampling protocol for herring surveys west of 4°W.

Thursday

09:00

- Report status
- Election of new chair
- Upcoming Workshops- tasks and review
  - Workshop on evaluating current national acoustic abundance estimation methods for HERAS surveys (WKEVAL), ICES 24–28 August 2015
  - Workshop on scrutinisation procedures for pelagic ecosystem surveys (WKSCRUT), ICES 7–11 September 2015.
- Emerging studies: Combining fishing vessel and survey data in high density rectangles (IMARES)

14:00

- ToR for next meeting
- Recommendations
- Collection of material for the final report
- AOB

Friday

09:00

- Review of final report

12:00

- Meeting closes

Annex 3: ToRs for WGIPS in 2015

The **Working Group of International Pelagic Surveys** (WGIPS), chaired by Sascha Fässler*, Netherlands, and Matthias Schaber*, Germany, will meet in Dublin, Ireland, 18–22 January 2016, to work on ToRs and generate deliverables as listed in the Table below.

WGIPS will report on the activities of 2015 (the first year) by 5 March 2016 to SSGIEOM.

ToR descriptors

ToR	Description	Background	Science Plan topics addressed	Duration	Expected Deliverables
a	Combine and review annual ecosystem survey data to provide: indices of abundance and spatial distribution for the stocks of herring, sprat, mackerel, boarfish and blue whiting in Northeast Atlantic waters.	a) Advisory Requirements b) Requirements from other EGs	Goal 3	years 1–3	Survey reports containing indices of stock biomass and abundance at age, spatial distributions, zooplankton biomass, and hydrographic conditions. HAWG WGWIDE
b	Coordinate the timing, area and effort allocation and methodologies for individual and multinational acoustic and larvae surveys on pelagic resources in the Northeast Atlantic waters covered (Multinational surveys: IBWSS, IESNS, IESSNS, HERAS, IHLS and individual surveys: CSHAS, BFAS, ISAS, PELTIC, GERAS).	a) Science Requirements b) Advisory Requirements c) Requirements from other EGs	Goal 1 & 3	years 1–3	Cruise plans for international and individual surveys. HAWG WGWIDE

c	Adopt standardized analysis methodology and data storage format utilizing the ICES pelagic database repository for all acoustically derived abundance estimates of WGIPS coordinated surveys	a) Science Requirements b) Advisory Requirements	Goal 3, 4 & 5	years 1–3	Common acoustic database for WGIPS coordinated surveys; Common analysis tools for acoustic and trawl data from WGIPS coordinated surveys including software scripts to produce results in common formats WKEVAL
d	Periodically review and update the WGIPS acoustic survey manual to adress and maintain monitoring requirements for pelagic ecosystem surveys	a) Science requirements b) Advisory requirements	Goal 3	years 1–3	Updated WGIPS survey manual.
e	Review and evaluate survey designs across all WGIPS coordinated surveys to ensure the integrity of survey deliverables	a) Science requirements b) Advisory Requirements c) Requirements from other EGs	Goal 3	years 1–3	Optimal sampling designs and precision estimates for the different surveys as a measure of survey quality. HAWG WGWIDE
f	Assess and compare scrutinisation procedures employed for the analysis of raw acoustic data from WGIPS coordinated surveys	a) Science requirements b) Advisory requirements	Goal 3	year 1	Documented standardized scrutinisation recommendations; Update of survey manual to adress and maintain monitoring requirements for pelagic ecosystem surveys. WKSCRUT
g	Develop alternative analysis methods (e.g. using geostatistics) to monitor the pelagic ecosystem by extracting metrics from the collected survey data other than those requirted for single-species stock assessments	a) Science requirements b) Advisory requirements	Goal 1 & 3	years 1–3	Manuscripts and working documents.

h	Assess auxilliary pelagic ecosystem surveying technology (e.g. optical technology, multibeam and wideband acoustics) to: (i) achieve monitoring of different ecosystem components, and/or (ii) derive ecosystem indicators from surveys covered by WGIPS	a) Science Requirements b) Advisory Requirements c) Requirements from other EGs	Goal 1 & 3	years 1–3	Overview of possible ecosystem indicators that can be derived from WGIPS surveys; and protocols/recommendations for practical implementation of auxiliary pelagic surveying technoologies.
i	Develop and refine methods to derive stock- or spawning component-specific survey indices for herring based on biological criteria (e.g. otolith shapa analysis or morphometric measurements)	a) Science Requirements b) Advisory Requirements c) Requirements from other EGs	Goal 1 & 3	years 1–3	Provide survey indices of stock biomass and abundance at age for herring in the North Sea and areas IIIa and Via, separated by spawnign component/stock based on biological criteria.

Summary of the Work Plan

Year 1	General meeting, preceded by 3 post-cruise meetings which collate data of multinational surveys Workshop to evaluate and develop joint methods from current participant-specific acoustic abundance estimation methods used in the HERAS surveys (WKEVAL) Workshop to standardize scruitinisation procedures for pelagic ecosystem surveys covered by the WG (WKSCRUT) Session to familiarise WG members with the use of the new standardized acoustic survey analysis tool (StoX) and data storage format from the ICES pelagic database repository Session to review and evaluate survey designs across all WGIPS coordinated surveys done in Year 1; and coordinate planning and discuss designs for surveys taking place in Year 2 Session to review and provide possible updates for the WGIPS acoustic survey manual Session to: (i) explore alternative analysis methods (e.g. geostatistics); and (ii) assess and document auxillary pelagic ecosystem surveying methodology (e.g. optical technology, multibeam and wideband acoustics), in order to monitor components of the wider ecosystem and derive ecosystem indicators from surveys covered by WGIPS Session to review and adapt stock and spawning component splitting methods applicable to herring in the North Sea, and areas IIIa and Via; and plan methods used on surveys in Year 2 accordingly. Contributing to Session C "Ecosystem Monitoring in Practice" at the 2015 ICES ASC through active involvement of WG members as session convener and presenters Contributing a paper analysing the HERAS survey time-series to the ICES Symposium on "Marine Ecosystem Acoustics (SOMEACOUSTICS) Submission of a manuscript on blue whiting distribution from the WGIPS survey time-series to a peer reviewed Journal
Year 2	General meeting, preceded by 3 post-cruise meetings which collate data of multinational surveys Session to review and evaluate survey designs across all WGIPS coordinated surveys done in Year 2; and coordinate planning and discuss designs for surveys taking place in Year 3 Session to exchange experiences and analyse progress with the use of the new standardized acoustic survey analysis tool (StoX) and data storage format from the ICES pelagic database repository Session to compare and evaluate scrutinisation of Year 2 survey databased on the standardized procedures developed in WKSCRUT Session to review and provide possible updates for the WGIPS acoustic survey manual Session to review and adapt stock and spawning component splitting methods applicable to herring in the North Sea, and areas IIIa and Via; and plan methods used on surveys in Year 3 accordingly. Session to draft a manuscript on an example of alternative analysis methods (e.g. geostatistics) used with WGIPS survey data Session to analyse progress and draft recommendations for auxiliary pelagic ecosystem surveying methodology (e.g. optical technology, multibeam and wideband acoustics) for monitoring components of the wider ecosystem in surveys covered by WGIPS Session to draft a list of potential ecosystem indicators to be measured during WGIPS surveys

Year 3	General meeting, preceded by 3 post-cruise meetings which collate data of multinational surveys Session to review and evaluate survey designs across all WGIPS coordinated surveys done in Year 3 Session to analyse progress with the use of the new standardized acoustic survey analysis tool (StoX) and data storage format from the ICES pelagic database repository Session to review and provide possible updates for the WGIPS acoustic survey manual Session to review and adapt stock and spawning component splitting methods applicable to herring in the North Sea, and areas IIIa and Via used on surveys in Years 1–3. Session to evaluate progress to draft a manuscript on an example of alternative analysis methods (e.g. geostatistics) used with WGIPS survey data Session to update recommendations for auxiliary pelagic ecosystem surveying methodology (e.g. optical technology, multibeam and wideband acoustics) for monitoring components of the wider ecosystem in surveys covered by WGIPS Session to evaluate progress in listing potential ecosystem indicators to be measured during WGIPS surveys

“Supporting information

Priority	The Group has a very high priority as its members have expertise in design and implementation of larval and acoustic-trawl surveys, including sampling of additional ecosystem parameters. It will therefore directly contribute to the implementation of integrated pelagic ecosystem monitoring programmes in the ICES area. The Group’s core task is the standardization, planning, coordination, implementation, and reporting of acoustic and larvae surveys for main pelagic fish species herring, sprat, blue whiting, mackerel, and boarfish in Northeast Atlantic waters. The work provides essential data in the form of survey indices to WGWIDE and HAWG in the aim to perform integrated ecosystem assessment.
Resource requirements	The research programmes which provide the main input to this group are already underway, and resources are already committed. The additional resource required to undertake additional activities in the framework of this group is negligible.
Participants	The Group is normally attended by some 20–25 members and guests.
Secretariat facilities	None.
Financial	No financial implications.
Linkages to ACOM and groups under ACOM	WGWIDE, HAWG
Linkages to other committees or groups	There is a very close working relationship with other groups in SSGIEOM, especially relevant links to WGACEGG, WGALES, WGBIFS, WGFAST, WGFTFB, WGISDAA, WGISUR, WGMEGS, WGTC, WGINOR, WGINOSE, WGIAB, WKEVAL, WKMSMAC2, WKSCRUT, WKSUREQ
Linkages to other organizations	EU H2020 project ‘AtlantOS’

Annex 4: Recommendations

Recommendation	For follow up by:
1. WGIPS recommends that in advance of WKEVAL that the ICES data centre and the Faroes (host nation and developers of WGNAPES DB) determine the outstanding meta-data requirements to fulfil the ICES meta-data standards and that this be communicated to the group as soon as possible to facilitate population of the new database.	SCICOM, SSGIEOM, ICES Data Centre, Faroes
2. WGIPS recommends that the survey manual is scheduled for periodic review with the current multi-annual ToR cycle. The review process shuld take into account new developments within the group and from wider research. This should include; WKSCRUT, WKEVAL and the new ICES database and StoX software.	Expert group members
3. WGIPS recommends that all acoustic and biological data from outstanding IESNS surveys from EU, Faroes and Russian participants for the years 1997–2001 and 2004–2007 be entered into the WGNAPES database in the specified database format as soon as possible.	Expert group members
4. WGIPS recommends that each of the survey coordinators attend the meeting annually or nominate someone to represent them well in advance of the meeting.	Expert group members
5. WGIPS recommends that survey effort around the Orkney/Shetlands and West of Scotland be maintained to provide sufficient area coverage of historic baselines.	Expert group members
6. In light of data needed to survey the whole ecosystem, WGIPS recommends that all participants in WGIPS coordinated surveys should collect the data at multiple frequencies (minimum 4; between 18 – 200 kHz) to facilitate species identification. In addition, participants should give consideration to using scientific multibeam echosounders to increase the sampled volume.	Expert group members
7. WGIPS recommends that a dedicated age reading workshop is scheduled for NSS herring	SSGIEOM
8. For combined coordinated surveys, the group recommends that post cruise meetings take place well in advance of the WGIPS meeting. The purpose of the meeting is to evaluate the data, address data issues, upload to the database and compile a joint report.	Expert group members
9. WGIPS recommends that cruise tracks are provided by the relevant survey coordinator (IBWSS, IESNS and IESSNS) to participants during the planning phase. Any deviations from agreed cruise plans and/or dates should be communicated via the survey coordinator as soon as possible to allow for timely effort reallocation.	Expert group members
10. WGIPS recommends all parts of the HERAS survey continue to be carried out within the same period of time (end of June – first few weeks of July).	Expert group members
11. It is recommended that the Northern Ireland egg and larval time-series be submitted for inclusion into the ICES egg and larval database.	ICES Data Centre

Annex 5: Post Cruise Reports 2015

Annex 5a: International Blue Whiting Spawning Stock Survey (IBWSS)

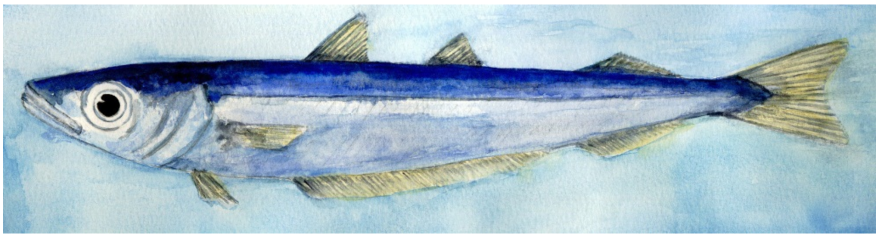
Working Document

Working Group on International Pelagic Surveys

Copenhagen, Denmark, 19–23 January 2015

Working Group on Widely Distributed Stocks

Copenhagen, Denmark, 26 August-1 September 2014



INTERNATIONAL BLUE WHITING SPAWNING STOCK SURVEY (IBWSS)

SPRING 2014

Sascha Fässler[1^*], Sven Gastauer[1*], Thomas Pasterkamp[1], Kees Bakker[1], Eric Armstrong[6], Dirk Thijssen[8], Matthias Schaber[7], Daniel Gallagher[5]

RV Tridens

Ciaran O'Donnel[5*×], Eugene Mullins[5], Graham Johnston[5], Niall Keogh[9], Machiel Oudejens[10]

RV Celtic Explorer

Alexander Pronyuk[3], Sergey Kharlin[3], Tatiana Sergeeva[3], Yurii Firsov[3], Alexander Krysov[3*]

RV Fritjof Nansen

Åge Høines[2*], Øyvind Tangen[2*], Valantine Anthonypillai[2]

RV G.O. Sars

Jan Arge Jacobsen[4*], Leon Smith[4*], Jens Arne Thomassen[4], Poul Vestergaard[4]

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5 Marine Institute, Galway, Ireland

6 Marine Scotland Marine Laboratory, Aberdeen, Scotland, UK

7 Johann Heinrich von Thünen-Institut, Hamburg, Germany

8 Danish Institute for Fisheries Research, Denmark

9 BirdWatch, Ireland

10 Irish Parks and Wildlife Service, Ireland

* Participated in post cruise meeting, × via correspondence

^ Survey coordinator

Material and methods

Survey planning and Coordination

Coordination of the survey was initiated in the meeting of the Working Group on International Pelagic Surveys (WGIPS) and continued by correspondence until the start of the survey. During the survey, updates on vessel positions and trawl activities were collated by the survey coordinator and distributed to the participants twice daily. Participating vessels together with their effective survey periods are listed below:

Vessel	Institute	Survey period
Fritjof Nansen	PINRO, Murmansk, Russia	25/3 – 5/4
Celtic Explorer	Marine Institute, Ireland	26/3 – 6/4
Magnus Heinason	Faroe Marine Research Institute, Faroe Islands	29/3 – 6/4
Tridens	Institute for Marine Resources and Ecosystem Studies (IMARES), the Netherlands	26/3 – 5/4
G.O. Sars	Institute of Marine Research, Norway	27/3 – 7/4

The survey design used and described in ICES (2014) allowed for a flexible setup of transects and good coverage of the spawning aggregations. Due to acceptable - good weather conditions throughout the survey period, the survey resulted in a high quality coverage of the stock. Transects of all vessels were consistent in spatial coverage and timing, delivering full coverage of the respective distribution areas within 14 days.

Cruise tracks and trawl stations for each participant vessel are shown in Figure 1. Figure 2 shows combined CTD stations. All vessels worked in a northerly direction (Figure 3). Regular communication between vessels was maintained during the survey (via e-mail and Internet weblog) exchanging blue whiting distribution data, echograms, fleet activity and biological information.

Sampling equipment

All vessels employed a midwater trawl for biological sampling, the properties of which are given in Table 5. Acoustic equipment for data collection and processing are presented in Table 2. The survey and abundance estimate are based on acoustic data collected through scientific echosounders using a frequency of 38 kHz. All transducers were calibrated with a standard calibration sphere (Foote *et al.*, 1987) prior, during or directly after 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. This year, no inter-calibration was carried out due to time constraints.

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 by vessel is shown in Table 1.

Hydrographic sampling

Hydrographic sampling by way of vertical CTD cast was carried out by each participant vessel at predetermined locations (Figure 2 and Table 1) with a maximum depth of 1000 m in open water. Hydrographic equipment specifications are summarized in Table 5.

Acoustic data processing

Acoustic scrutiny was mostly based on categorization by experienced experts aided by trawl composition information. Post-processing software and procedures differed among the vessels:

On Fridtjof Nansen, the FAMAS 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 Myriax's EchoView (V 4.8) post-processing software for the previous day's work. Data were partitioned into the following categories: plankton (<120 m depth layer), mesopelagic species and blue whiting.

On Magnus Heinason, acoustic data were scrutinised every 24 hrs on board using Myriax's EchoView (V 5.2) post-processing software. Data were partitioned into the following categories: plankton (<200 m depth layer), mesopelagic species (pearlside in the upper layer and lanternfish in the deeper layer), blue whiting and krill. Partitioning of data into the above categories was based on trawl samples.

On Tridens, acoustic data were backed up continuously and scrutinized every 24 hrs using the Large Scale Survey System LSSS (V 1.8) post-processing software. Blue whiting were identified and separated from other recordings based on trawl catch information and characteristics of the recordings.

On G.O. Sars, the acoustic recordings were scrutinized using the Large Scale Survey System (LSSS) once or twice per day. Data were partitioned into the following categories: plankton (<120 m depth layer), mesopelagic species and blue whiting.

Acoustic data analysis

The acoustic 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 to the area that was representatively covered by the survey track. This was particularly important in the shelf break zone where high densities of blue whiting dropped quickly to zero at depths less than 200 m.

To obtain an estimate of length distribution within each stratum, 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). Following the decisions made at the "Workshop on implementing a new TS relationship for blue whiting abundance estimates (WKTSBLUES)" (ICES, 2012), the following target strength (TS)-to-fish length (L) relationship (Pedersen *et al.*, 2011) used is:

$$TS = 20 \log10 (L) - 65.2$$

For conversion from acoustic density (sA, m²/n.m.²) to fish density (ρ) the following relationship was used:

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

where $\langle\sigma\rangle = 3.795 \cdot 10^{-6} L^{2.00}$ 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 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

Distribution of blue whiting

In total 8,231 n.m. (nautical miles) of survey transects were completed and the total area of all the sub-survey areas covered was 125,319 n.m.^{2} (Figure 1, Tables 1 and 3). Covered survey track length was 10% longer and surveyed areas 30% larger than last year as a result of increased and more detailed coverage of the Rockall and Porcupine Bank areas.

Within the Irish EEZ (Exclusive Economic Zone), blue whiting distributions were seen to extend from the shelf edge to the west of the Porcupine Bank. Maximum sA values observed there reached 64095 $m^2/mile^2$ with a vertical extension of up to 50–100 m over depths more than 1500 m (near the shelf edge), and 59221 $m^2/mile^2$ over depths of 770 m in the western area of the Rockall Trough (north of the Porcupine Bank).

Within the UK EEZ, blue whiting were distributed in a continuous layer along the shelf edge up to 58N. The latitudinal width of the aggregation was from 20 to 58 miles. Maximum sA values observed there reached 41360 $m^2/mile^2$ with a vertical extension of up to 100 m near the shelf edge.

The highest concentrations of blue whiting were recorded in the Hebrides area but the observed biomass there was 37% less than in the previous year. Due to the perceived later northward migration of the stock as compared to 2013 the centre of gravity was located further south within the northern Porcupine Bank area. This area saw an increase in biomass of 310% as compared to 2013. Medium and high density registrations were concentrated along the shelf slope extending up to 15 nm from the shelf edge (Figures 4 and 5).

Compared to the last year, more high density aggregations were found on the Rockall Bank.

Stock size

The estimated total abundance of blue whiting for the 2014 international survey was 3.25 million tonnes, representing an abundance of 31.1x109 individuals (Figure 6, Tables 3 and 4). Spawning stock was estimated at 3.2 million tonnes and 24.4x109 individuals. In comparison to the 2013 survey estimate, there is a decrease (-3%) in the observed stock biomass and a related increase in stock numbers (+15%).

		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Change from 2013 (%)
Biomass	Total	2.6	3.4	3.6	2.6	2	1.3	1.6	2.2	3.4	3.3	-3%
(mill. t)	Mature	2.4	3.3	3.6	2.6	2	1.3	1.5	2.2	3.2	3	-6%
Numbers	Total	29	34.7	33.5	22.1	15.2	9.3	12.1	18.2	27	31.1	15%
(10^9)	Mature	26.7	33.8	32.9	21.7	15.0	8.9	9.7	16.5	24.4	26.4	8%
Survey area (nm^2)		172,000	170,000	135,000	127,000	133,900	109,320	68,851	88,746	87,895	125,319	43%

The Hebrides core area was found to contain 48% of the total biomass observed during the survey, which is lower than seen in previous years (73% of the stock found in this area in 2013 and 71% in 2012). The major part of the biomass recorded in the area was found more towards the southern part, while in previous years, the bulk of the aggregation was observed further north. The North Porcupine and Rockall areas ranked second and third highest contributing 27% and 15% to the total biomass respectively. Compared to the previous year, less biomass was observed in the Hebrides and Faroes/Shetland area, but more in the Northern Porcupine area, reflecting again the more southern distribution seen this year. An increase in absolute blue whiting biomass was observed in the Rockall area, both on the bank itself and in the Rockall Trough as compared to 2013. However, this increase can be attributed primarily to a high density area in the eastern Rockall Trough, as compared to the lower density echotraces found on the Rockall Bank itself. The breakdown of survey biomass by subarea is shown below:

		Biomass (million tonnes)				
		2013		2014		
	Sub-area		% of total		% of total	Change (%)
I	S. Porcupine Bank	-	-	0.03	1	-
II	N. Porcupine Bank	0.21	6	0.86	27	310%
III	Hebrides	2.44	73	1.54	48	-37%
IV	Faroes/Shetland	0.43	13	0.34	10	-21%
V	Rockall	0.27	8	0.47	15	74%

Stock composition

Individuals of ages 1 to 15 years were observed during the survey. A comparison of age reading between nations was carried out and the results are presented in Appendix 2. Results showed less agreement across participants for especially the younger year classes compared to 2013, with a broad spread of lengths for the youngest and oldest fish in the range.

The stock biomass within the survey area is dominated by age-classes 3, 4, and 5 and 1 years of the 2010, 2009, 2008 and 2013 year classes respectively (Table 4 and Figure 10). The main contribution (76%) to the spawning-stock biomass were the age groups 4, 3, 5 and 6 (Table 4).

The Hebrides area has consistently been the most productive in the current time-series with the exception of this year where a slightly lower but still significant proportion of the overall biomass was located in that area (Figure 6). However, this year the contribution was 48% while the Porcupine area contained a significant portion of the spawning stock in 2014. Mean lengths and weights of the fish caught in the Hebrides area were also among the highest within the whole survey area (Figures 7 and 8). The Faroe/Shetland subarea was dominated by mainly 1 and 3 year old fish, with some 2 year olds, and Porcupine subareas were dominated by 3–5 year old fish. One year old fish were mainly observed in subarea IV (Faroes-Shetland). Older fish (8+ years) were predominantly observed in subarea III (Hebrides) and V (Rockall; Figure 11).

From the survey data, the Faroese/Shetland subarea was found to contain significant proportion of young blue whiting (1–3 years), consistent with previous years. This together represents 70% (238,000t) of the total biomass and 85% (4183 million individuals) of the total abundance in this area. This is close to the proportions seen in 2012 (75% and 86% respectively), and larger than last year.

The largest blue whiting were observed on the Rockall Bank and here most of the fish were mature (97%).

Immature blue whiting were present to various extents in all subareas in 2014 (Figure 11). Maturity analysis of survey samples indicate that 14% of 1-year old, 56% of 2-year old and 90% of 3-year old fish were mature as compared to the 2013 estimates, where 18% of 1-year old fish, 54% of 2-year old fish and 82% of 3-year old fish were considered mature (Table 4). Overall, immature blue whiting from the estimate represented 7.4% (242,000t) of the total biomass and 15% (4667 million) of the total abundance recorded during the survey.

Hydrography

A combined total of 167 CTD casts were undertaken over the course of the survey (Table 1). Horizontal plots of temperature and salinity at depths of 50m, 100m, 200m and 500m as derived from vertical CTD casts are displayed in Figures 12–15 respectively.

Concluding remarks

Main results

- The 11th International Blue Whiting Spawning stock Survey 2014 shows a slight decrease in total biomass of -3% (+15% abundance) when compared to the 2013 estimate, with increased area coverage (2013: 88’000 nmi²; 2014: 125’000 nmi²).
- Favourable weather conditions allowed the five survey vessels to successfully cover the entire planned area within the time available and achieved good containment of the stock.
- The survey was carried out over 14 days this year as compared to 19 days in 2013. Temporal progression of the survey was very good and this was achieved through vigilant survey coordination by means of regular updates. Temporal coverage is well within the 21 daytime window recommended by the group to cover the spawning stock and was facilitated by good weather conditions.
- Estimated uncertainty around the mean acoustic density is low and comparable to the previous two years. It is about half as large as those observed in earlier years (2004–2011) with the exception of 2007, when a much higher uncertainty was recorded.
- The stock biomass within the survey area is dominated by age-classes 4, 3, 5 and 6 of the 2010, 2011, 2009 and 2008 year classes respectively, contributing 74% of total-stock biomass
- Mean length (27 cm) and weight (104.6 g) are lower than in 2013 and in previous years. This can be attributed to the increasing contribution of young fish to the total-stock biomass.
- A positive signal of 3 and 4-year old fish (strong 2010 and 2011 year classes) continues to be observed across all areas and the 2009 and 2010 year classes are now considered fully recruited to the spawning stock. Signs of a potentially strong 2013 year class could be seen in the survey. However, it is too early to predict the magnitude of that year class yet with any degree of accuracy until it can be confirmed in upcoming surveys.

Interpretation of the results

- The 2014 estimate of abundance can be considered as robust. Stock containment was achieved for the core stock areas, with close temporal progression between vessels and a high amount of supporting biological data contributing to the analysis. 85% of the total biomass was observed in target areas surveyed by more than one vessel.
- The bulk of the stock was once again located in the Hebrides core area. Within this area the stock was located further south than at the same time in previous years indicating a later than normal migration of the stock northwards.
- Cohort tracking through the time-series is possible for the most dominant year classes at present (2010 and 2011) and to a lesser extent for older fish. The presence of three successive years of good recruitment is a positive signal after a prolonged period of poor recruitment. The number of 3 year old fish observed in 2014 (2011

year class) is comparable in terms of weight and numbers to that of the strong 2010 year class. The strong 2009 year class has now fully recruited to the stock.

Recommendations

- It is recommended that Norway update the group as soon as possible regarding participation in 2015 to allow for timely planning and allocation of survey effort for the remaining participants.
- It is recommended that all participants with the capacity to do so begin collecting fluorescence data during routine CTD casts in 2015 and submit the data accordingly.
- The 2015 survey will be carried out as detailed in Appendix 3.
- It is the responsibility of individual survey participants to ensure that all data are screened prior to submission to the PGNAPES database following the details outlined in the WGIPS survey manual.
- Group members should discuss the blue whiting maturity stage key (use of 7 stages or 8 stages) and use of inter-transects during biomass estimation at the next WGIPS meeting to decide on a common standardized method.
- Due to difficulties in confirming vessel availability in recent years, the possibility of limiting participating vessels by use of a rotation system should be investigated at the next WGIPS meeting. Potential reduction of survey precision should be investigated in this process.
- Vessels should adhere to the common survey speed of 10 knots. If this cannot be achieved, relevant participants have to communicate this prior to the survey to facilitate planning.
- Vessels surveying the Rockall area should be able to sample blue whiting that is occurring close to the seabed there.

Achievements

- The whole survey area (c.125,000nmi²) was covered within 14 days within the recommended 21 day maximum.
- Comprehensive trawling and hydrographic sampling were carried out.
- Delivery of survey data to Leon Smith (Faroes, data repository) was achieved prior to the post cruise meeting. Most data were quality controlled prior to submitting to the database. Remaining errors were resolved during the post-cruise meeting.

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Table 1. Survey effort by vessel. March-April 2014.

Vessel	Effective survey period	Length of cruise track (nmi)	Trawl stations	CTD stations	Plankton sampling	Aged fish	Length-measured fish
Celtic Explorer	26/3-6/4	1451	11	24		550	1650
Magnus Heinason	29/3-6/4	1173	10	21	21	337	721
G.O.Sars	27/3- 7/4	1962	8	41	38	204	625
Tridens	26/3-5/4	1997	11	24		1101	1100
Fritjof Nansen	25/3-5/4	1648	12	57		1100	3632
Total	25/3-7/4	8,231	52	167	59	3,292	7,728

Table 2. Acoustic instruments and settings for the primary frequency. March-April 2014.

	Fridtjof Nansen	Celtic Explorer	Magnus Heinason	Tridens	G.O. Sars
Echo sounder	Simrad EK60	Simrad EK 60	Simrad EK60	Simrad EK 60	Simrad EK 60
Frequency (kHz)	**38**	**38**, 18, 120, 200	**38**	**38**, 120	18, 70, **38**, 120, 200,
Primary transducer	ES38B	ES 38B	ES38B	ES 38B	ES 38B
Transducer installation	Hull	Drop keel	Hull	Towed body	Drop keel
Transducer depth (m)	5	8.7	3	7	8.5
Upper integration limit (m)	10	15	7	13	15
Absorption coeff. (dB/km)	10	9.8	10.2	10	10.1
Pulse length (ms)	1.024	1.024	1.024	1.024	1.024
Band width (kHz)	2.425	2.425	2.43	2.43	2.43
Transmitter power (W)	2000	2000	2000	2000	2000
Angle sensitivity (dB)	21.9	21.9	21.9	21.9	21.9
2-way beam angle (dB)	-20.6	-20.6	-20.8	-20.6	-20.6
Sv Transducer gain (dB)					
Ts Transducer gain (dB)	25.52	25.98	25.61	26.18	25.5
s_A correction (dB)	-0.64	-0.69	-0.72	-0.67	-0.65
3 dB beam width (dg)					
alongship:	6.99	6.93	7.02	7.05	6.84
athw. ship:	6.99	7	7.01	7.06	6.85
Maximum range (m)	750	750	750	750	750
Post processing software	FAMAS	Sonardata Echoview	Sonardata Echoview	LSSS	LSSS

Table 3. Assessment factors of blue whiting for IBWSS March-April 2014.

	Sub-area		Numbers (10^9)			Biomass (10^6 tonnes)			Mean weight	Mean length	Density
		nmi^2	Mature	Total	%mature	Mature	Total	%mature	g	cm	ton/n.mile^2
I	S. Porcupine Bank	7,999	0.28	0.35	80	0.027	0.031	87	85.3	26.3	3.9
II	N. Porcupine Bank	16,175	8.35	9.37	89	0.8	0.865	92	92.3	26.9	53.5
III	Hebrides	37,371	12.07	12.94	93	1.483	1.544	96	119	28.2	41.3
IV	Faroes/Shetland	23,516	2.38	4.92	48	0.237	0.337	70	68.5	22.6	14.3
V	Rockall	40,258	3.35	3.5	96	0.463	0.475	97	135.8	29.2	11.8
Tot.		125,319	26.43	31.08	85	3.01	3.252	93	121.8	28	25.9

Table 4. Survey stock estimate of blue whiting, March-April 2014.

Length	Age in years (year class)										Numbers	Biomass	Mean weight	Prop. mature*
	1	2	3	4	5	6	7	8	9	10+				
(cm)	2012	2011	2010	2009	2008	2007	2006	2005	2004		($*10^{-6}$)	(10^6 kg)	(g)	(%)
11.0 – 12.0											0			
12.0 – 13.0											0			
13.0 – 14.0											0			
14.0 – 15.0											0			
15.0 – 16.0											0			
16.0 – 17.0	77	0	0	0	0	0	0	0	0		77	1.7	22	0
17.0 – 18.0	388	6	0	0	0	0	0	0	0		394	10.1	26	0
18.0 – 19.0	784	49	6	0	0	0	0	0	0		839	26.1	31	13
19.0 – 20.0	993	150	1	0	0	0	0	0	0		1144	42	37	14
20.0 – 21.0	435	246	1	0	0	0	0	0	0		682	28.8	42	14
21.0 – 22.0	164	164	4	0	0	0	0	0	0		332	16.9	51	52
22.0 – 23.0	35	113	46	0	0	0	0	0	0		194	11.2	58	62
23.0 – 24.0	0	154	226	18	1	0	0	0	0		399	26.2	66	74
24.0 – 25.0	10	299	941	411	74	0	0	0	0		1735	128.8	75	75
25.0 – 26.0	0	229	2244	1376	597	41	11	0	0		4498	366.5	82	85
26.0 – 27.0	0	81	2476	1834	1320	61	19	0	0		5791	517.7	90	94
27.0 – 28.0	0	11	1660	1888	987	94	0	0	0		4640	462.8	100	98
28.0 – 29.0	0	0	527	1188	1039	228	10	0	0		2992	334.4	112	100
29.0 – 30.0	0	0	206	557	759	208	24	0	10		1764	219.4	125	100
30.0 – 31.0	0	0	28	352	568	285	84	23	0	55	1395	197.4	142	100
31.0 – 32.0	0	0	0	68	278	234	90	70	115	158	1013	169.2	168	100
32.0 – 33.0	0	0	20	49	142	124	109	167	116	276	1003	184.7	185	100
33.0 – 34.0	0	0	9	30	108	85	51	176	73	269	801	163.1	205	100
34.0 – 35.0	0	0	1	0	47	33	58	38	113	228	518	115.1	224	100
35.0 – 36.0	0	0	0	0	4	43	41	21	84	212	405	99.3	246	100
36.0 – 37.0	0	0	0	0	0	25	8	27	59	112	231	58.3	254	100
37.0 – 38.0	0	0	0	0	0	6	21	6	19	78	130	35.1	273	100
38.0 – 39.0	0	0	0	0	3	1	6	6	3	32	51	14.9	280	100
39.0 – 40.0	0	0	0	0	0	0	0	0	4	22	26	8.4	321	100
40.0 – 41.0	0	0	0	0	0	0	0	0	0	0	0	0	.	100
41.0 – 42.0	0	0	0	0	0	0	0	2	0	2	4	1.4	407	100
42.0 – 43.0	0	0	0	0	0	0	0	0	0	10	10	3.9	383	100
43.0 – 44.0	0	0	0	0	0	0	0	0	3	12	15	6.9	455	100
44.0 – 45.0	0	0	0	0	0	0	0	0	0	2	2	1.1	519	100
TSN (10^6)	2886	1502	8396	7771	5927	1468	532	536	599	1468	31085	3251		
TSB (10^6 kg)	102.1	96	761.2	767.4	660.7	215.3	93.7	106.7	127.7	320.6	3251			
Mean length (cm)	19.2	22.8	26.3	27.3	28.2	30.4	32.3	33.2	33.9	34.5				
Mean weight (g)	35.4	63.8	90.7	98.7	111.4	146.5	176.4	199	212.8	225				
Condition (g/dm^3)														
% mature*	14	56	90	94	97	99	99	100	100	100				
SSB	14.7	53.5	685.2	721.8	637.6	213.6	93.2	106.7	127.7	320.6	2974.6			

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

Table 5. Country and vessel specific details, March-April 2014.

	Fritjof Nansen	Celtic Explorer	Magnus Heinason	Tridens	G.O. Sars
Trawl dimensions					
Circumference (m)	716	768	640	1120	832
Vertical opening (m)	50	50	40	30-70	45
Mesh size in codend (mm)	16	20	40	±20	40
Typical towing speed (kn)	3.0-3.7	3.5-4.0	3.0-4.0	3.5-4.0	3.0-3.5
Plankton sampling	0	0	21	0	38
Sampling net	-	-	WP2 plankton net	-	WP2 plankton net
Standard sampling depth (m)	-	-	200	-	400
Hydrographic sampling					
CTD Unit	SBE19plus	SBE911	SBE911	SBE911	SBE911
Standard sampling depth (m)	1000	1000	1000	1000	1000

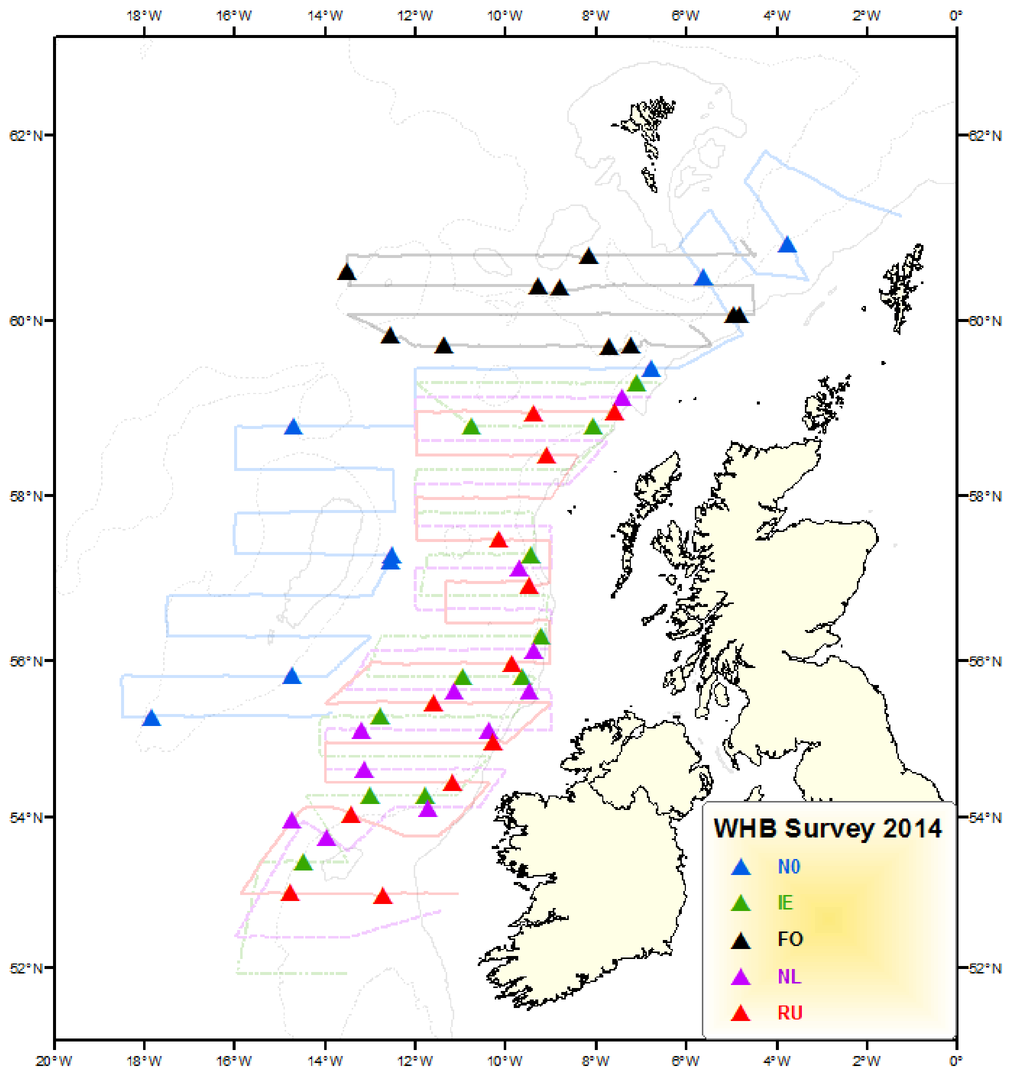


Figure 1. Vessel cruise tracks and trawl stations of the International Blue Whiting Spawning stock Survey (IBWSS) from March-April 2014. IE: Ireland (Celtic Explorer); FO: Faroe Islands (Magnus Heinason); NL: Netherlands (Tridens); RU: Russia (Fritjof Nansen); NO: Norway (G.O. Sars).

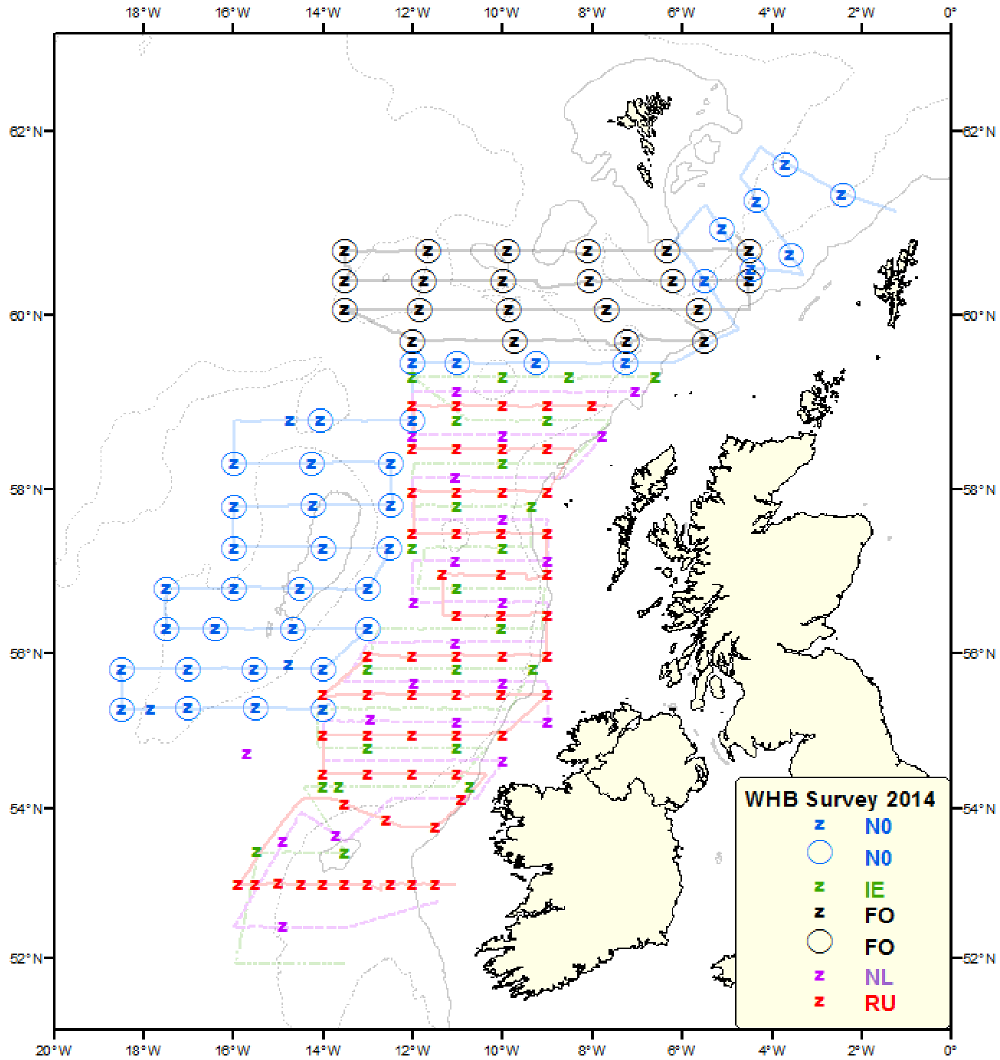


Figure 2. CTD stations overlaid onto vessel cruise tracks for the combined survey ('z'). Circles represent plankton trawls. green: Celtic Explorer; black: Magnus Heinason; purple: Tridens; red: Fritjof Nansen; blue: G.O. Sars. March-April 2014.

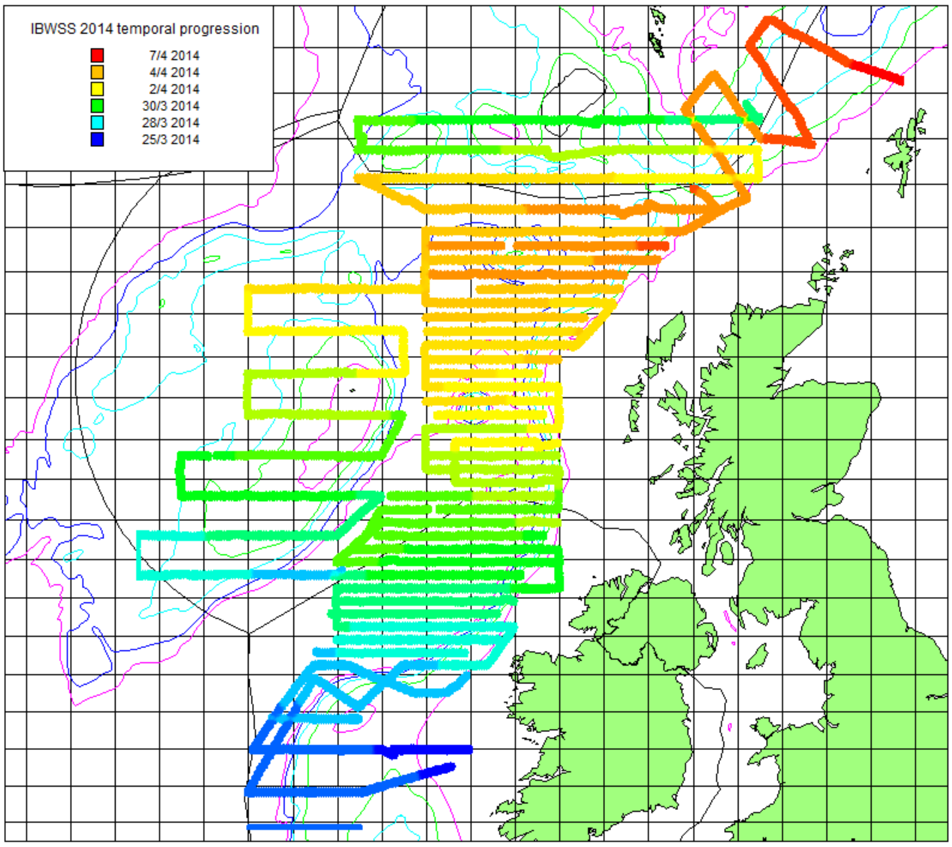


Figure 3. Temporal progression for the International Blue Whiting Spawning stock Survey (IBWSS), 25 March – 7 April 2014.

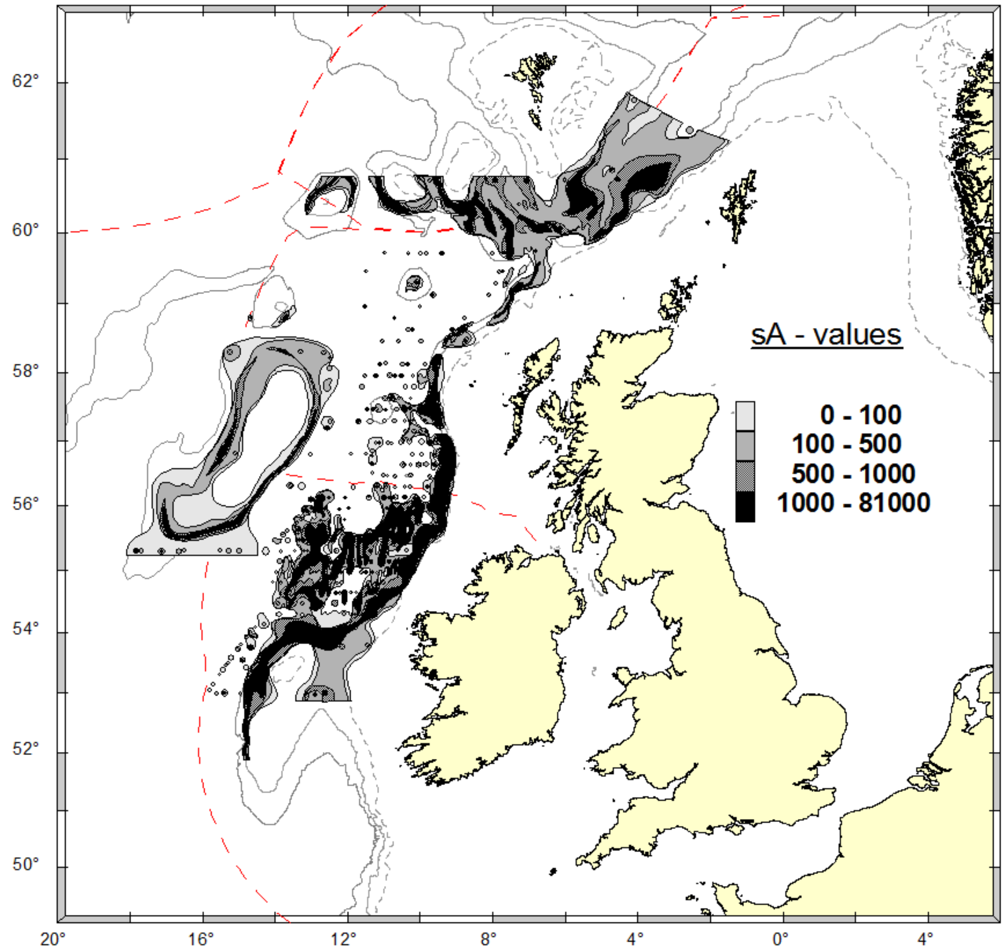


Figure 4. Map of blue whiting acoustic density (s_A, m²/n.m.²) , 24 March – 7 April 2014.

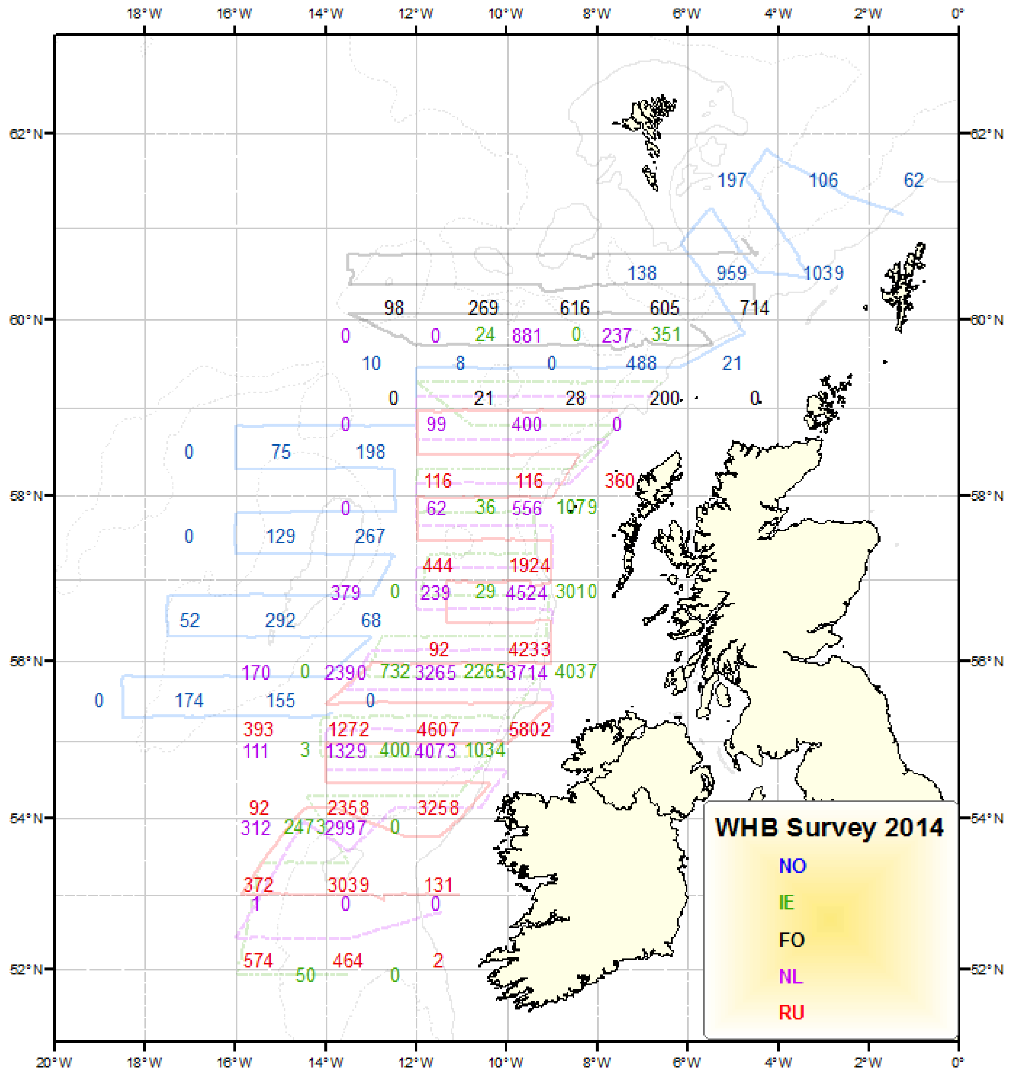


Figure 5. Mean blue whiting acoustic density (s_A, m²/n.m.²) for IBWSS 2013 by individual vessel: Celtic Explorer: green, Magnus Heinason: black, Tridens: grey, Fritjof Nansen: red, G.O. Sars: blue. March-April 2014.

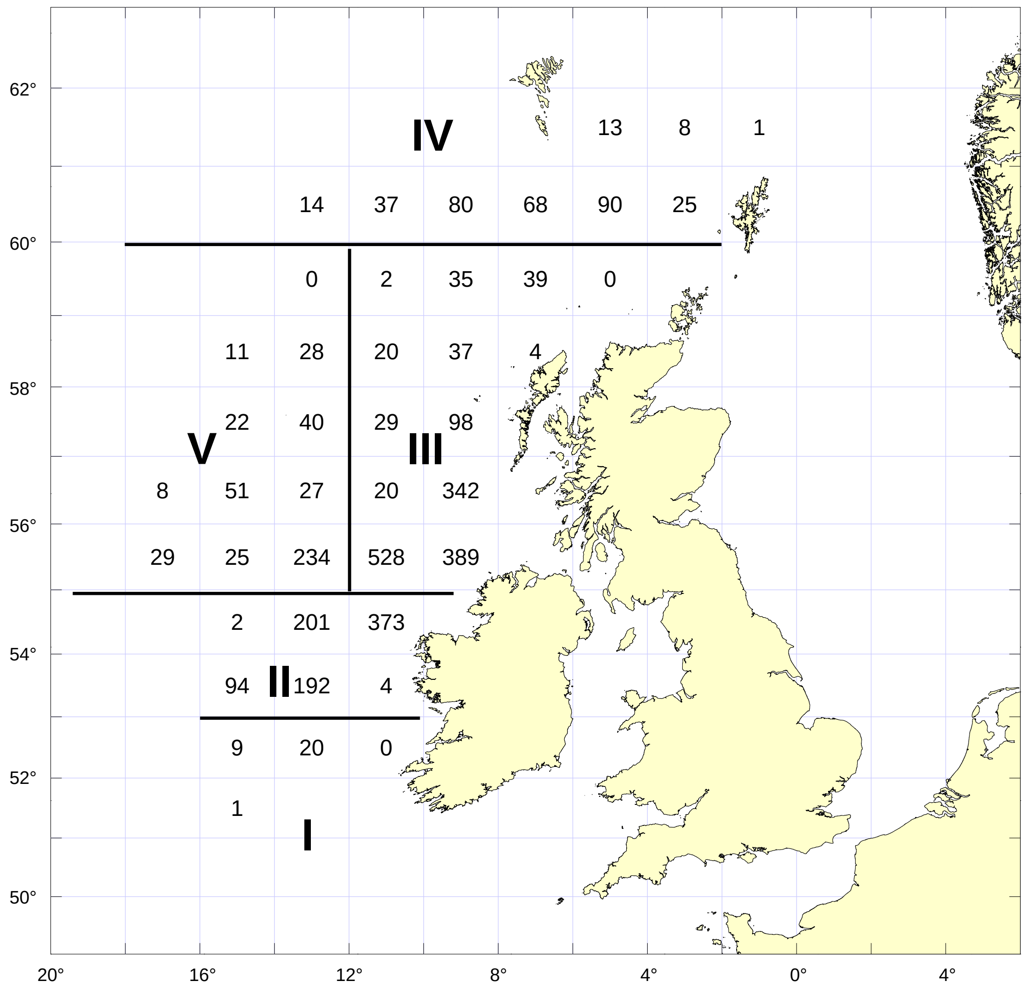


Figure 6. Blue whiting biomass (x1000t) from IBWSS 2014 by subarea as used in the assessment.

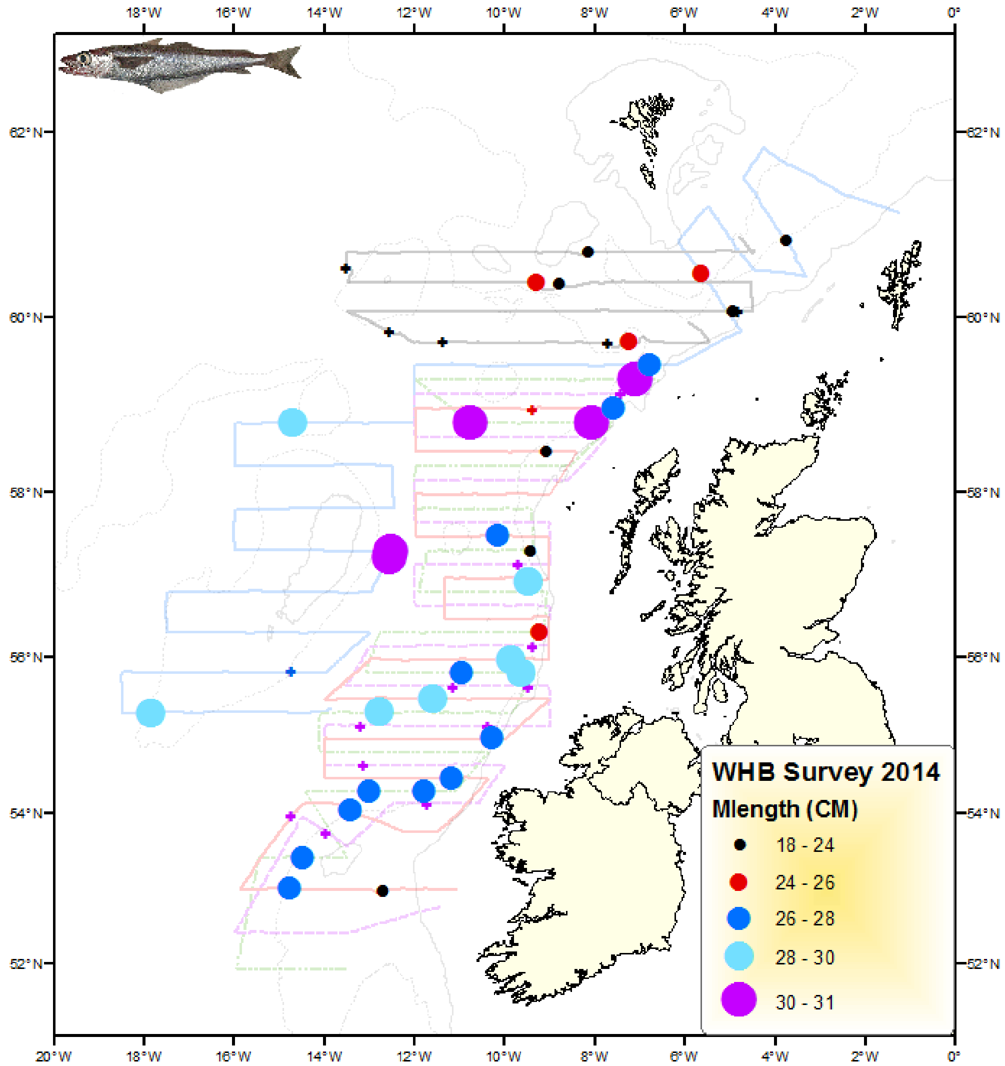


Figure 7. Mean length of blue whiting caught in trawl catches during IBWSS 2014 by individual vessels in March-April 2014. Crosses indicate trawls without any blue whiting catches.

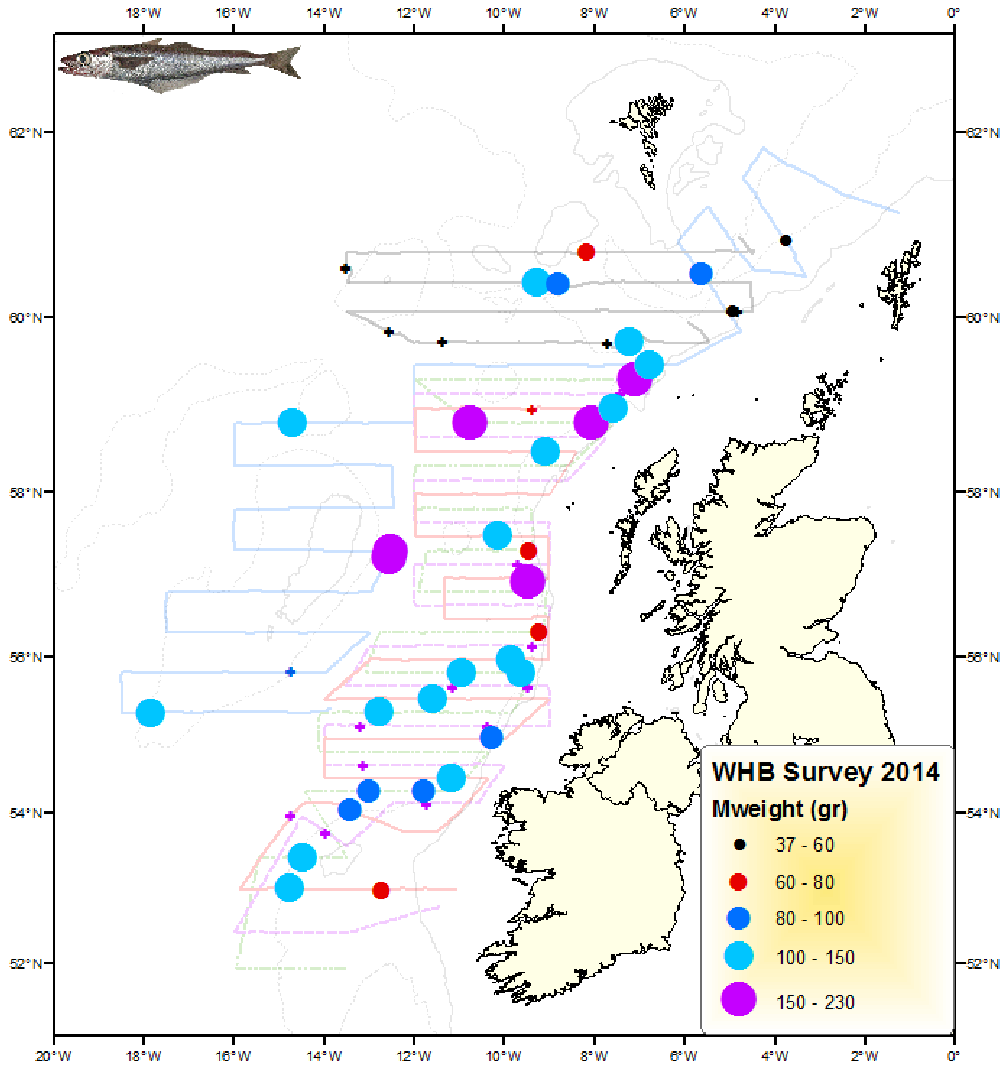
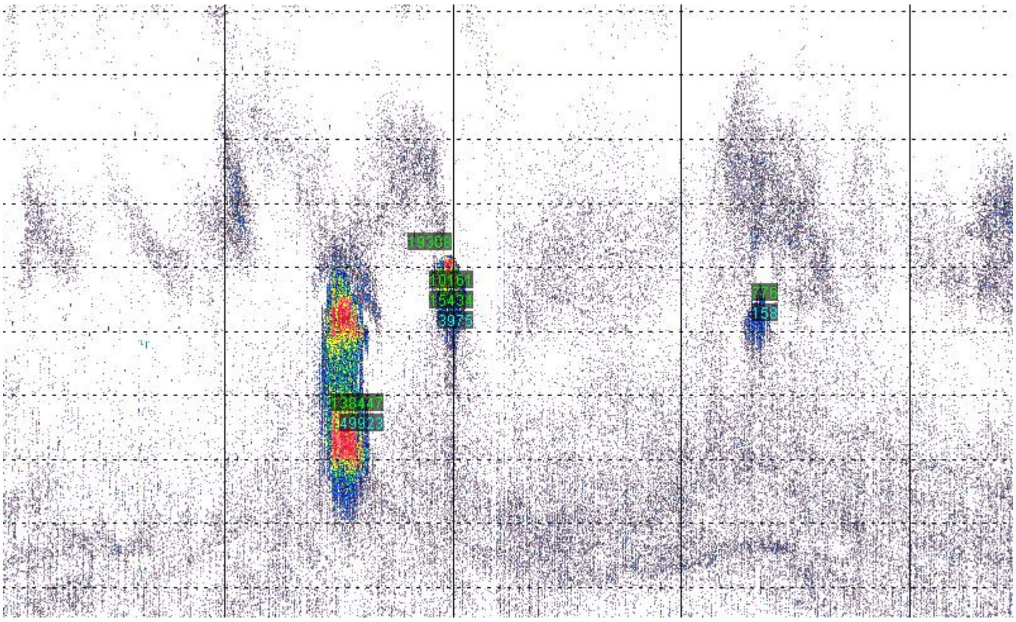
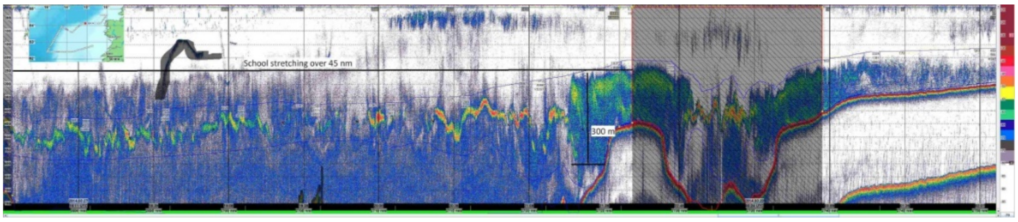


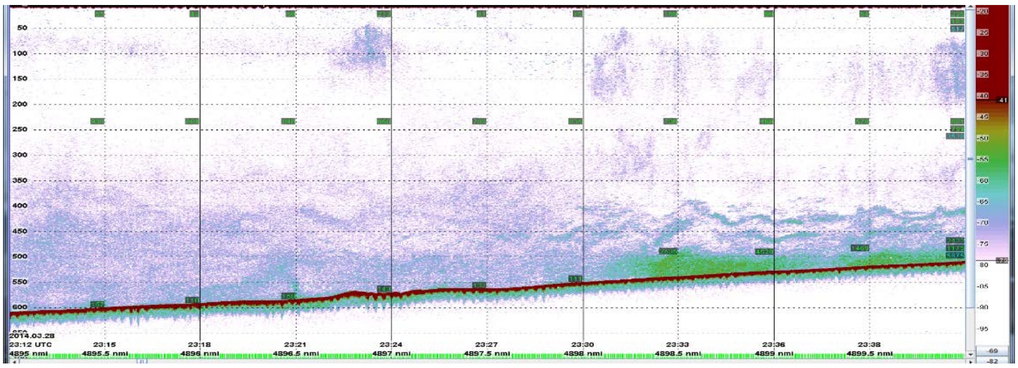
Figure 8. Mean weight of blue whiting caught in trawl catches during IBWSS 2014 by individual vessels in March-April 2014. Crosses indicate trawls without any blue whiting catches.



a). Scattered Double blue whiting echotrace observed by Tridens in the Northern part of the survey area.



b) Long blue whiting school observed onboard Tridens in subarea II (northern Porcupine).



c) Blue whiting schools close to the seabed on Rockall observed by G.O. Sars.

Figure 9. Echograms of interest encountered during the combined International blue whiting survey in March-April 2014.

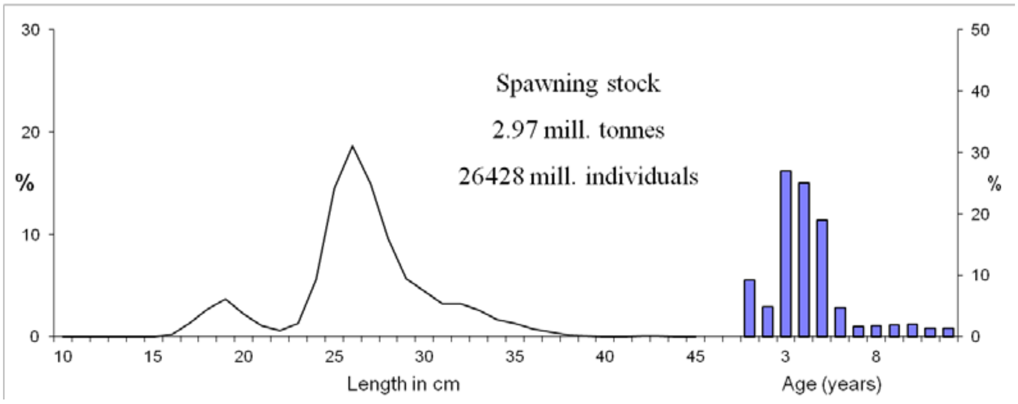


Figure 10. Length and age distributions (numbers) of total stock of blue whiting. Spawning-stock biomass is given. March-April 2014.

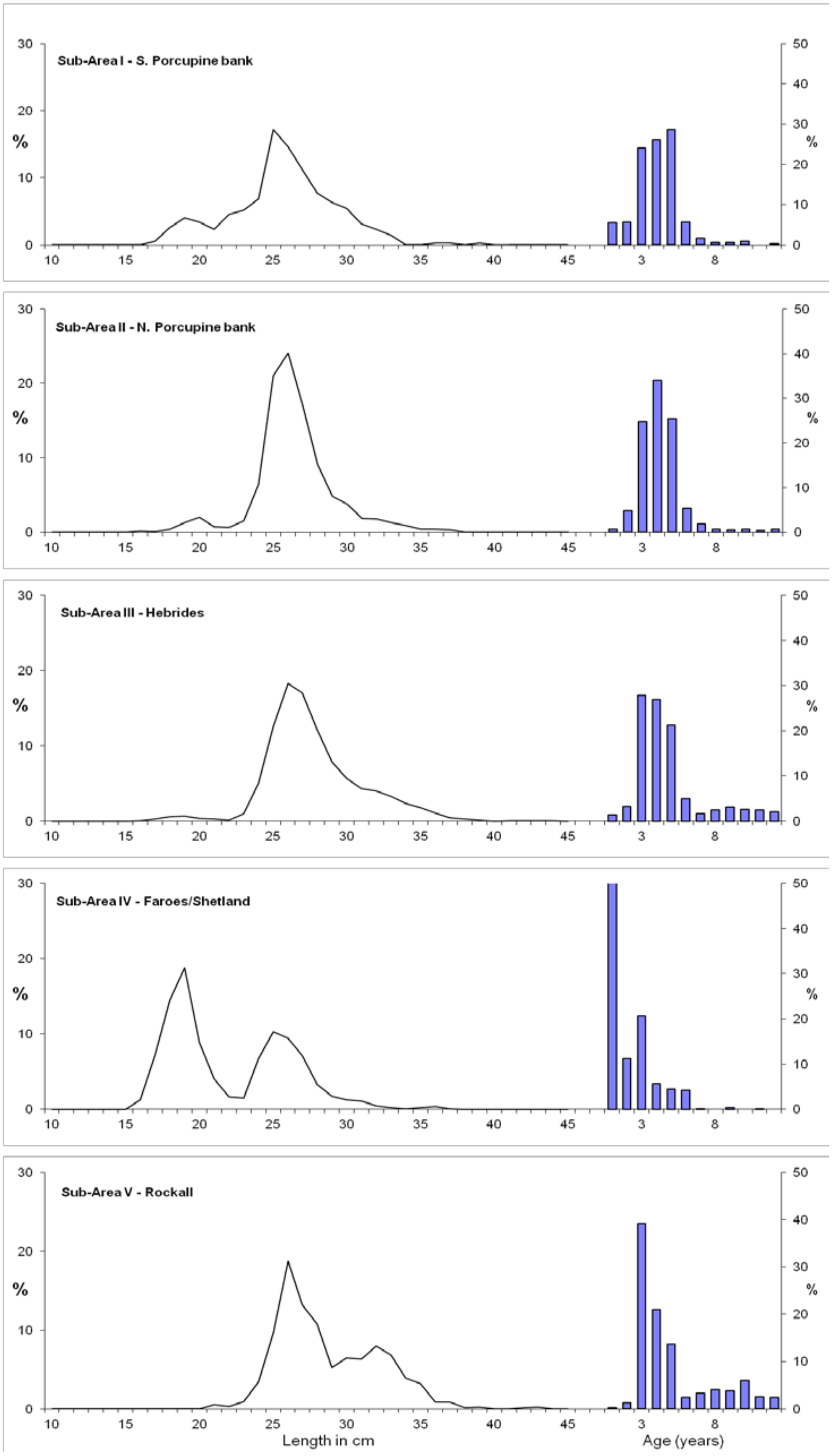


Figure 11. Length and age distribution (numbers) of blue whiting by covered subarea (I–V). March-April 2014.

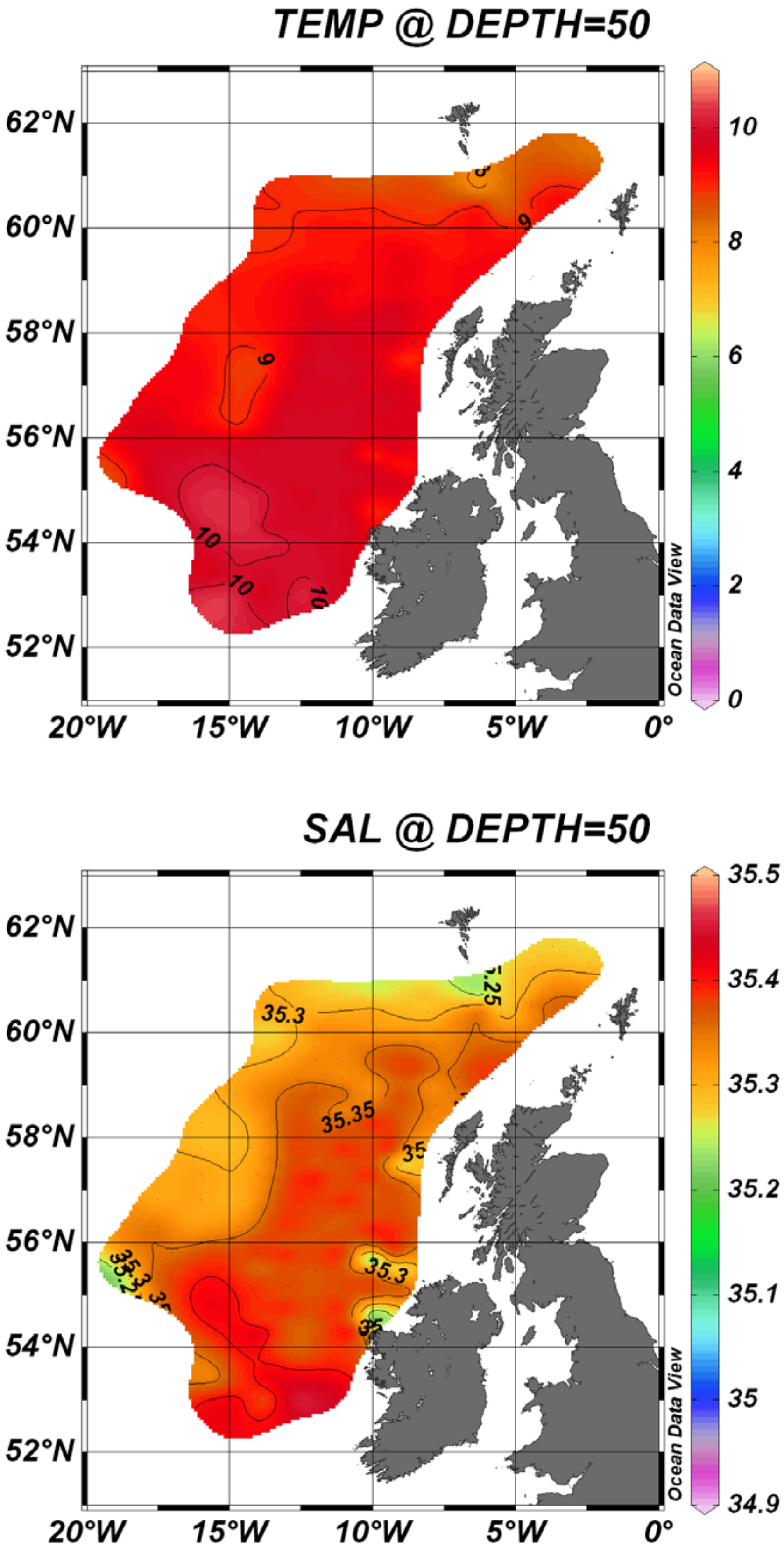


Figure 12. Horizontal temperature (top panel) and salinity (bottom panel) at 50m subsurface as derived from vertical CTD casts. March-April 2014.

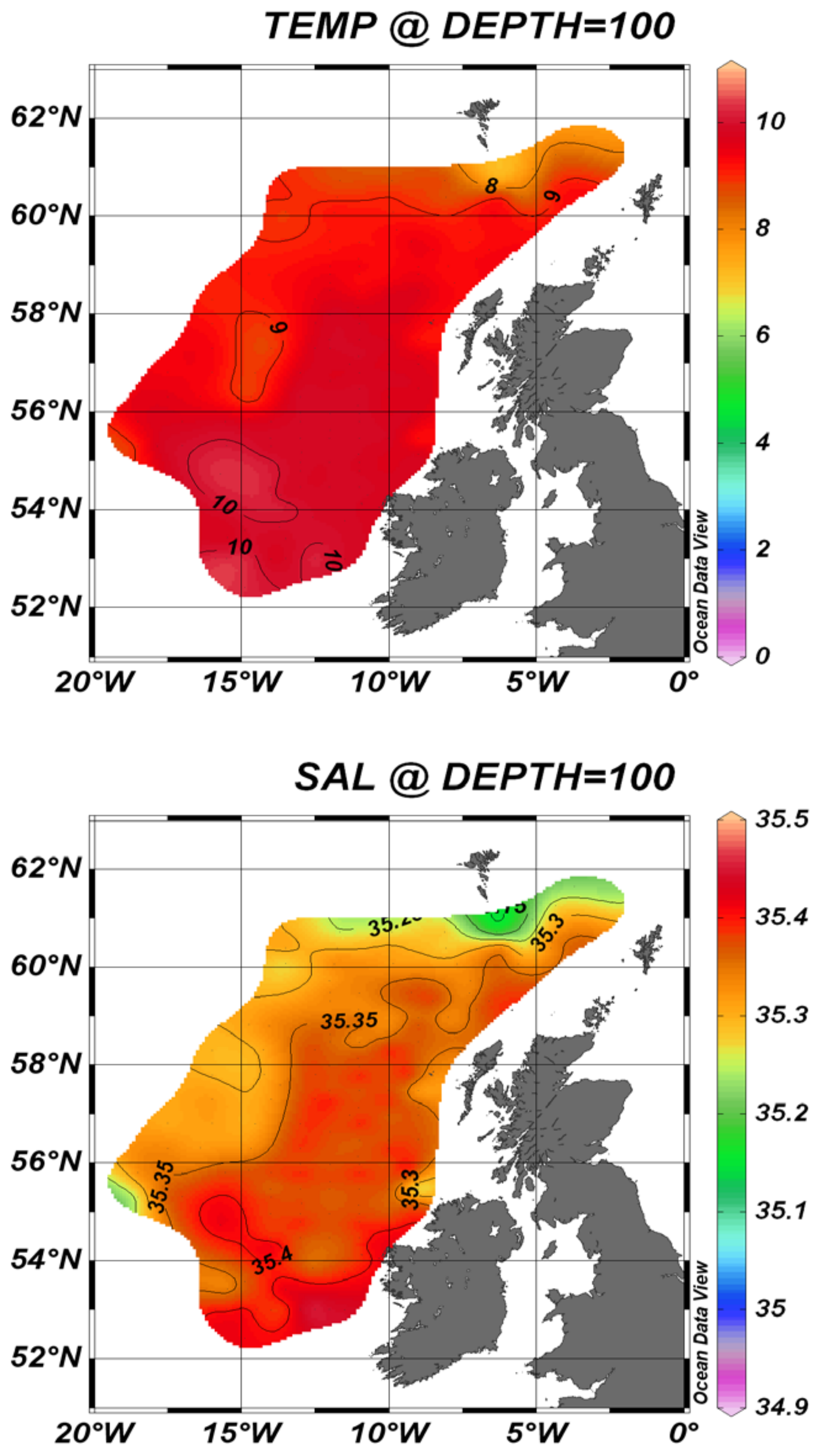


Figure 13. Horizontal temperature (top panel) and salinity (bottom panel) at 100m subsurface as derived from vertical CTD casts. March-April 2014.

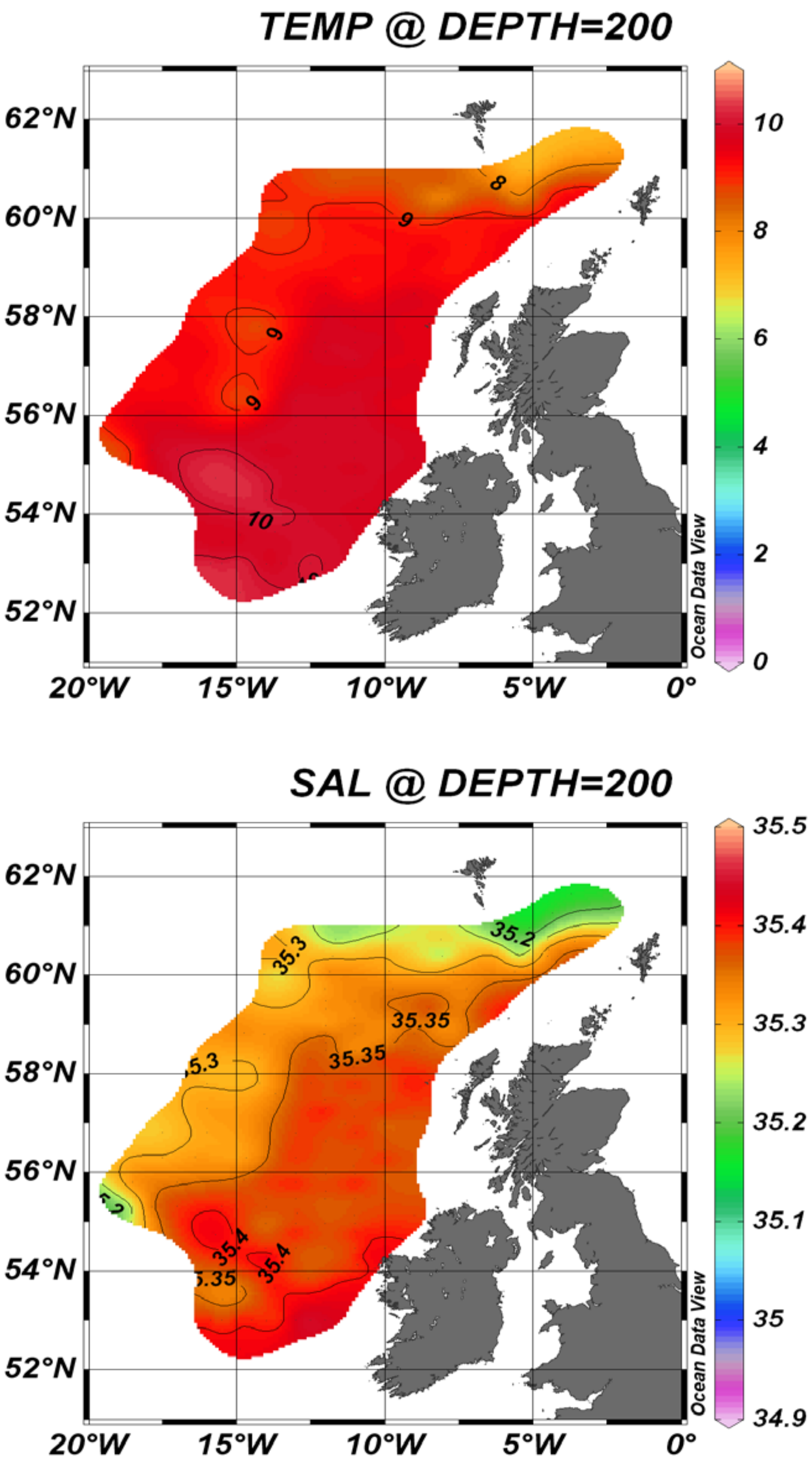
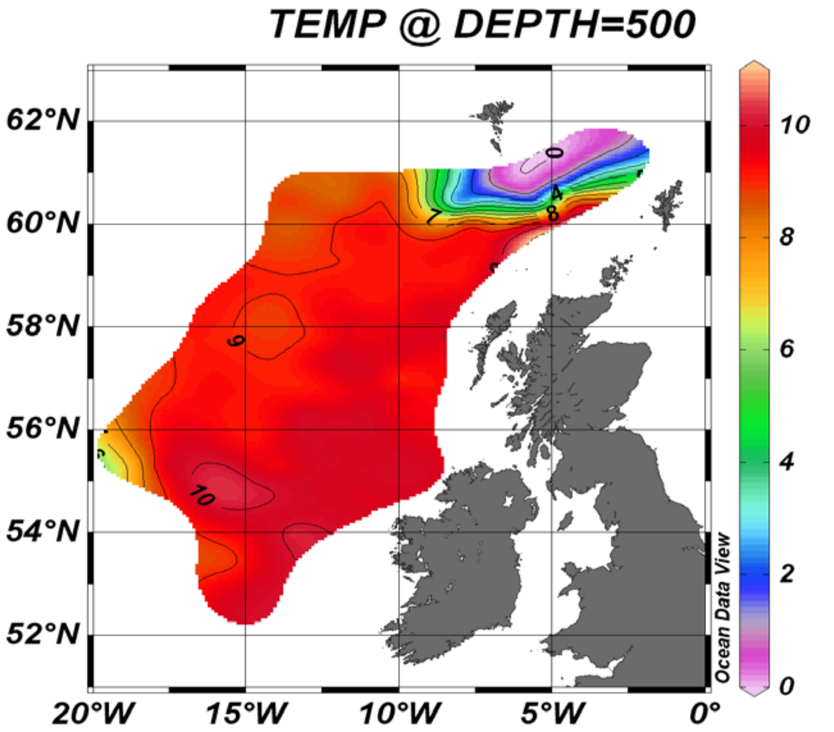


Figure 14. Horizontal temperature (top panel) and salinity (bottom panel) at 200m subsurface as derived from vertical CTD casts. March-April 2014.



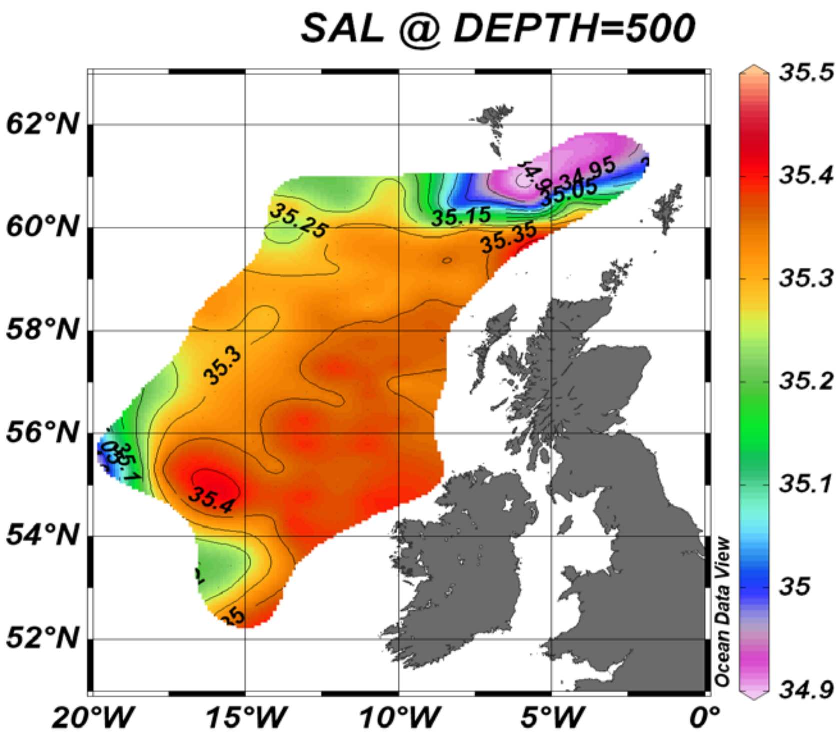


Figure 15. Horizontal temperature (top panel) and salinity (bottom panel) at 500m subsurface as derived from vertical CTD casts. March-April 2014.

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

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).

When calculating stock estimates from acoustic surveys, the data (acoustics density [sA] allocated to blue whiting, in units of $m^2/n.m.^2$) from each vessel are expressed as average values over so-called EDSUs (equivalent distance sampling unit) ranging between 1 and 5 n.m. Acoustic density for each survey stratum (subarea with similar fish length distributions) is calculated as an average across all observations (EDSUs) within a stratum, weighted by the length of survey track behind each observation. Normally, these values are then converted to stratum-specific biomass estimates based on information on mean length-at-age of fish in the stratum and the assumed acoustic target strength of the fish; the total survey biomass estimate is the sum of stratum-specific estimates. In the precision estimation exercise routinely performed for the International Blue Whiting Spawning stock Survey (IBWSS), the whole estimation procedure is not repeated, but instead, uncertainty in global mean acoustic density estimates is characterized. As mean size of blue whiting does not vary very much in the survey area, uncertainty in mean acoustic density provides a conservative estimate of uncertainty in total-stock biomass.

Bootstrapping is used to estimate uncertainty in the mean acoustic density. It is calculated 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 2014 survey as well as ten earlier international surveys. Mean acoustic density over the survey area was 698.5 $m^2/n.m.^2$ (as compared to 959.2 $m^2/n.m.^2$ in 2013) with 95% confidence interval being 644.1 (lower) and 754.8 (upper) $m^2/n.m.^2$. Relative to the mean, the approximate 95% confidence limits are –7.8% and +8.0%, and 50% confidence limits are –3.0% and +2.9%. This level of uncertainty in acoustic densities is comparable to previous years and among the lowest in the time-series so far. Overall, mean acoustic density has shown a consistent decrease annually from 2007 to 2010 and an increase thereafter until 2013. This year, the density has decreased again.

Figure 2 summarizes the results and puts them in the biomass context. The overall trend indicates a continued decrease year-on-year in biomass from 2007–2011 for this stock. The uncertainty around the decline in biomass from 2008 to 2011 is more than could be accounted for from spatial heterogeneity alone and is regarded as statistically significant. The biomass estimate from 2010 was omitted in the assessment process due to coverage problems in the survey and a resulting possibility of biomass underestimation. The 2014 estimate shows a slightly decreasing trend in biomass again when compared to the previous two years.

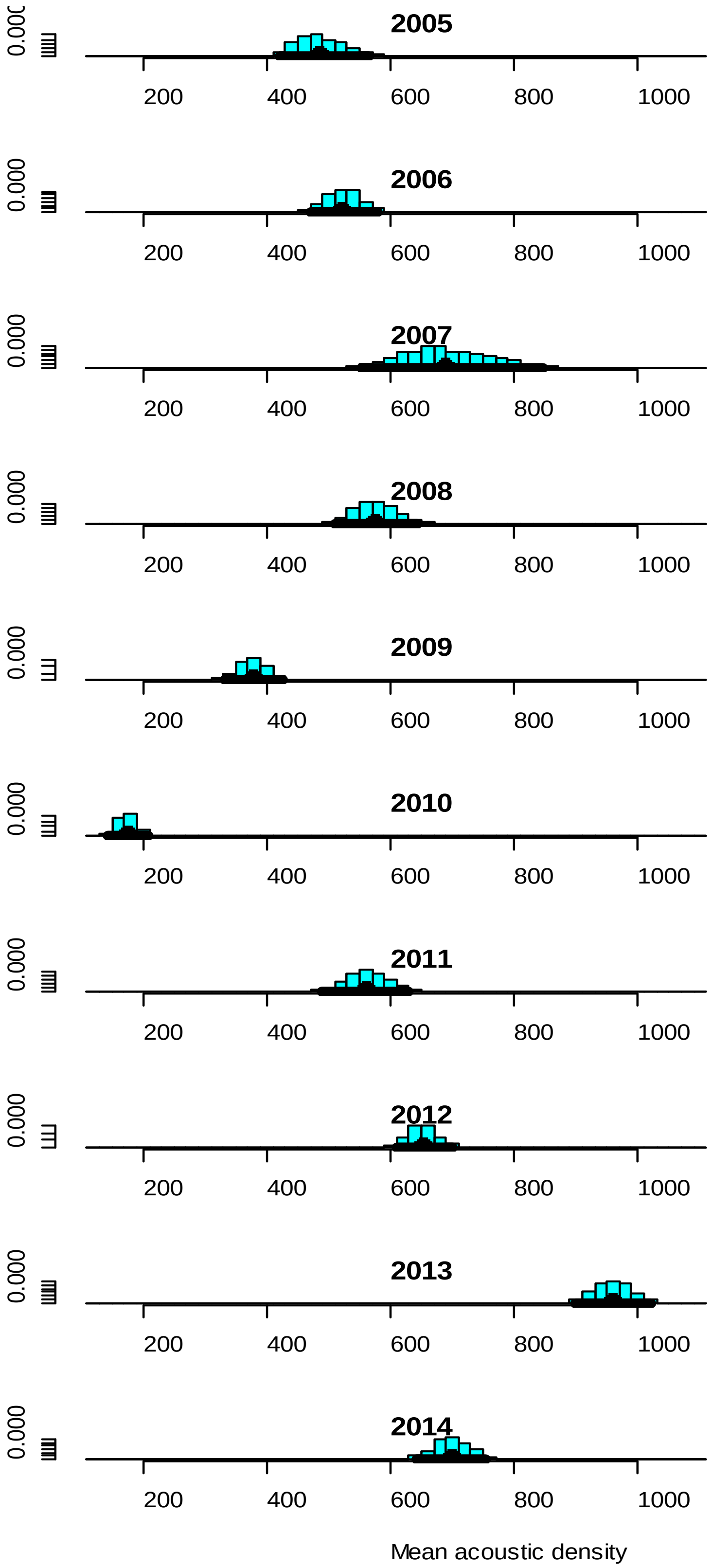


Figure 1. Distribution of mean acoustic density (in m²/n.m.²) by year based on 1000 bootstrap replicates of acoustic data from blue whiting surveys. Mean acoustic density is indicated with a black dot on the x-axis, while the horizontal bar shows 95% confidence limits.

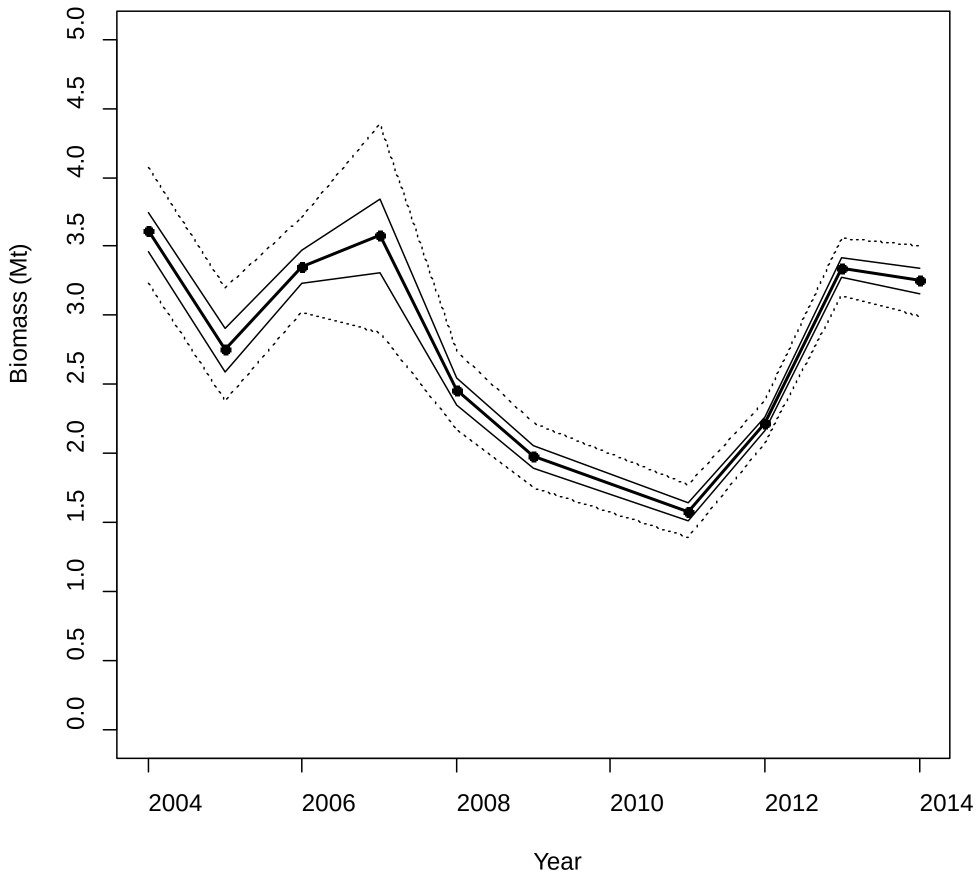


Figure 2. Approximate 50% and 95% confidence limits for blue whiting biomass estimates. The confidence limits are based on the assumption that confidence limits for annual estimates of mean acoustic density can be translated to confidence limits of biomass estimates by expressing them as relative deviations 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.

A review of consistency of age readings was carried out using data collected from all nations. A broad range of ages were observed from 1 to 15 years from survey data in 2014 with a corresponding length range of 16–46cm.

Results show a relatively good agreement for ages 1–6 years (Figure 1). Some inconsistencies still exist for older age-classes (6+ years) which are considered the most difficult to age due to the presence of false rings and the smaller number of samples overall. However, for the youngest fish (1–3 year olds) some discrepancies were again observed in 2014. There is an indication that Russia seem to have a lower mean length-at-age for two and three year old fish than the other countries in 2014 (i.e. reading the small fish too old), and perhaps Norway had a higher mean length-at-age that the rest for ages two to four (Figure 1).

A review of data across years (2010–2014) shows a year on year improvement especially for younger age classes up to 2013, however, with some discrepancies again for the youngest fish in 2014 (Figure 2).

Most of the survey age reader personnel participated in the blue whiting age reading workshop (Bergen, June 2013), where otoliths collected during the combined survey in 2013 were used as a worked example for the participants. It is recommended that the age readers look into the discrepancy problem for ages 1–3 in the 2014 blue whiting age reading material.

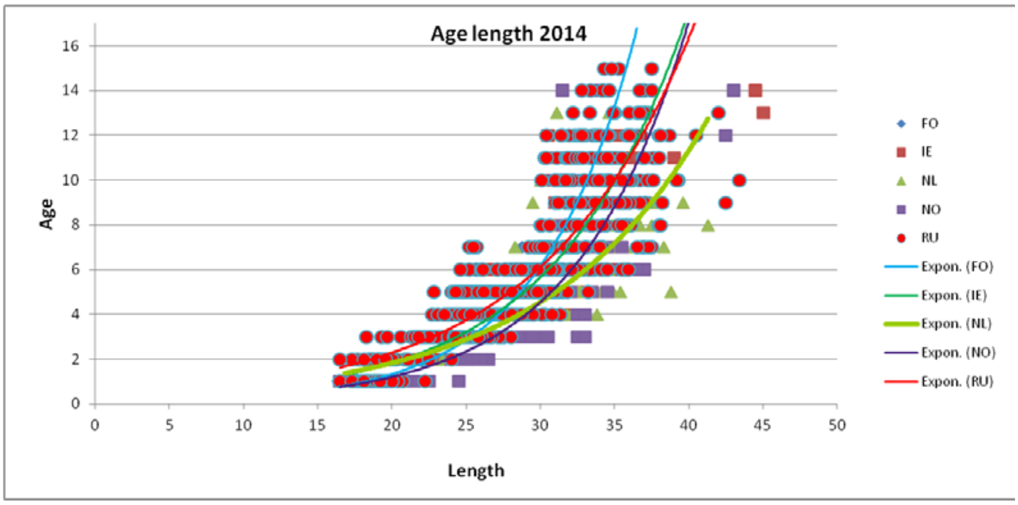


Figure 1. Profile of length-at-age by nation of blue whiting collected during individual surveys in 2014 (FO; Faroes, IE; Ireland, NL; Netherlands, NO; Norway and RU; Russia).

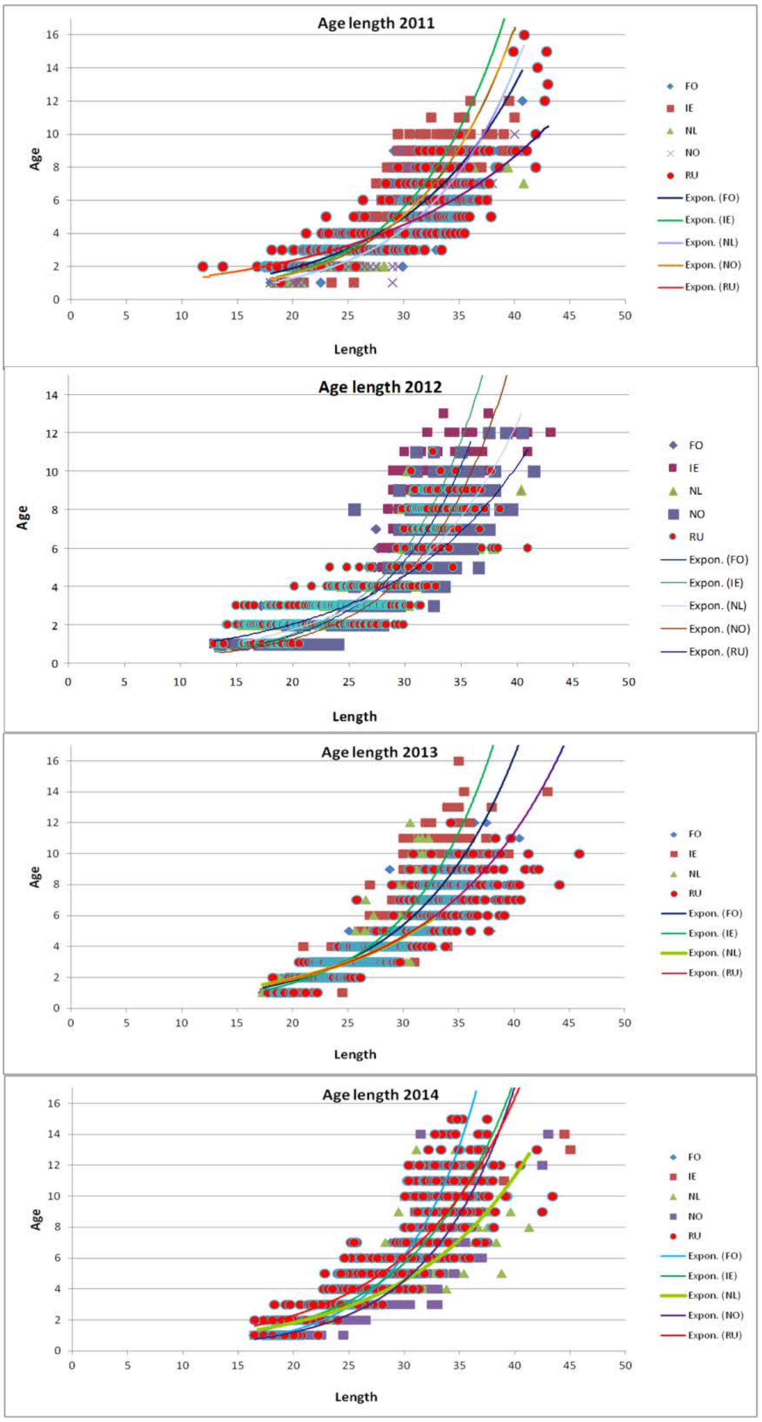


Figure 2. Profile of length-at-age by nation of blue whiting collected during individual surveys from 2011–2014 (FO; Faroes, IE; Ireland, NL: Netherlands, NO; Norway* and RU; Russia).* No participation from Norway in 2013.

Appendix 3. Planned acoustic survey of the NE Atlantic blue whiting spawning grounds (IBWSS) in 2015

Five vessels representing the Faroe Islands, the Netherlands (EU-coordinated), Ireland (EU-coordinated), Norway and Russia are expected to participate in the 2015 spawning stock survey. There is still uncertainty about the Norwegian participation. Preliminary planning is again based on four vessels at this stage until final participation will be confirmed at the 2015 WGIPS meeting.

Survey timing and design were discussed during the meeting. The group decided that in 2015, the survey design should follow the principle of the one used during the three previous surveys. The focus will still be on a good coverage of the shelf slope in areas II and III. However, given the increasing stock biomass observed over recent years, it can be expected that the distribution will be more extended over the whole survey area as well, as was observed in the 2014 survey. In previous years when larger stock sizes were observed (2004–2007), blue whiting aggregations were distributed more evenly over the whole survey area, including on the Rockall Bank and Rockall Trough. Therefore, the survey design in 2015 will again allocate more effort in these areas as well.

The design is based on variable transect spacing, ranging from 30 nm in areas containing less dense aggregation (e.g. subarea I, south Porcupine), to 10 nm in the core survey area (subarea III, Hebrides; Figure 4.1). The western borders of the transects in subarea III are extending to 12°W in order to cover potential blue whiting aggregations extending further from the continental slope into the Rockall Trough. To avoid replication, transects will be allocated systematically with a random start location.

The aim is to have three vessels start surveying on their transects just north of subarea II (North Porcupine) at the same time (25.03.2015; Table 1). That way, the core survey subarea III can be covered synoptically by several vessels with a similar temporal progression.

It was decided that the Russian and Irish vessels would start the survey in the southern subareas I and II (Porcupine). 2–4 days after beginning their individual surveys, these vessels will be joint by G.O. Sars and continue surveying the north of subarea II and afterwards area III from the south progressing northwards. Once the Norwegian G.O. Sars vessel has finished surveying subarea III, she will continue northwards into the Faroese-Shetland channel and continue coverage in a northeastern direction until time allows. The Faroese vessel will primarily survey subarea V (Faroese/Shetland) and join the other vessels in the north of area III once they are present there towards the end of the survey period. The Rockall area will be covered by Tridens, starting in the south on 25.03.2015, progressing northward. Survey extension in terms of coverage (51–61ºN) will be in line with the previous year to ensure containment of the stock and survey timing will also remain fixed as in previous years.

Key will be to achieve coverage of area III in a consistent temporal progression between vessels. It is therefore very important that all vessels covering the core Hebrides area are present on station in the north of subarea II (just north of Porcupine Bank) on 25 March 2015 (Table 1). Nonetheless, if some vessels are found to lag behind others, the tight 10 n.m. transect spacing will allow for adaptation of the survey design without great loss of coverage. For instance, this may mean either skipping or extending some of the horizontal transects to catch up or keep pace with the other vessels. Biological sampling should be carried out following methods normally applied to sampling acoustic registrations.

If registrations of blue whiting marks are continuing at the end of any planned transects, the length of these transects should be extended until no more marks are registered for a distance of 3 n.m. (or 20 minutes at normal survey speed).

Preliminary cruise tracks for the 2015 survey are presented in Figure 1. A new survey coordinator has to be appointed during the next WGIPS meeting, 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 have been communicated (after WGIPS, latest by the end of January 2015).

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.

Participants are also required to use the logbook system for recording course changes, CTD stations and fishing operations. An example format can be circulated to participants at the 2015 WGIPS meeting. The survey will be carried out according to survey procedures described in the "MANUAL FOR INTERNATIONAL PELAGIC SURVEYS (IPS)" (WGIPS report 2012).

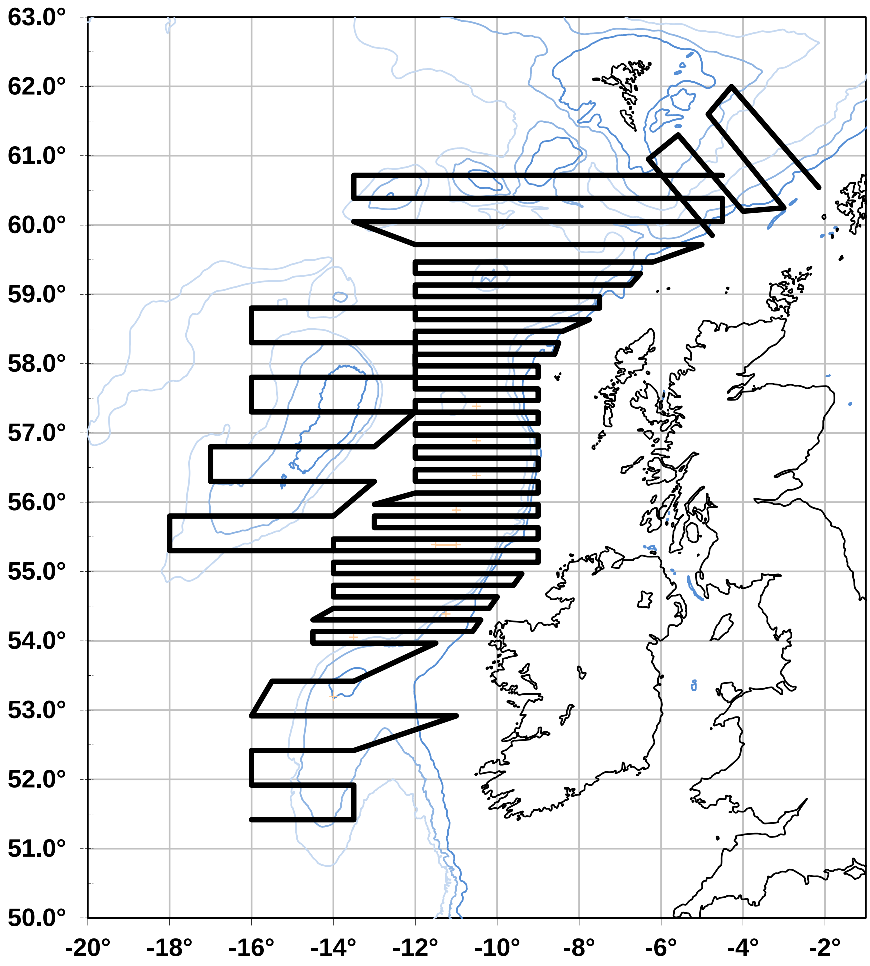


Figure 1. Preliminary survey tracks for the combined 2015 International Blue Whiting Spawning stock Survey (IBWSS).

Table 1. Preliminary individual vessel dates for the 2015 International Blue Whiting Spawning stock Survey (IBWSS).

Ship	Nation	Active survey time (days)	Preliminary survey dates
Fritjof Nansen	Russia	19	23.3.2015 – 10.4.2015
Celtic Explorer	Ireland (EU)	19	23.3.2015 – 10.4.2015
G.O. Sars	Norway	14	25.3.2015 – 7.4.2015
Tridens	Netherlands (EU)	17	23.3.2015 – 8.4.2015
Magnus Heinason	Faroe Islands	11	25.3.2015 – 8.4.2015

Annex 5b: International Ecosystem Survey in Nordic Seas (IESNS)

Working Document to:

Working Group on International Pelagic Surveys (WGIPS)

Copenhagen, Denmark, 19 –23 January 2015

Working Group on Widely distributed Stocks (WGWIDE)

Copenhagen, Denmark, 26 August –1 Sept. 2014

INTERNATIONAL ECOSYSTEM SURVEY IN NORDIC SEA (IESNS) IN April – June 2014

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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]
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Introduction

In April-June 2014, 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 Southwestern 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: Anonymous 2014, Magnus Heinason: Smith and í Homrum FAMRI 1416–2014, Arni Friðriksson: Oskarsson and Sveinbjornsson 2014, Fridtjof Nansen: Rybakov PINRO 2014 and G.O. Sars: not (yet) available.

Material and methods

Coordination of the survey was done only by correspondence as its main platform for discussions, the Working Group on Northeast Atlantic Pelagic Ecosystem Surveys (WGNAPES), was emerged with WGIPS in 2012 and only few scientists involved in this survey attend its meetings. 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	13/5–1/6
G. O. Sars	Institute of Marine Research, Bergen, Norway	3/5–31/5
Fridtjof Nansen	PINRO, Russia	14/5–10/6
Magnus Heinason	Faroe Marine Research Institute, Faroe Islands	1/5- 12/5
Arni Friðriksson	Marine Research Institute, Island	30/4–22/5

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 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
Echosounder	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	4.5
Upper integration limit (m)	5	15	15	7	10
Absorption coeff. (dB/km)	6.9	10.1	10	10	10
Pulse length (ms)	1.024	1.024	1.024	1.024	1.024
Bandwidth (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	-20.6	-20.9	-20.8	-20.73
Sv Transducer gain (dB)					
Ts Transducer gain (dB)	25.33	25.5	24.64	25.61	25.72
s_A correction (dB)	-0.55	-0.65	-0.84	-0.72	-0.63
3 dB beam width (dg)					
alongship:	6.73	6.84	7.31	7.02	6.99
athw. ship:	6.77	6.85	6.95	7.01	7.04
Maximum range (m)	500	500	750	500	500
Post-processing software	LSSS	LSSS	LSSS	Sonardata Echoview 5.1	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).

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	3.1–4.3

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 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 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 (sA) 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 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.

For the first time, 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, transects were distributed equally apart and the distance was based on available survey time and surveys in previous years. Thus the survey coverage was comparable to previous years, but with more organized interval between transects. This approach will allow for robust statistical analyses of uncertainty of the acoustic estimates in future.

A new software package (StoX) is under development by IMR, Norway. This is 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. the IESNS survey plan 2014) and standard statistical methods to estimate mean and variance of abundance will 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.

StoX was used for verification and sensitivity analyses of the biomass estimates of herring. This was done to verify the effect of leaving out transects from Dana because of time-lag of their coverage compare to other vessels (around 10 days later) and obvious nearly lack of herring registrations in parallel adjoining transects with G.O. Sars. This was an exploratory work and the obtained biomass estimates from the program will not be used until a thorough investigation and comparison with the estimates from the BEAM software has taken place. The expectation is that the StoX software will replace the outdated BEAM program in the near future.

Further work on the stratification will take place in the coming years, including defining the most appropriate stratum size and layout of each stratum.

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 four fixed hydrographical transects (Slétta, Langanes-NE, Langanes-E and Krossanes; Figure 15; total 32 stations) east and northeast of Iceland were also used. They were sampled in the spring survey around Iceland by RV Bjarni Sæmundsson during 18–22 May 2014 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

Temperature distribution for April-June 2014

The temperature distributions in the ocean at selected depths between 10 m and 400 m depths are shown in Figures 5–10. The temperatures at the surface ranged between 2°C in the Iceland Sea and 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 70° N in the surface layers and to 68 ° N at 200 m depth.

Relative to a 19 years long-term mean, from 1995 to 2013, the temperature at 20 m depth northeast of Iceland was considerable higher in 2014 compared to the long-term mean (Figure 11). There, the anomaly was maximum 2°C. This pattern was also observed at 0–50 m depth at the standard hydrographic sections northeast off Iceland (Figures 15–17). At greater depths the difference between 2014 and the long-term mean was smaller (Figures 12–14). In general, at 200 m and shallower depths the western part of the Norwegian Sea and the Iceland Sea was somewhat warmer than the long-term mean. It was also observed at the standard hydrographic section off northeast Iceland (Figure 18). In the eastern part of the Norwegian Sea the temperature was lower than the mean, particular in the upper layer where it was about 0.5 °C colder than the mean (Figure 11). At 200 m and particular at 400 m depth the temperature was lower than the long-term mean (about 0.25–0.50 °C) in the central Norwegian Basin.

Zooplankton

Biomass of zooplankton and sampling stations are shown in Figure 19. Sampling stations were relatively evenly spread over the area, and most oceanographic regions were covered. The zooplankton biomass was relatively uniform over the whole area, except for higher concentrations off the Norwegian coast around 65°N, and still continues the upwards trend since the lowest recorded value in the time-series in 2009 (Figure 20). Recorded zooplankton biomass in the two areas west and east of 2°W equalled 9.4 and 9.8 g dry weight m-2, respectively, while total mean was 9.7 g dry weight m-2. When limiting the area to west of 17°E (eliminating Barents Sea measurements), the biomass indices become 9.4 (west), 9.9 (east) and 9.7 (total) g dry weight m-2. This year, no zooplankton was sampled on the continental slope south and west of Iceland (west of 14°W).

In the Barents Sea, the mean zooplankton biomass was 1.6 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 2014 and in line with previous years. It is therefore recommended that the results can be used for assessment purpose. The herring distribution in 2014 was similar to the 2013 distribution.

The highest concentrations were found in the central to southwestern part of the Norwegian Sea (Figures 21 and 22), and consisted mainly of older part of the stock (age 8 and older; Table 2). A dense concentration was also found in the northeast (around 69°N and 5°E) and consisted of a mixture of all age classes from age 2–14. Overall the herring density was relatively low and herring was never observed in big schools. In 2014, like in previous three years, almost no herring were observed north of 70°N, while it was found further north in 2010. The center of gravity of the acoustic recordings of herring reflects the distribution and shifted in a southwesterly direction compared to 2013 (Figure 23).

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 10 year old herring (2004 year class) in numbers but 5, 8, 9, 11 and 12 year old herring (the 2009, 2006, 2005, 2003 and 2002 year classes) are also numerous (Table 2), which is similar to previous years. The 2009 year class appears to be the largest of the younger age groups even it appears to be only around 50% of average size of five year olds in the time-series since 1997. The six year classes from 2002 to 2006 and 2009 contribute to 6%, 10%, 22%, 14%, 12% and 14%, respectively, of the total biomass.

The total biomass estimate of herring in the Norwegian Sea from the 2014 survey was 5.1 million tons. This estimate is 0.3 million tons lower than in 2013. The biomass estimates in the last six years has fluctuated, with 10.7 million tons in 2009, 5.8 million tons in 2010, 7.4 million tons in 2011, 4.6 million tons in 2012, 5.4 million tons in 2013 and now 5.1 million tons in 2014.

The investigations of herring in the Barents Sea covered the area from 44°E to the 20°30′ E. The total abundance estimate was higher than in the last two years, with 5876 million individuals of age 1 (mean length of 11.5 cm and weight of 8.7 g), 2185 million individuals of age 2 (mean length of 17.8 cm and mean weight of 32.4 g), 2156 million individuals of age 3 herring (mean length of 23.8 cm and mean weight of 76.3 g) and 242 million individuals of age 4 herring (mean length of 25.7 cm and mean weight of 95.9 g). Only very few older herring were observed.

The total number of herring recorded in the Norwegian Sea was 9.6 billion in the northeastern area and 10.4 billion in the southwestern area, compared to 12.8 and 13.0 billion in the northeastern and 7.2 and 7.4 billion in the southwestern area in 2012 and 2013, respectively.

Blue whiting

The total biomass of blue whiting registered during the May 2014 survey was 0.63 million tons (Table 3), which is somewhat less than the biomass estimate in 2013. The stock estimate in number for 2014 is 8.9 billion, which is approximately the same number as in 2012 estimate. The decrease in biomass without a decrease in abundance is caused by more young fish in the stock. Age one is dominating the estimate whereas in 2013 the 1-group was more or less absent. The estimate of 1-goup in 2014 is 3.7 billion compared to only 0.6 billion in 2013. The number of 2 year olds was lower than in 2013, 2.5 billion compared to 6.3 billion. These results confirm the weak 2012 year class and suggest that the 2013 year class is stronger. This year class constituted to 41% of the total number and 26% of the total biomass.

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 dominated by fish at age 2 in terms of numbers and age 3 in terms of biomass, i.e. the youngest fish (age 1) is mostly found outside the "standard survey area".

The distribution of blue whiting in 2014 was similar to 2013, but the strong concentration found in the northeastern corner of the Norwegian Sea found in 2013 was absent in 2014. 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 25 and 26). The mean length of blue whiting is shown in Figure 27. 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 2014, with few exceptions at western stations further south. This distribution is comparable to the May surveys in 2012 and 2013. 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, Icelandic and Faroese vessels. These samples have however, not been analysed yet and will be reported by other means later.

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.

Plankton

The zooplankton biomass has been estimated since 1997 (Figure 20). After a severe decline from 2003 until 2009 (~4 g/m^2), the biomass has now been showing an upward trend for 5 years and reached 9.7 g/m^2 in 2014. The biomass now is close to what it was in the period prior to 2004 and shows an increase both in the west and particularly in the east. The decrease in zooplankton biomass until 2009 - was dramatic in the sense that biomass in the cold water decreased by 80% since 2003, while in the warmer water, the biomass decreased by 55% since 2002. The reason for this drop in biomass, or the increase since 2010, 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 relationship between NAO and zooplankton biomass was observed, particularly during the late 1990s. However, this relationship seems to be less pronounced now. The linkage between sea temperature and zooplankton abundance is also not fully understood and needs further explorations.

The zooplankton biomass in Barents Sea showed an increase from last year, from 1.2 to 1.6 g dry weight m-2, and in 2012 the biomass was 1.7 g dry weight m-2. 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.

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 itself, 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.

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 2014 survey was 6% lower than in 2013. The biomass estimates in the last six years has fluctuated, with 10.7 million tons in 2009, 5.8 in 2010, 7.4 in 2011, 4.6 million tons in 2012, 5.4 million tons in 2013 and 5.1 million tons in 2014. Work is currently being conducted to obtain an estimate of uncertainty in the survey. 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., 2014). However, the downward trend in the biomass is apparent.

The new approach of dividing the survey area into stratum 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 future.

In the last years there have been concerns regarding age reading of herring, because the age distribution from the different participants have showed differences. This is also the case in 2014. Partly, the differences may 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, as was suggested by the survey group in last year's survey report to address these issues. The results have not yet been finally analysed, and therefore possible necessary changes in age reading procedures have not yet been implemented. The survey group recommend that a age reading workshop is held as soon as possible.

There are concerns with the acoustic estimates from Dana during this year's survey, which adds uncertainty to the present acoustic estimates of the herring. The concerns are because of almost zero registrations of herring on their fourth and fifth east-west transects, and also weak registrations on the third, compare to neighbour transects from G.O. Sars with much higher registrations (Figures 21 and 22). The fact that herring was caught by Dana along these transects in areas without herring registrations adds to the concerns that something is wrong with the data from Dana and needs a further attention. Two possible reasons for this discrepancy are of consideration: (1) Time-lag where Dana was around 10 days later compare to other vessels; (2) Problems related to the scrutinizing procedure in Dana. Catches of herring where herring was not recorded acoustically, only blue whiting, supports the second option and calls for re-scrutinizing of the acoustic data where the procedure described in the WGIPS manual is strictly followed. Until the re-scrutinizing has been done there is not much to add to this discussion.

Blue whiting

The abundance estimate of blue whiting confirms that the 2012 year class is weak and that there is a good signal that the 2013 year class is stronger. 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 larger numbers than the previous years. The number of 1 year old in the standard area (Table 4) this year is low, but they are found in a higher degree outside the standard area stating that the 2013 year class is stronger than the previous one.

General recommendations and comments

Recommendation	Adressed to
1. A workshop on scrutinizing of acoustic data from the survey is highly recommended by the group. The procedure is to a large extent subjective and therefore it is very important that all scientists responsible for the scrutinization are following the same general procedure. The workshop should preferably take place during the autumn/winter 2013/2014, or prior to the surveys in 2014. The uncertainty regarding the scrutinizing procedure onboard of Dana in this years survey (above), emphasizes the need for the workshop and also involvement of new scientists responsible for the scrutinizing in the survey (e.g. from Iceland, Norway and the Faroes) since the last workshop was held.	ACOM, WGWIDE, WGIPS
2. The survey group recommends that an age reading workshop will be held as soon as possible. This is to follow up on issues identified following analyses of otoliths and scales exchanges in 2014 (preliminary report available from Jane A. Godiksen, IMR, Norway).	ACOM, WGWIDE
3. 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 year's post-cruise meeting

Preliminary dates are 16–18 June, in Copenhagen or Murmansk. Will be decided at WGIPS in January 2015.

Concluding remarks

- At 200 m and shallower depths the western part of the Norwegian Sea and the Iceland Sea was somewhat warmer than the 19 years mean. The temperature at 20 m depth northeast of Iceland was up to 2°C higher than the long-term mean, while around and just above mean in other areas.
- The index of plankton biomass in the Norwegian Sea continues to increase and is now close to the level prior to the period of decline (2004–2010.)
- The estimate of NSSH was 6% lower compared to last year
- NSSH was dominated by the 2004 year class, but also the 2009 year class contributed significantly
- 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 similar to last year.
- The blue whiting estimate is dominated by three year classes, 2013, 2012 and 2011, and they constitute 28% of the biomass and 87% of the abundance.

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Tables

Table 1. Survey effort by vessel for the International ecosystem survey in the Nordic Seas in April-June 2014.

Vessel	Effective survey period	Effective acoustic cruise track (nm)	Trawl stations	Aged fish (HER)	Length fish (HER)	CTD stations	Plankton station
Dana	13/5–1/6	2539	32	466	1709	35	36
G.O.Sars	4/5–26/5	3332	52	488	1554	66	68
Fridtjof Nansen	15/5–6/6	3525	47	369	2458	104	106
Magnus Heinason	1/5–12/5	1210	12	285	576	20	20
Árni Friðriksson	30/4–22/5	4039	32	690	2646	43	53
Total	1/5–6/6	14645	171	2298	8943	268	284

Table 2. Age and length-stratified abundance estimates of Norwegian spring-spawning herring in April-June 2014 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																0		
11																0		
12																0		
13																0		
14																0		
15																0		
16																0		
17																0		
18	62	125	0	0	0	0	0	0	0	0	0	0	0	0	0	187	8.4	45
19	0	56	0	0	0	0	0	0	0	0	0	0	0	0	0	56	3.1	55
20	0	248	0	0	0	0	0	0	0	0	0	0	0	0	0	248	15.4	62
21	0	97	63	0	0	0	0	0	0	0	0	0	0	0	0	160	11.6	73
22	0	91	97	0	0	0	0	0	0	0	0	0	0	0	0	188	15.8	84
23	0	27	292	0	0	0	0	0	0	0	0	0	0	0	0	319	30.9	97
24	0	9	195	0	0	0	0	0	0	0	0	0	0	0	0	204	22.4	110
25	0	0	456	15	0	0	0	0	0	0	0	0	0	0	0	471	56	119
26	0	14	254	28	0	0	0	0	0	0	0	0	0	0	0	296	39.9	134
27	0	6	114	72	12	0	0	0	0	0	0	0	0	0	0	204	30.6	150
28	0	0	53	178	125	18	0	0	0	0	0	0	0	0	0	374	62.4	167
29	0	0	64	270	651	79	32	0	0	0	16	0	16	16	0	1144	211.7	185
30	0	0	24	327	533	48	36	24	12	0	0	0	0	0	0	1004	202.8	202
31	0	0	13	91	431	78	26	26	39	13	26	13	0	26	0	782	173.3	221
32	0	0	0	85	693	99	14	85	57	28	0	0	0	0	0	1061	260.9	246
33	0	0	0	29	405	87	260	477	361	246	87	14	0	0	0	1966	529.1	269
34	0	0	0	11	261	109	381	871	828	1275	359	261	54	0	0	4410	1274.1	287
35	0	0	0	0	20	30	163	600	773	1586	763	366	102	41	40	4484	1362.5	303
36	0	0	0	0	9	0	18	71	266	443	363	327	195	62	71	1825	585.6	321
37	0	0	7	0	0	0	0	7	21	63	42	56	91	28	42	357	120	336
38	0	0	0	0	6	0	0	0	0	13	0	25	31	19	32	126	44.9	357
39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	6	2.1	383
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	2	2	0.8	405
42																0		
Number 10^6	62	673	1632	1106	3146	548	930	2161	2357	3667	1656	1062	489	192	193	19874	5064	
Biomass 10^3 t	5.9	45.1	198.7	214	711.7	138.9	257.1	617.3	686.8	1091	497.2	325.9	153.8	57.1	63.4	5064	5064.2	
Mean length cm	20.8	20.8	25.4	29.9	31.6	32.3	34	34.5	34.8	35.1	35.3	35.7	36.2	35.4	37		32.8	
Mean weight g	79.9	67.1	121.7	193.4	226.1	241	276.4	285.6	291.5	297.6	300.3	306.4	314.3	298.1	332		254.4	

Table 2. (cont'd)

Area 1

Age	1	2	3	4	5	6	7	8	9	10	11	12+	Total
Number 10^6	5876	2185	2156	242	45	2	1	1	0	0	0	0	10508
Biomass 10^3 t	51	70.9	164.6	23.2	6.9	0.6	0.5	0.6					318.3
Mean length cm	11.5	17.8	23.8	25.7	30	31.3	31.9	32.5					15.7
Mean weight g	8.7	32.4	76.3	95.9	151.5	179.6	192.8	202.7					30.3

Area 2

Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total
Number 10^6	63	673	1549	983	2267	262	352	562	660	1117	446	263	214	62	81	9554
Biomass 10^3 t	2.8	45	186.4	186.9	488.9	57.1	93.9	158.4	187.5	327.5	131	79.2	64.2	15	26.5	2050.3
Mean length cm	18.4	20.8	25.3	29.8	31.2	31.3	33.8	34.5	34.7	35.2	35.2	35.5	35.6	32.7	37.1	30.7
Mean weight g	44.2	67.1	120.4	190	215.7	217.3	266.8	281.7	284.1	293.1	293.7	298.6	300.1	245	320	214.5

Area 3

Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total
Number 10^6	0	0	81	86	777	328	582	1664	1724	2556	1244	823	254	136	101	10356
Biomass 10^3 t			24.1	19.1	196.6	83.4	162.2	482.6	512.2	772.2	379.7	256.6	83.7	44.9	33.1	3050.4
Mean length cm			26.9	30.4	32.3	33.2	34	34.4	34.8	35.1	35.3	35.7	36.7	36.8	36.9	34.7
Mean weight g			175.5	221.7	252.3	269.5	284.3	290.1	297.1	302	305.2	312.1	329.6	332.7	340	294.6

Area 2 and 3

(Norwegian Sea)

Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total
Number 10^6	62	673	1632	1106	3146	548	930	2161	2357	3667	1656	1062	489	192	193	19874
Biomass 10^3 t	5.9	45.1	198.7	214	711.7	138.9	257.1	617.3	686.8	1091	497.2	325.9	153.8	57.1	63.4	5063.9
Mean length cm	20.8	20.8	25.4	29.9	31.6	32.3	34	34.5	34.8	35.1	35.3	35.7	36.2	35.4	37	32.8
Mean weight g	79.9	67.1	121.7	193.4	226.1	241	276.4	285.6	291.5	297.6	300.3	306.4	314.3	298.1	332	254.4

Total

(All areas)

Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total
Number 10^6	5939	2858	3787	1312	3080	601	934	2228	2386	3676	1691	1088	468	198	183	30429
Biomass 10^3 t	60	116	365	229.2	689.4	143	260.3	641.3	700.1	1100	510.8	335.9	147.9	59.9	59.6	5418.4
Mean length cm	11.6	18.5	24.5	29.1	31.4	32.3	33.9	34.4	34.8	35.1	35.3	35.7	36.2	35.5	37.1	26.9
Mean weight g	9.6	40.6	96.4	174.7	223.9	245	277.5	287.9	293.5	299.3	302.2	308.8	316.1	305.1	340	178.2

Table 3. Age and length-stratified abundance estimates of blue whiting in April-June 2014, 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
10													0		
11													0		
12													0		
13													0		
14													0		
15	0	1	0	0	0	0	0	0	0	0	0	0	1	0	19
16	3	10	0	0	0	0	0	0	0	0	0	0	13	0.3	26
17	63	54	0	0	0	0	0	0	0	0	0	0	117	3.3	28
18	484	403	9	0	0	0	0	0	0	0	0	0	896	29.5	33
19	941	662	10	0	0	0	0	0	0	0	0	0	1613	62.5	39
20	1115	588	4	0	0	0	0	0	0	0	0	0	1707	77.6	46
21	688	250	16	0	0	0	0	0	0	0	0	0	954	50.8	53
22	349	277	48	24	0	0	0	0	0	0	0	0	698	43.1	62
23	22	65	84	15	0	0	0	0	0	0	0	0	186	13.6	73
24	3	36	186	36	0	0	0	0	0	0	0	0	261	21.7	83
25	0	41	229	77	6	0	0	0	0	0	0	0	353	33.5	95
26	0	55	421	122	19	4	0	0	0	0	0	0	621	65.7	106
27	0	28	357	118	34	0	0	0	0	0	0	0	537	64.6	120
28	0	3	181	106	31	0	0	0	0	0	0	0	321	42.5	132
29	5	0	85	113	17	14	0	0	0	0	0	0	234	34.8	150
30	0	0	14	25	27	4	4	2	2	2	0	0	80	13.2	167
31	0	0	0	23	20	13	5	5	3	3	0	0	72	13.3	187
32	0	0	0	17	39	14	5	4	13	8	5	0	105	20.8	200
33	0	0	3	3	0	10	3	15	9	3	0	4	50	10.8	221
34	0	0	0	1	1	5	4	6	1	4	2	2	26	6.3	234
35	0	0	0	0	0	0	12	14	11	1	2	2	42	10.7	257
36	0	0	0	0	1	1	1	1	12	0	12	12	40	12.1	303
37	0	0	0	0	0	1	0	2	0	2	0	0	5	1.8	281
38	0	0	0	0	0	0	2	1	0	0	0	0	3	0.9	282
39													0		
40													0		
41													0		
42													0		
43													0		
Number 10^6	3673	2473	1647	680	195	66	36	50	51	23	21	20	8935	633	
Biomass 10^3 t	167.4	118.3	174.6	83.4	29.8	12.1	7.7	11.5	12.4	4.8	5.7	5.7	633.4	633.4	
Length cm	20.3	20.6	26.4	27.6	29.6	31.7	33.9	34.1	34.3	33.3	35.3	35.5		22.7	
Weight g	45.6	47.9	106.1	122.6	153	187	225.5	230.2	242	216.3	270.6	287		70.9	

Area 2

Age	1	2	3	4	5	6	7	8	9	10	11	12+	Total
Number 10^6	1436	2234	1135	494	85	22	24	39	20	16	0	0	5505
Biomass 10^3 t	59.2	96.6	114.3	57	12.2	3.5	5.5	9	4.7	3.5			365.5
Length cm	19.9	20.1	26	27.1	29	30.4	34.7	34.1	33.7	33.3			22.3
Weight g	41.2	43.2	100.9	115.7	145.1	166.4	240.1	229.7	225	216.8			66.5

Area 3

Age	1	2	3	4	5	6	7	8	9	10	11	12+	Total
Number 10^6	2238	238	514	189	112	45	12	11	31	6	21	20	3437
Biomass 10^3 t	108.2	21.7	60.3	26.4	17.6	8.6	2.2	2.5	7.7	1.3	5.7	5.7	267.9
Length cm	20.6	24.8	27.1	28.8	30	32.3	32.4	34.3	34.6	33.4	35.3	36	23.2
Weight g	48.3	91.5	117.5	140.6	159	197	196	231.9	253.6	214.8	270.6	285	78.1

Area 2 and 3 (Norwegian Sea)

Age	1	2	3	4	5	6	7	8	9	10	11	12+	Total
Number 10^6	3673	2473	1647	680	195	66	36	50	51	23	21	20	8935
Biomass 10^3 t	167.4	118.3	174.6	83.4	29.8	12.1	7.7	11.5	12.4	4.8	5.7	5.7	633.4
Length cm	20.3	20.6	26.4	27.6	29.6	31.7	33.9	34.1	34.3	33.3	35.3	35.5	22.7
Weight g	45.6	47.9	106.1	122.6	153	187	225.5	230.2	242	216.3	270.6	287	70.9

Table 4. Blue whiting in "Standard Area" 8°W - 20°E and north of 63°N in IESNS 2014.

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	10	0	0	0	0	0	0	0	0	0	0	10	0.2	26
17	33	53	0	0	0	0	0	0	0	0	0	0	86	2.3	27
18	334	373	10	0	0	0	0	0	0	0	0	0	717	23.1	32
19	449	559	9	0	0	0	0	0	0	0	0	0	1017	38.6	38
20	356	495	0	0	0	0	0	0	0	0	0	0	851	38	45
21	152	219	8	0	0	0	0	0	0	0	0	0	379	19.9	52
22	74	222	49	25	0	0	0	0	0	0	0	0	370	22.7	61
23	0	18	75	13	0	0	0	0	0	0	0	0	106	7.5	71
24	0	4	141	23	0	0	0	0	0	0	0	0	168	13.4	80
25	0	6	152	69	3	0	0	0	0	0	0	0	230	21.1	92
26	0	7	249	75	14	0	0	0	0	0	0	0	345	35.9	104
27	0	0	200	75	15	0	0	0	0	0	0	0	290	34.8	120
28	0	0	84	62	16	0	0	0	0	0	0	0	162	21.6	134
29	4	0	41	64	4	11	0	0	0	0	0	0	124	18.8	152
30	0	0	3	9	8	2	3	2	0	2	0	0	29	4.7	173
31	0	0	0	5	3	3	3	5	3	0	0	0	22	4.1	196
32	0	0	0	13	25	6	0	6	19	13	0	0	82	17.4	213
33	0	0	3	3	0	3	3	12	9	3	0	0	36	8.2	226
34	0	0	0	2	2	0	2	4	2	2	0	0	14	3.7	258
35	0	0	0	0	0	0	8	11	4	0	4	4	31	8.2	270
36	0	0	0	0	7	7	7	7	0	0	7	0	35	10.3	279
37	0	0	0	0	0	1	0	2	0	2	0	0	5	1.7	279
38	0	0	0	0	0	0	2	1	0	0	0	0	3	0.8	285
39													0		
40													0		
41													0		
42													0		
43													0		
Number 10^6	1402	1966	1024	438	97	33	28	50	37	22	11	4	5112	357.0	
Biomass 10^3 t	57.7	84.9	103.3	51.9	15.9	6.9	6.9	12.5	8.1	4.8	3.1	1	357	357.3	
Length cm	19.9	20.1	26	27.2	30	32.5	34.8	34.3	33.1	33.3	36.2	35.5		22.5	
Weight g	41.1	43.2	101	118.7	166.3	207.3	250.2	243.4	223.4	223.6	275.9	270.3		69.9	

Figures

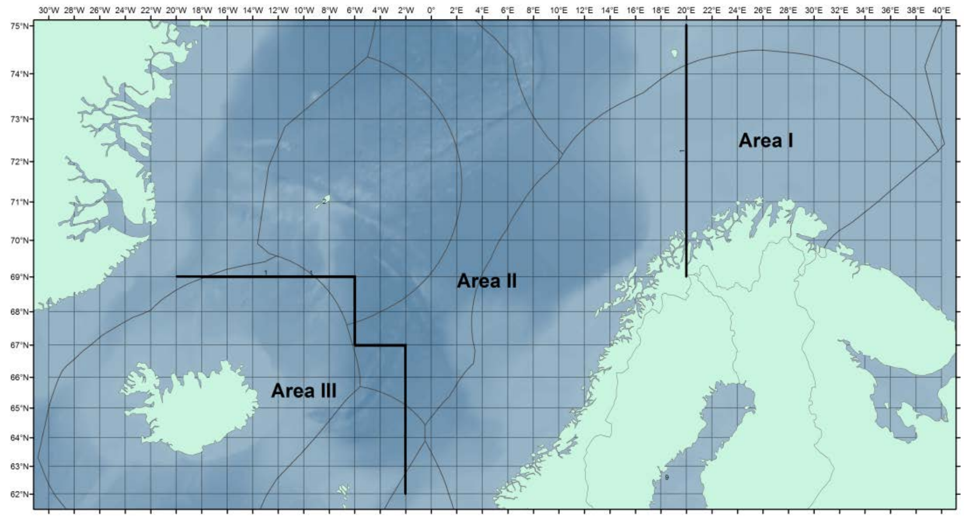

Figure 1. Areas defined for acoustic estimation of blue whiting and Norwegian spring-spawning herring in the Nordic Seas.

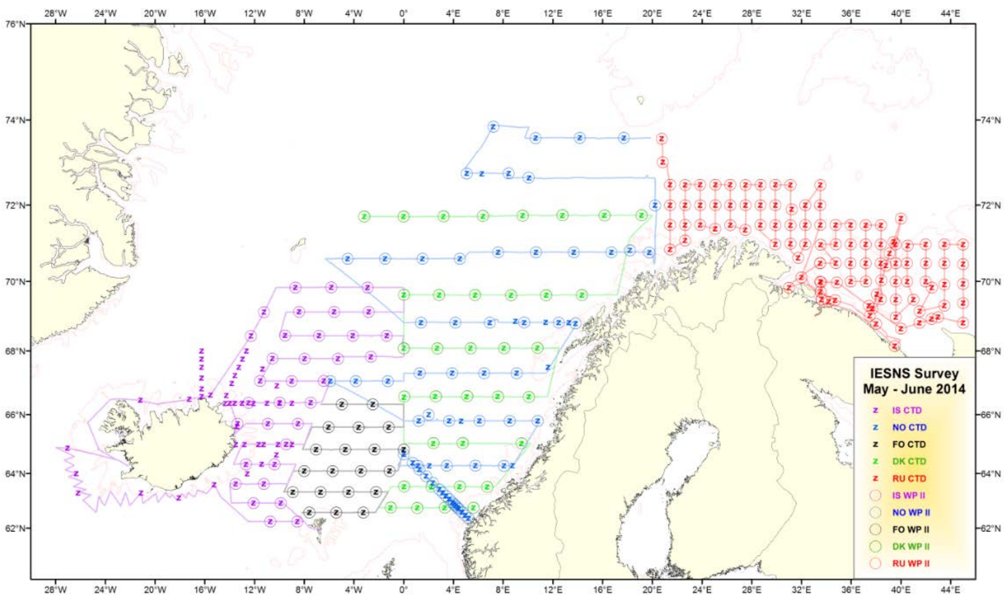

Figure 2. Cruise track, CTD and WP II stations by country for the International ecosystem survey in the Nordic Seas in April-June 2014.

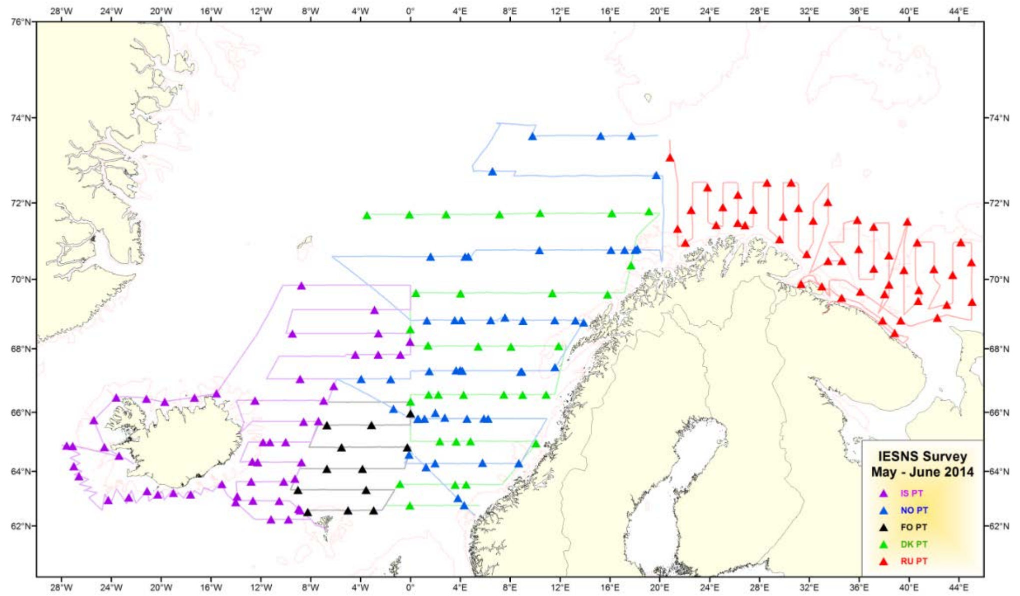

Figure 3. Cruise tracks during the International Northeast Atlantic Ecosystem Survey in April-May 2014 and location of trawl stations.

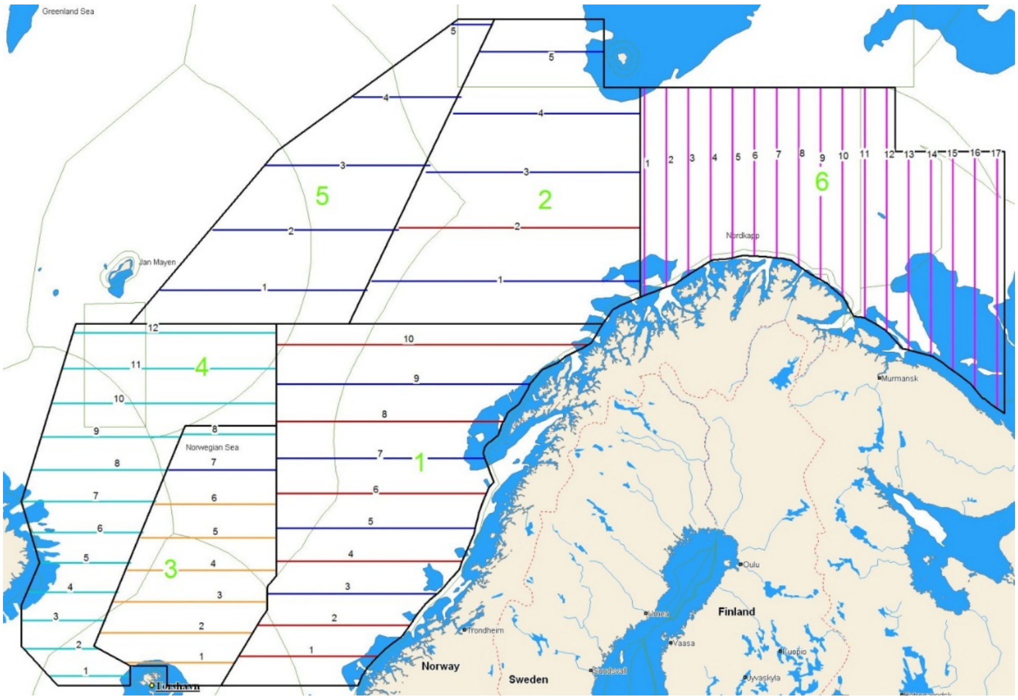

Figure 4. The planed cruise tracks and division of the five stratum used in the IESNS survey 2014.

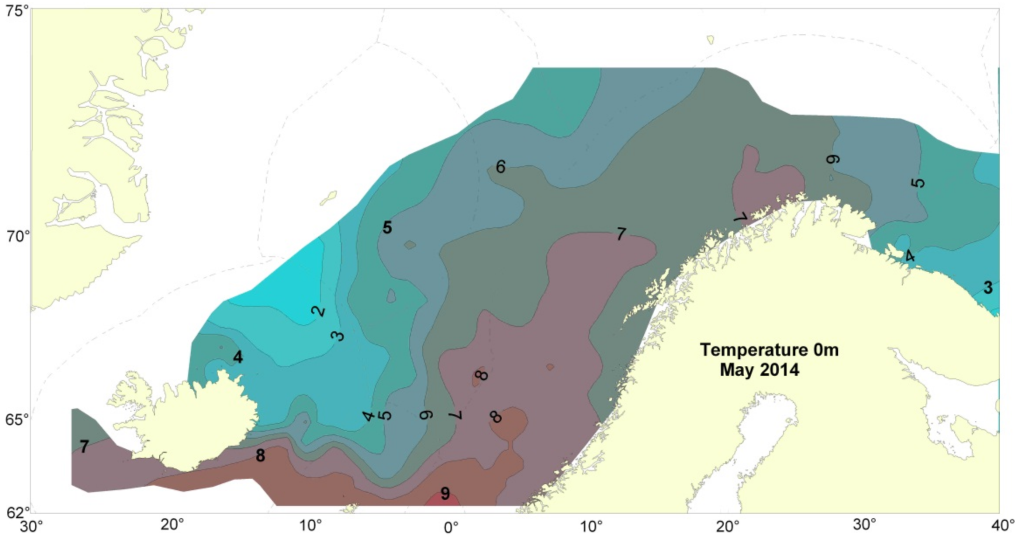

Figure 5. The horizontal sea surface temperature distribution in April-June 2014.

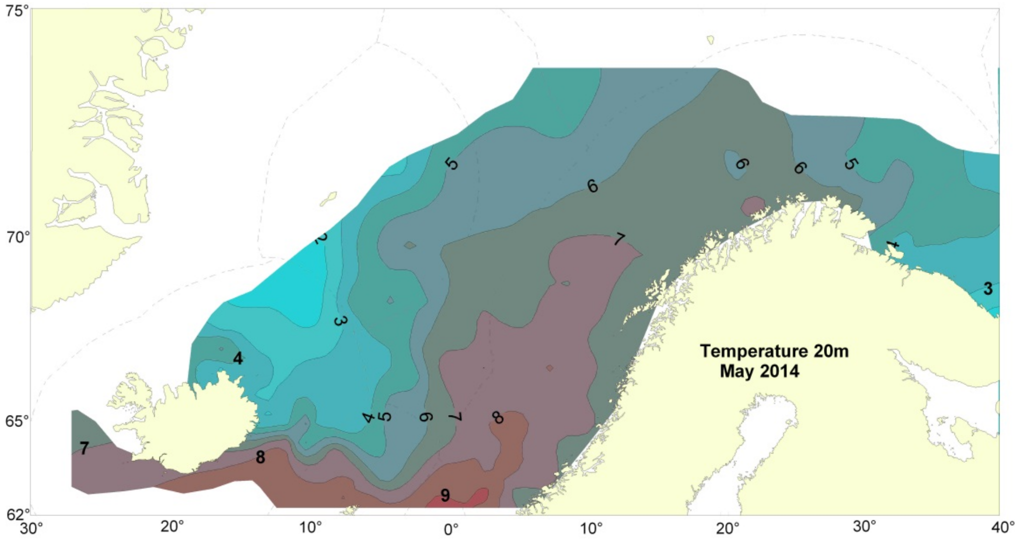

Figure 6. The horizontal distribution of temperatures at 20 m depth in April-June 2014.

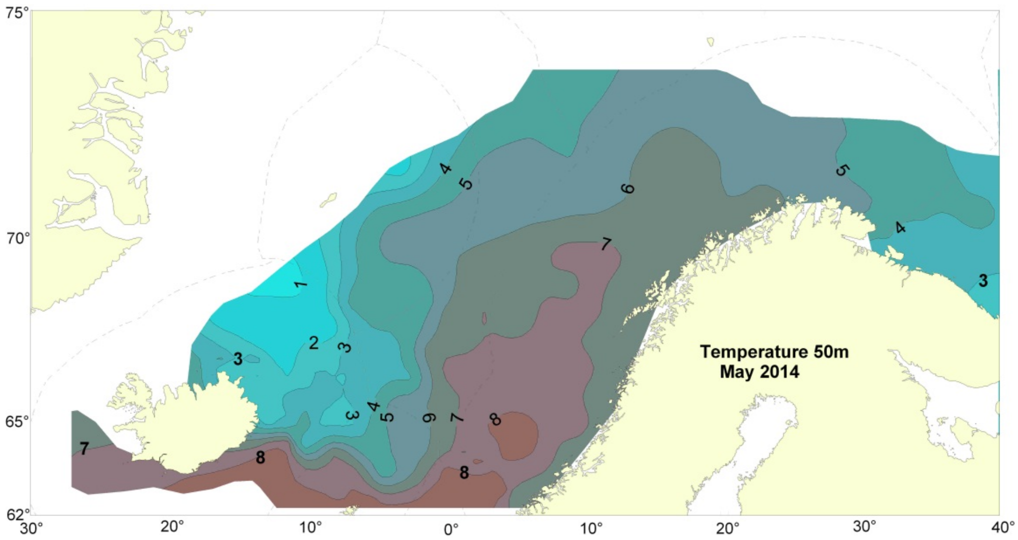

Figure 7. The horizontal distribution of temperatures at 50 m depth in April-June 2014.

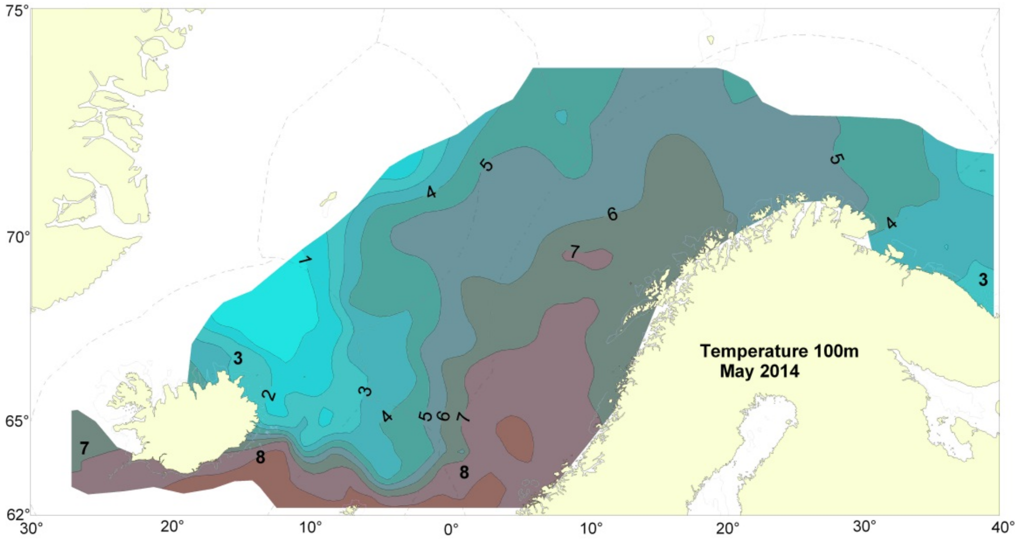

Figure 8. The horizontal distribution of temperatures at 100 m depth in April-June 2014.

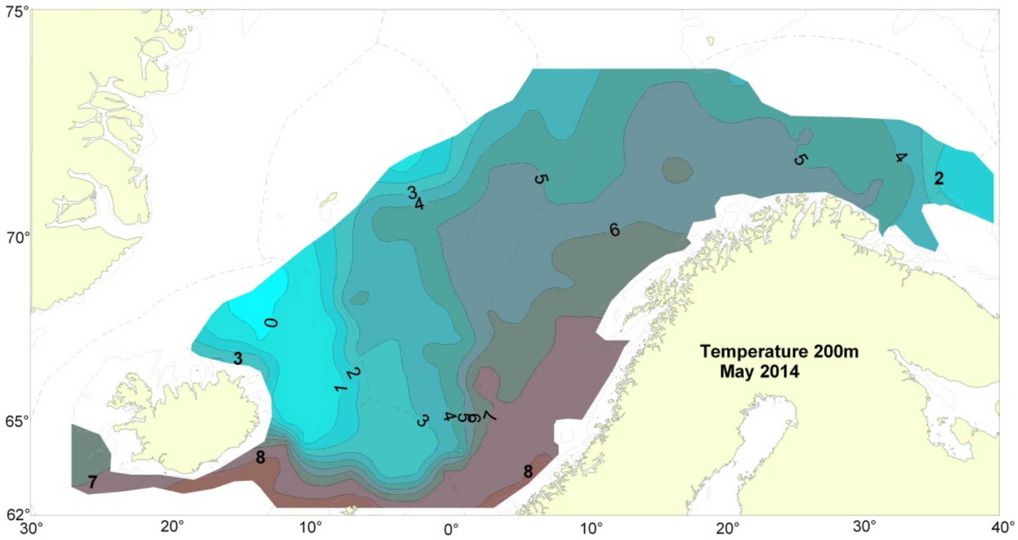

Figure 9. The horizontal distribution of temperatures at 200 m depth in April-June 2014.

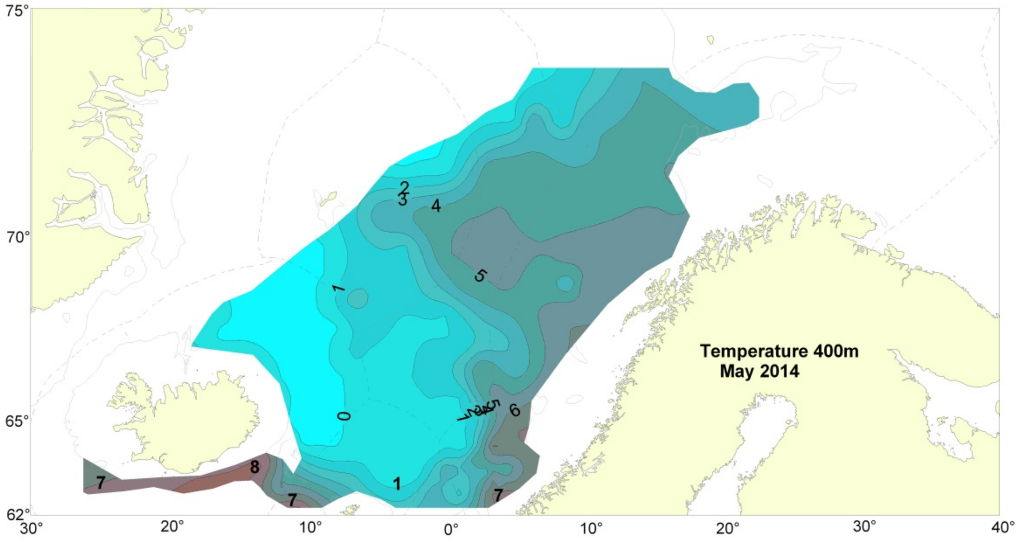

Figure 10. The horizontal distribution of temperatures at 400 m depth in April-June 2014.

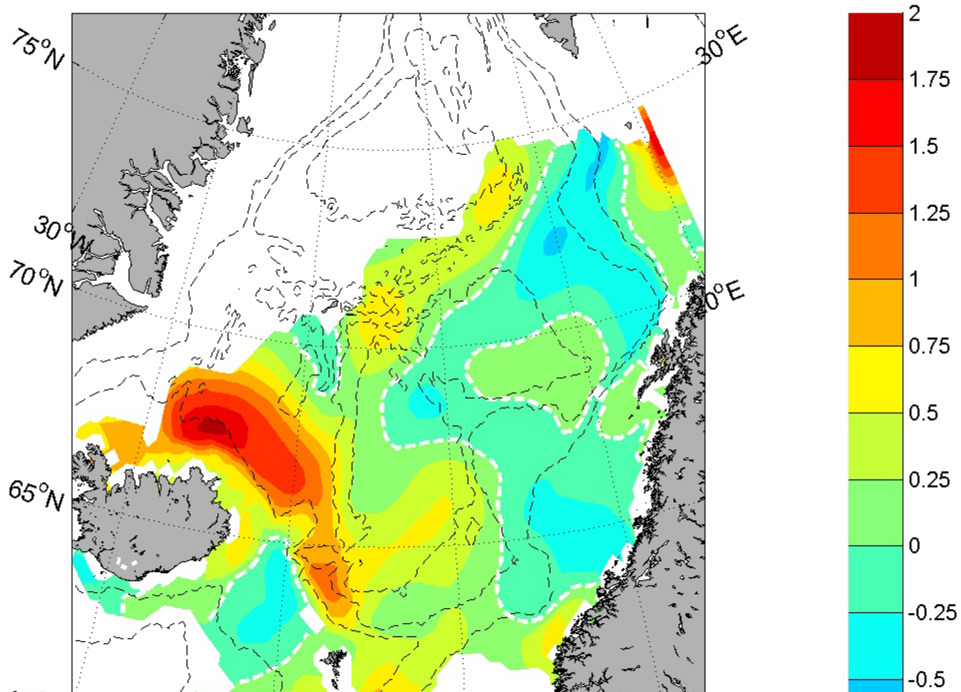

Figure 11. Temperature anomaly at 20 m depth for May 2014. Reference period: 1995–2013.

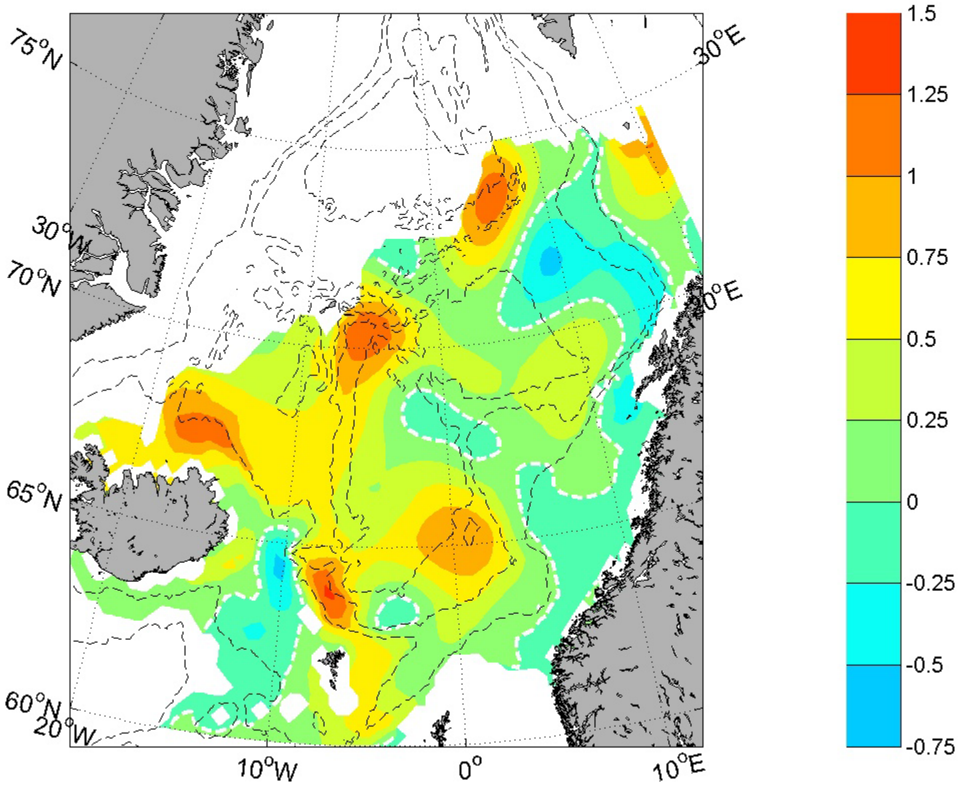

Figure 12. Temperature anomaly at 100 m depth in May 2014. Reference period: 1995–2013.

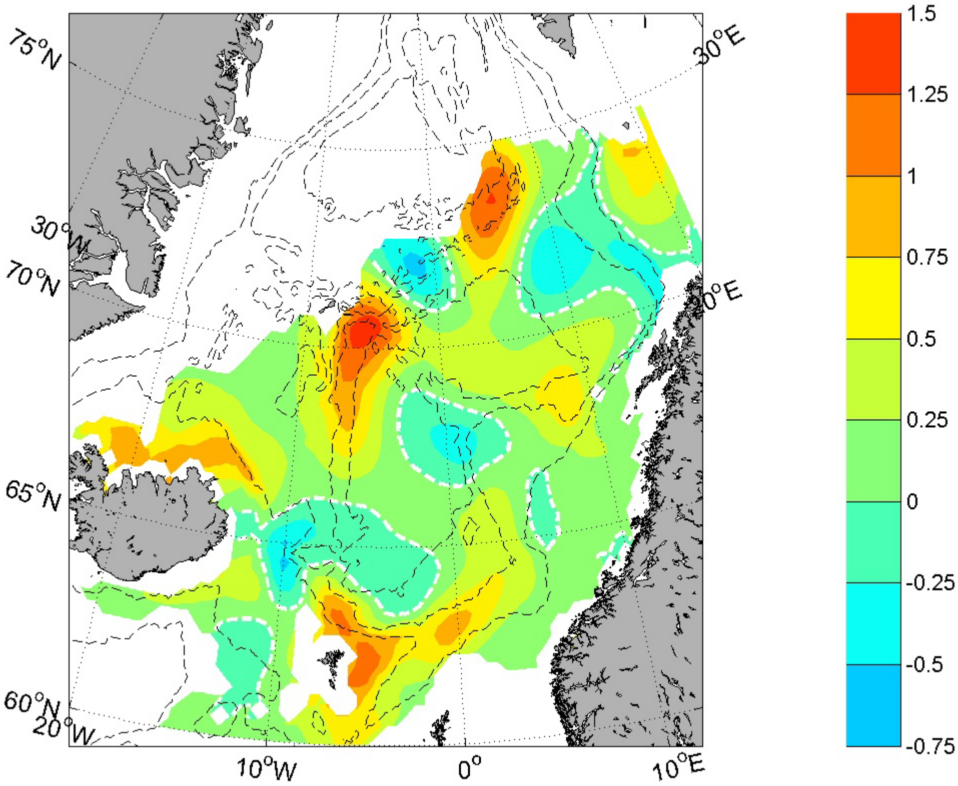

Figure 13. Temperature anomaly at 200 m depth in May 2014. Reference period: 1995–2013.

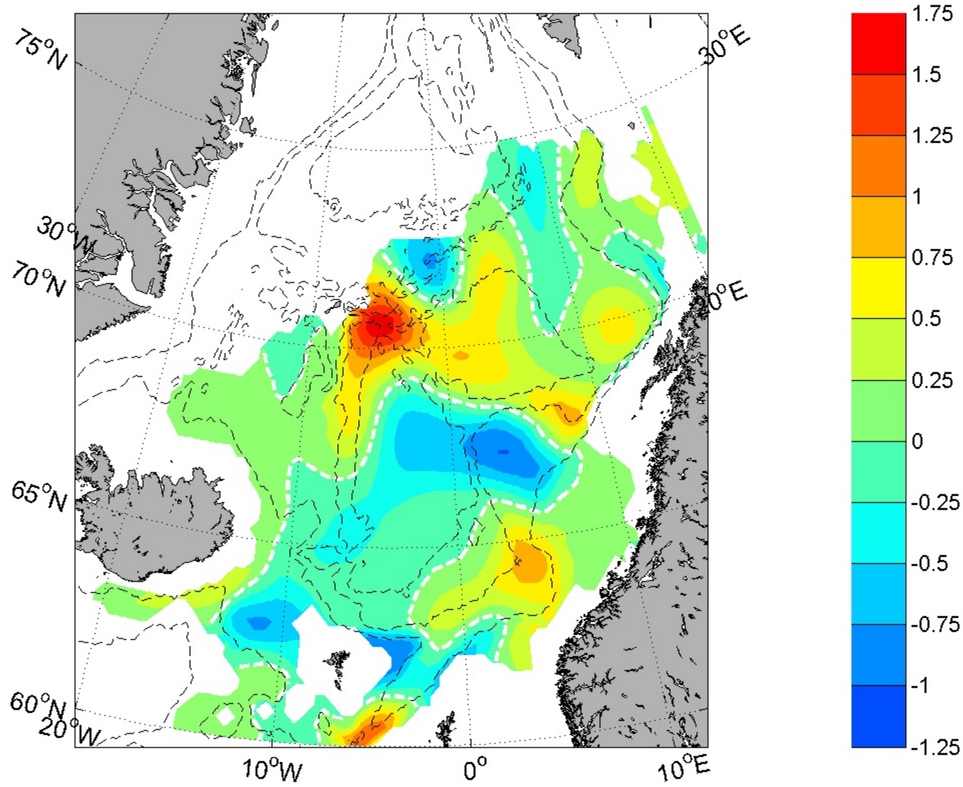

Figure 14. Temperature anomaly at 400 m depth in May 2014. Reference period: 1995–2013.

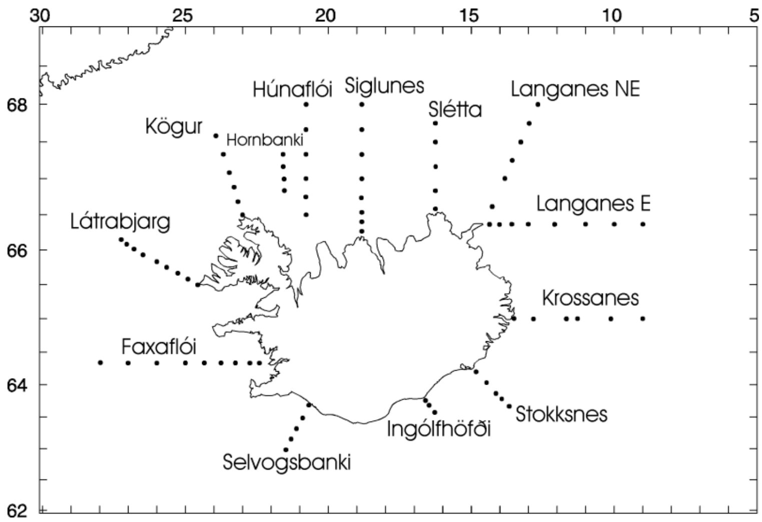

Figure 15. Location of the fixed Icelandic hydrographic sections referred to in the text and Figures 16–18.

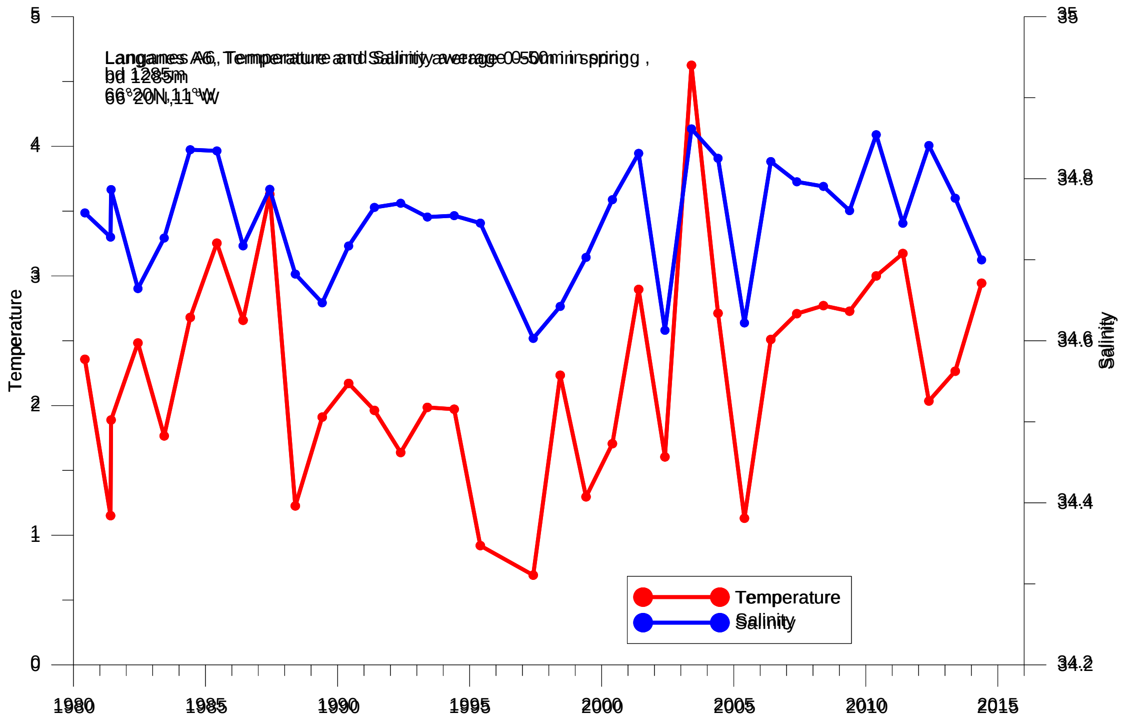

Figure 16. Temperature and salinity in May 2014 east of Iceland, at station Langanes A6 (66°22′N, 11°00′W). Depth averaged 0–50m.

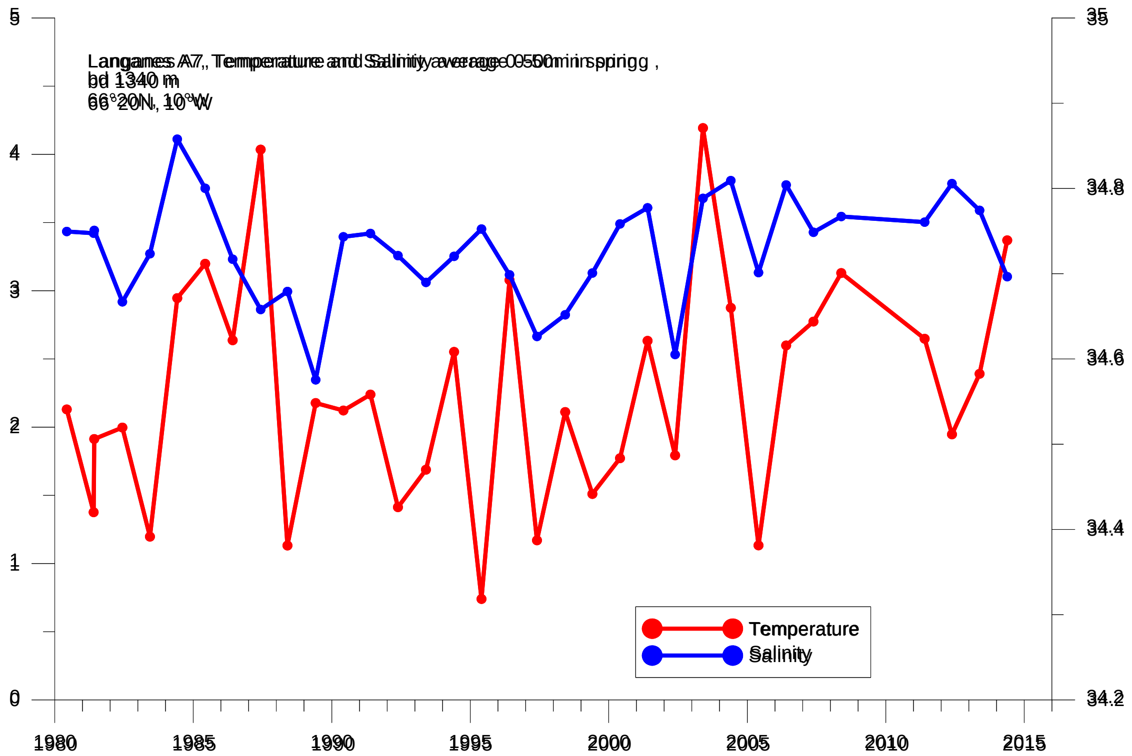

Figure 17. Temperature and salinity in May 2014 east of Iceland, at station Langanes A7 (66°22′N, 10°00′W). Depth average 0–50m.

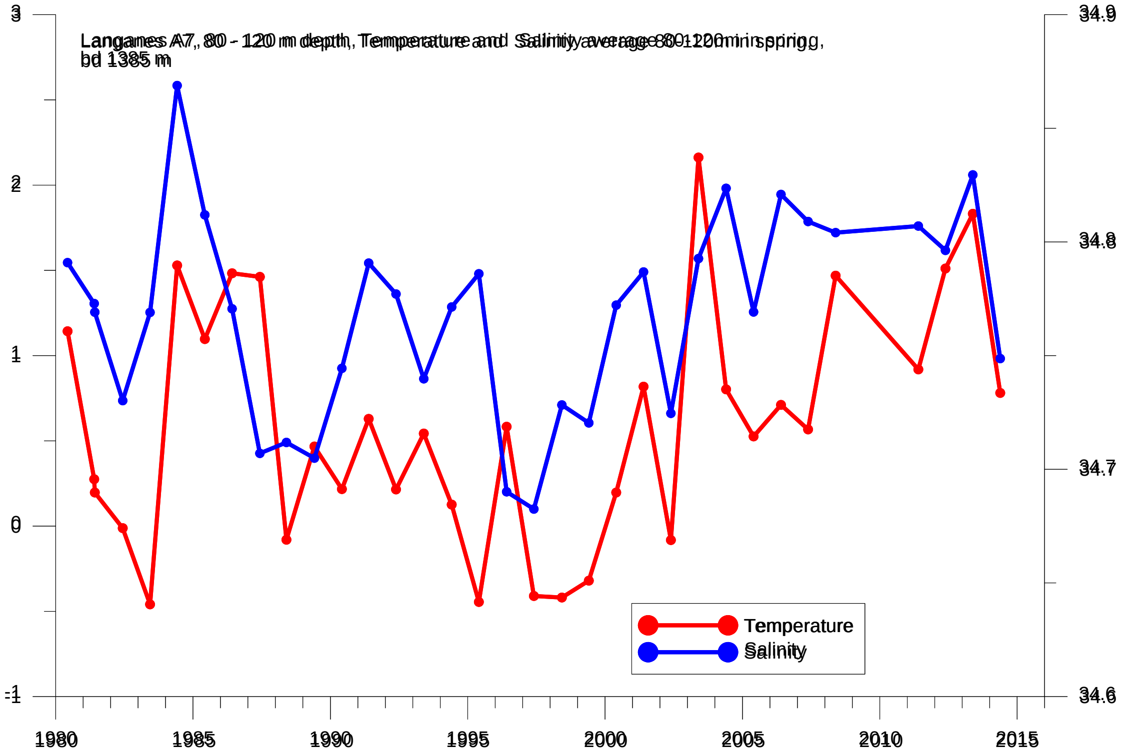

Figure 18. Temperature and salinity in May 2014 east of Iceland at station Langanes A7 (66°22'N, 10°00'W). Depth average 80–120m.

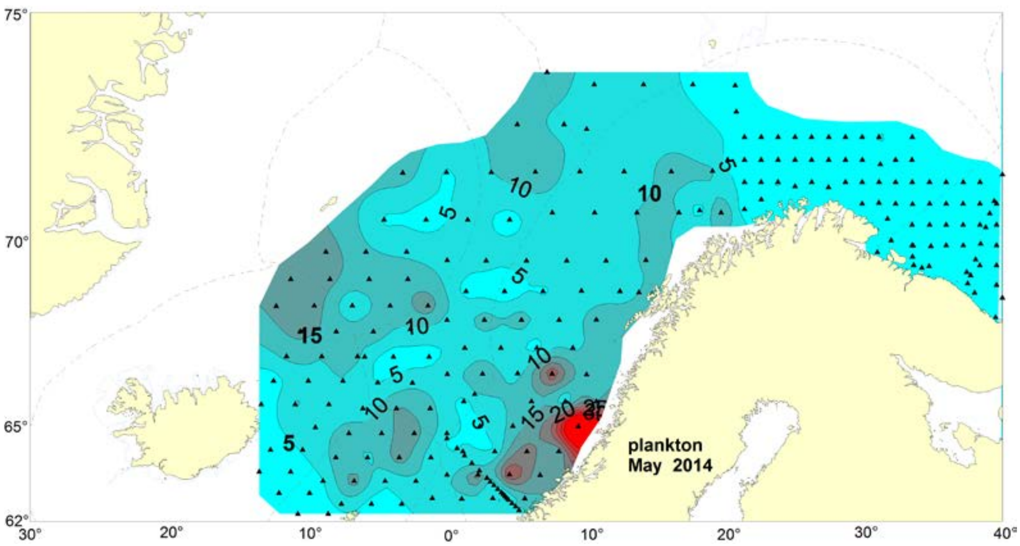

Figure 19. Zooplankton biomass (g dw m-2; 200–0 m in April-June 2014.

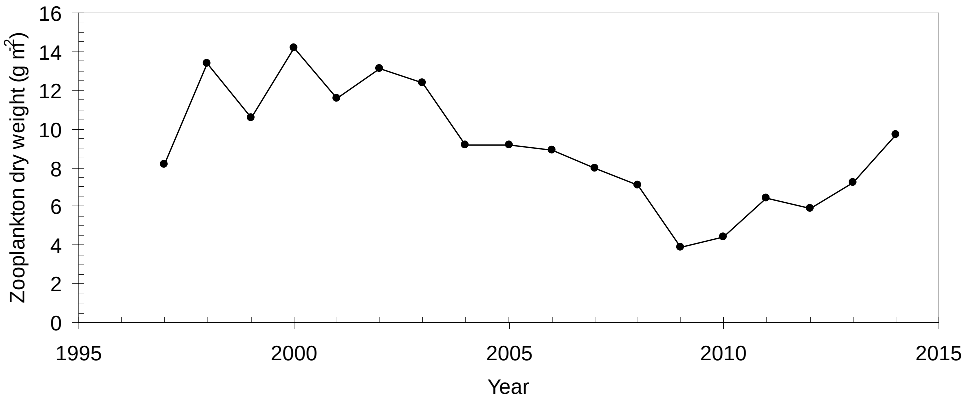

Figure 20. The annual mean dry weight of zooplankton across the whole coverage area in the May surveys in the Norwegian Sea and adjacent waters from 1997 to 2014.

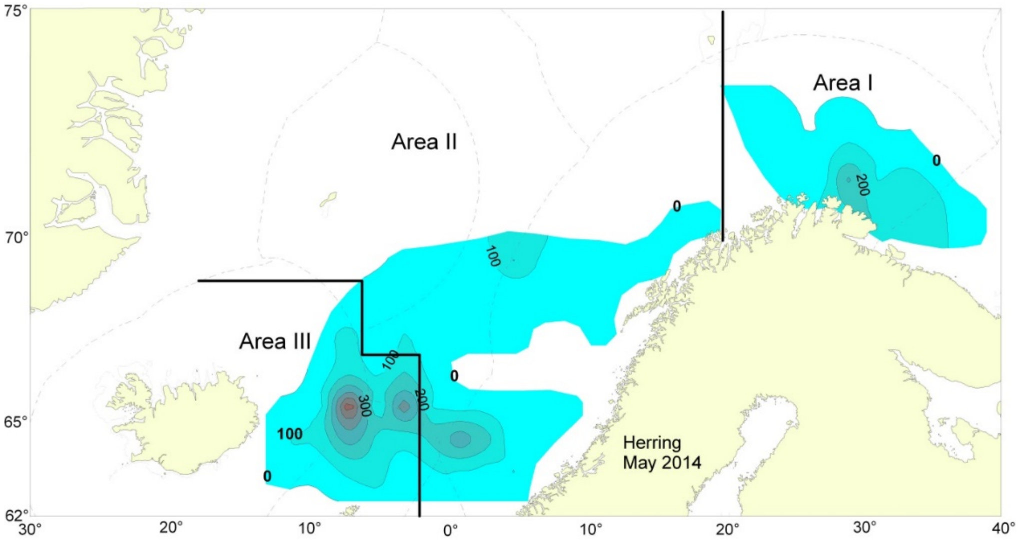

Figure 21. Distribution of Norwegian spring-spawning herring as measured during the International survey in April-June 2014 in terms of s_A-values (m^2/nm^2) based on combined 5 nm values.

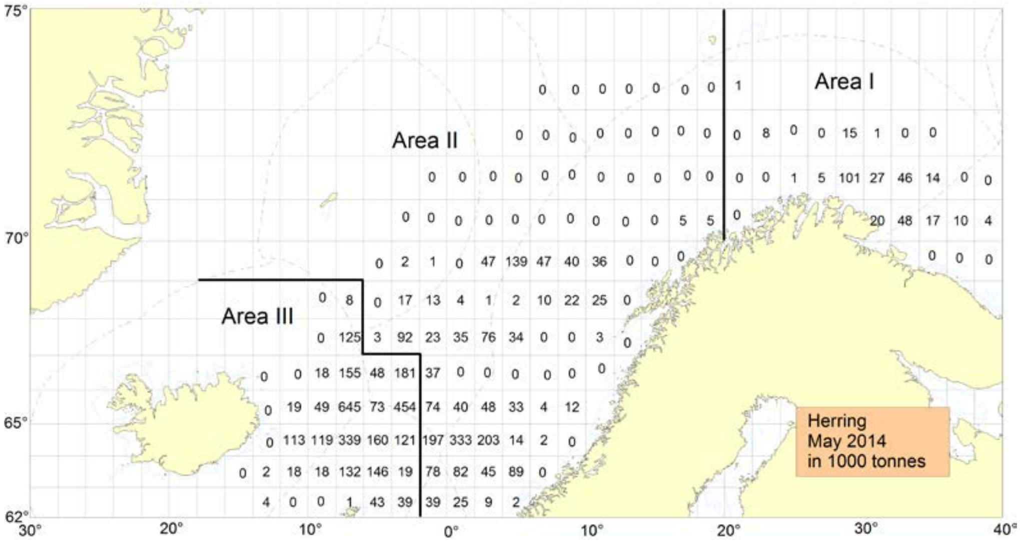

Figure 22. Norwegian spring-spawning herring biomass from IESNS 2014 by subarea.

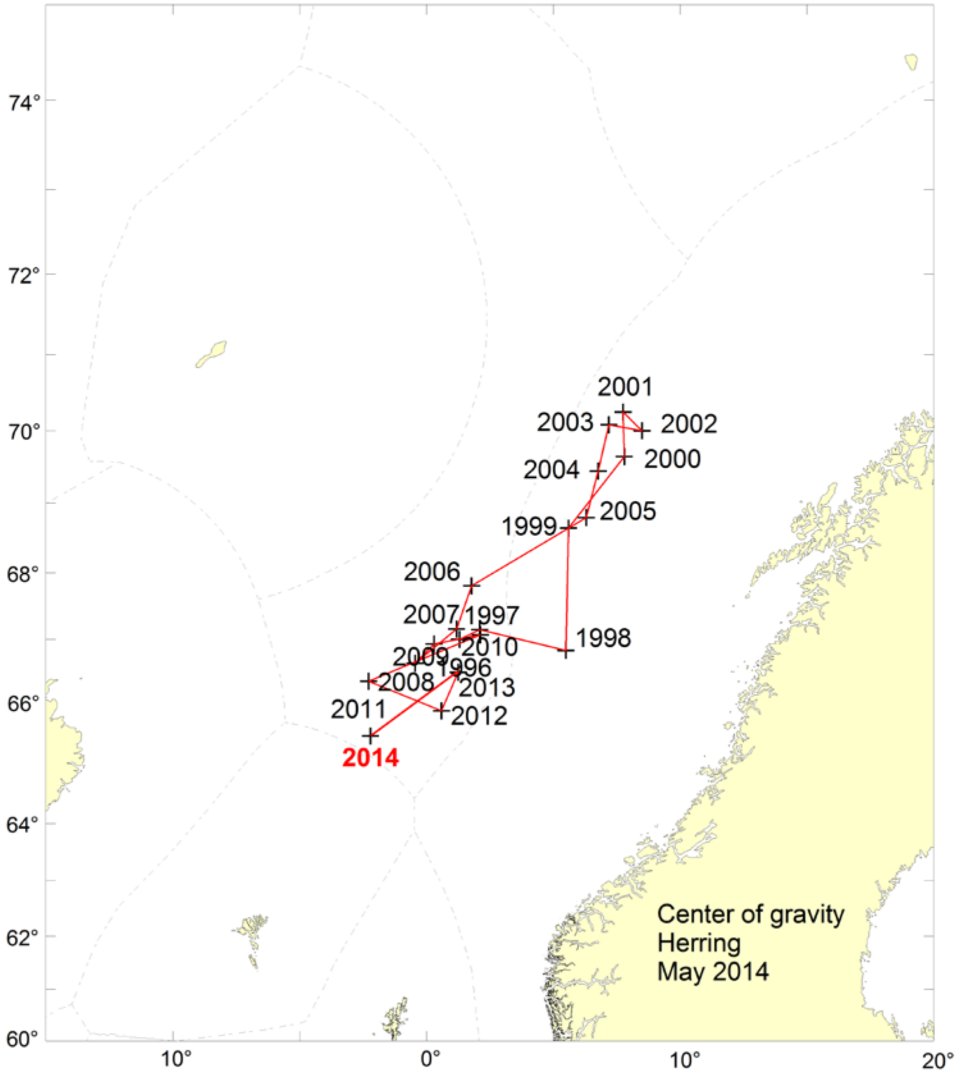

Figure 23. Centre of gravity of herring during the period 1996–2014 derived from acoustic. Acoustic data from area II and III only, i.e. west of 20° E

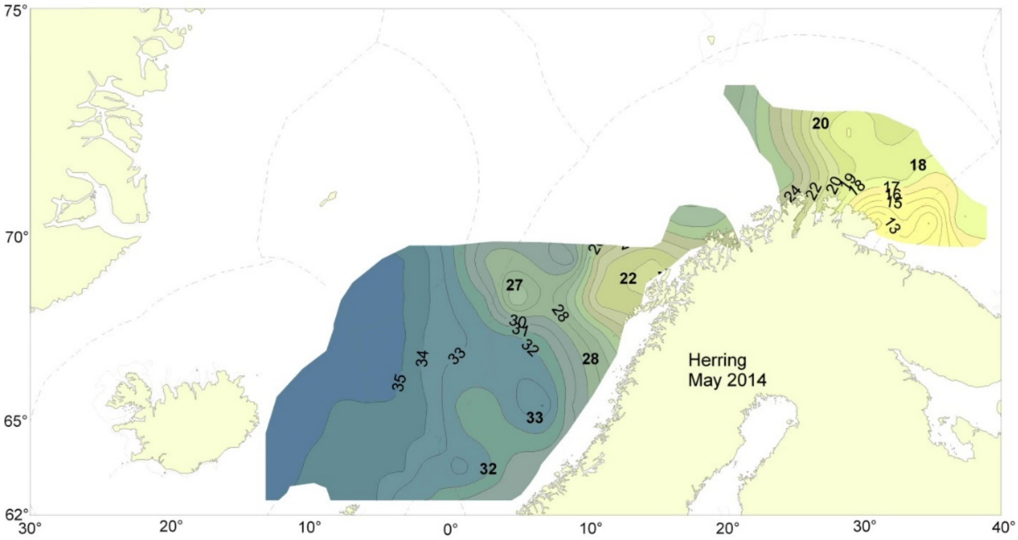

Figure 24. Mean lemgth of Norwegian spring-spawning herring as measured during the International survey in April-June 2014.

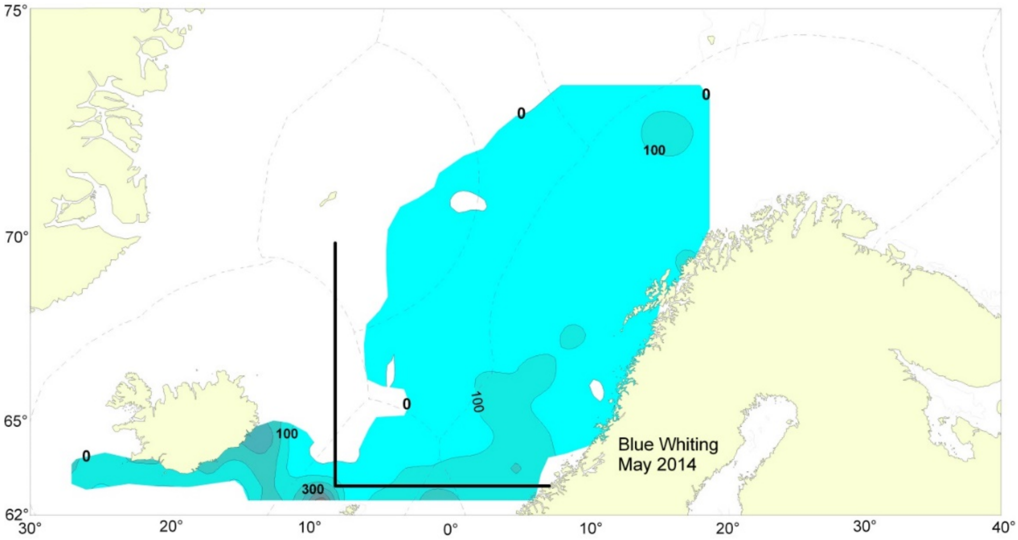

Figure 25. Distribution of blue whiting as measured during the International survey in April-June 2014 in terms of sA-values (m^2/nm^2) based on combined 5 nm values. The standard area is shown on the map.

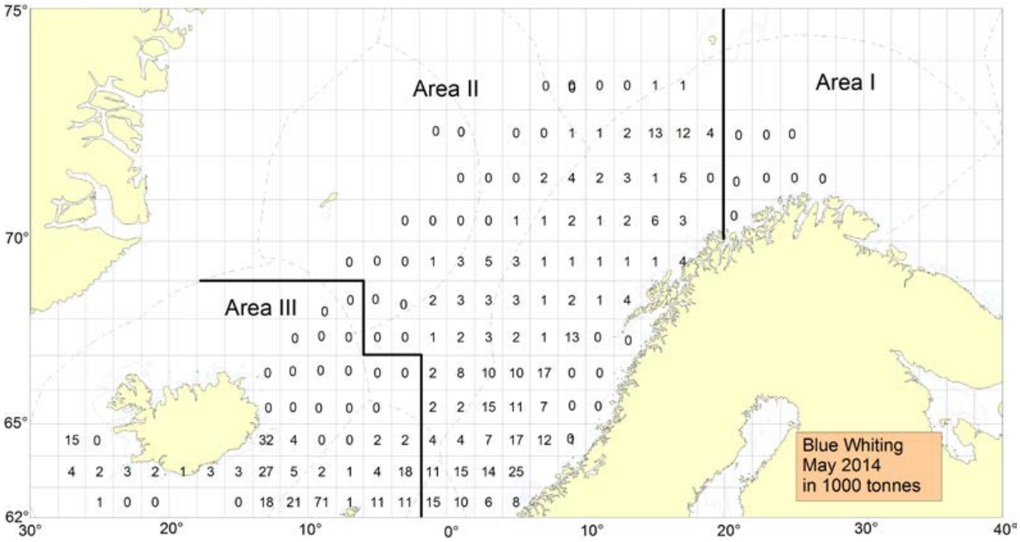

Figure 26. Blue whiting biomass from IESNS 2014 by subarea.

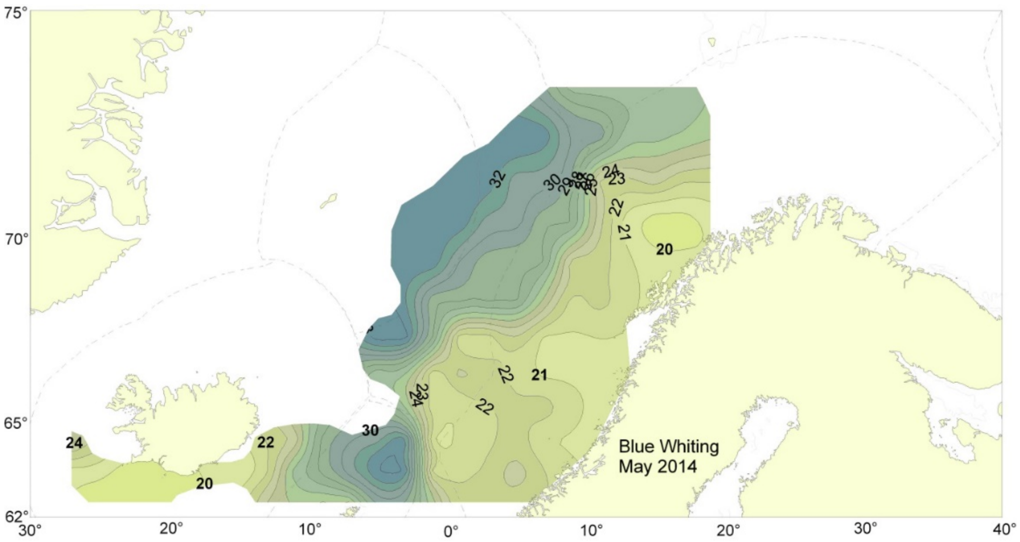

Figure 27. Mean length (cm) of blue whiting recorded in the Northeast Atlantic Ecosystem Survey in April–June 2014.

Annex 5c: The 2014 ICES Coordinated Acoustic Survey in the Skagerrak and Kattegat, the North Sea, West of Scotland and the Malin Shelf area

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[2] Wageningen-IMARES, IJmuiden, The Netherlands
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[5] Institute of Marine Research, Bergen, Norway
[6] DTU-Aqua, Hirtshals, Denmark

Seven surveys were carried out during late June and July covering most of the continental shelf in the North Sea, West of Scotland and the Malin Shelf. The surveys are presented here as a summary in the report of the ICES Working Group for International Pelagic Surveys (WGIPS) and component survey reports are available individually on request. One of the Scottish surveys, charter vessel, has so far been excluded from the global estimate (refer to Quality considerations for explanation). The global estimate of herring and sprat from the remaining surveys is reported here. The global survey results provide spatial distributions of herring and sprat abundance by number and biomass at age by statistical rectangle; and distributions of mean weight and fraction mature at age.

The estimate of North Sea autumn spawning herring spawning-stock biomass is slightly higher than previous year at 2.6 million tonnes and also comprised of a larger number of fish (2014: 14 392 mill. fish, 2013: 11 689 mill. fish).

The 2014 estimate of Western Baltic spring-spawning herring SSB is 128 000 tonnes and 791 million herring. In terms of biomass the SSB increased by 42 000 tonnes, while the amount of fish is in the same order of magnitude as in 2013.

The West of Scotland estimate (VIaN) of SSB is 272 000 tonnes and 1 400 million herring, a slight increase over the 2013 estimate.

The SSB estimate for the Malin Shelf area (divisions VIaN-S and VIIb,c) is 285 000 tonnes and 1 471 million herring. This is a marginal increase on 2013 and the second lowest SSB estimate in the seven year time-series.

The total abundance of North Sea sprat (Subarea IV) in 2014 was estimated at 88 219 million individuals and the biomass at 728 300 tonnes (Table 5.10). This is the highest estimate ever observed in the time-series, both in terms of abundance and biomass.

In Division IIIa, the abundance is estimated at 913 mill individuals and the biomass at 10 134 tonnes. The stock is dominated by 1-year-old sprat.

The Irish Sea survey program is reported separately in the WGIPS report (Section 4.3.2).

Introduction

Seven surveys were carried out during late June and July covering most of the continental shelf north of 52°N in the North Sea and to the west of Scotland and Ireland to a northern limit of 62°N. The eastern edge of the survey area was bounded by the Norwegian, Danish, Swedish and German coastline and to the west by the shelf edge between 200 and 400 m depth. Individual survey reports from participants are available on request from the nation responsible. The vessels, areas and dates of cruises are given in Table 5.1 and in Figure 5.1.

Table 5.1. Vessels, areas and cruise dates during the 2014 herring acoustic surveys.

VESSEL	PERIOD	AREA	RECTANGLES
Celtic Explorer (IR)	22 June – 12 July	53°30′-58°30′N ,12°-5°W	35D8-D9, 36D8-D9, 37D9-E1, 38D9-E1, 39E0-E2, 40E0-E2,41E0-E3, 42E0-E3, 43E0-E3, 44E0-E3, 45E0-E4
Scotia (SCO)*	28 June – 17 July	58°30′-62°N, 7°W-2°E	46E3-F1, 47E3-F1, 48E4-F1, 49E5-F1, 50E6-F1, 51E8-F1, 52E9-F1
Johan Hjort (NOR)	30 June – 15 July	56°30′-62°N, 2°-6°E	42F2-F5, 43F2-F5, 44F2-F5, 45F2-F5, 46F2-F4, 47F2-F4, 48F2-F4, 49F2-F4, 50F2-F4, 51F2-F4, 52F2-F4
Tridens (NED)	23 June – 18 July	54°25′– 58°24′N, 3° W–5°E	37E9-F1, 38E8-F1, 39E8-F1, 40E8-F4, 41E7-F4, 42E7-F1, 43E7-F1, 44E6-F1, 45E6-F1
Solea (GER) DBFH	25 June – 15 July	52°-56°N, Eng to Den/Ger coasts	33F1-F4, 34F2-F4, 35F2-F4, 36F0-F7, 37F2-F8, 38F2-F7, 39F2-F7, 40F6-F7
Dana (DEN) OXBH	25 June – 8 July	Kattegat and North of 56°N, east of 6°E	41F6-F7, 41G1-G2, 42F6-F7, 42G0-G2, 43F6-G1, 44F6-G1, 45F8-G1, 46F9-G0

*Scottish chartered vessel the MFV *Sunbeam* covered the same area and rectangles as MRV *Scotia* using interlaced transects.

Methods

The acoustic surveys were carried out using Simrad EK60 38 kHz echosounders with transducers mounted either on the hull, drop keel or in towed bodies. Echo integration and further data analyses were carried out using either LSSS (Large Scale Survey System), Myriax Echoview or Echoann software. The survey track was selected to cover the whole area with sampling intensities based on the herring densities of previous years. Transect spacing of 4, 7.5, 15 and 30 nautical miles were used in various parts of the area according to perceived abundance and variance from previous years' surveys.

The following target strength to fish length relationships were used to analyse the data:

herring	TS = 20 log L - 71.2 dB
sprat	TS = 20 log L - 71.2 dB
gadoids	TS = 20 log L - 67.5 dB
mackerel	TS = 21.7 log L - 84.9 dB

Acoustic and biological data were combined to provide an overall global estimate. Estimates of numbers-at-age, maturity stage and mean weights-at-age were calculated as weighted means of individual survey estimates by ICES statistical rectangle. The weighting applied was proportional to the length of survey track for each vessel in each ICES statistical rectangle. The data were combined to provide estimates of the North Sea autumn spawning herring, Western Baltic spring-spawning herring, West of Scotland (VIaN) herring and Malin Shelf stocks (VIaN-S and VIIb-c).

Combined Acoustic Survey Results for 2014

Herring

The estimate of North Sea autumn spawning herring spawning-stock biomass has increased from 2.3 million tonnes in 2013 to 2.6 million tonnes this year (Table 5.6).

This can largely be attributed to an increase in abundance of mature fish from 11 689 million fish in 2013 to 14 392 in 2014 (Table 5.2). In particular we saw an increase in abundance of 5, 6 and 7 winter ring fish but also a significant drop in abundance of older fish (above 8-winter rings). The increase in abundance was offset by a fall in mean weight for nearly all ages, reducing the mean weight across all ages from 73.6g in 2013 to 54.7g in 2014.

The abundance of immature fish in the stock has increased almost by a factor of two this year from 24 794 million in 2013 to 46 947 million in 2014 with the 1 winter ring abundance being the 5th highest in the time-series (Table 5.6).

Maturities were marginally higher than last year with full maturity-at-age 3 and over and 85% of 2 winter ringers fully mature (Table 5.2).

The 2008 and 2009 year classes (4 and 5-winter ringers this year) continues to be strong and are consistent with the high estimate of 1-wr fish in 2010 and 2011 (Table 5.6). The 2007 year class (6-winter rings this year) is also emerging as a numerically strong year class in the stock, however this year class continues to grow very slow and mean weight is still lower than the one year younger fish (Table 5.2).

The distribution of adult herring in the North Sea is still concentrated in the areas east and north of Scotland. Similarly to last year the distribution is stretching south in the western North Sea but less diffuse in this part of the distribution compared to last year. A dense concentration is still observed to the west of Orkney, but the bulk of the distribution was in a concentrated area centred on 44F0.

The 2014 estimate of Western Baltic spring-spawning herring SSB is 128 000 tonnes and 791 million herring (Table 5.3). In terms of biomass the SSB increased by 42 000 tonnes, while the amount of fish is in the same order of magnitude as in 2013 (853 million). The stock is dominated by 1 and 2 ring fish. The abundance of 1 ringers increased by a factor of 10 when compared to last year's estimate, but is still not in the same order of magnitude as it has been in the past (Table 5.7). The numbers of older herring (3+ group) in the stock has continued to be relatively low, as it has been since six years in a row now. When compared to 2013, the mean weight at age has increased considerably for herring aged 2 and above.

The West of Scotland estimate (VIaN) of SSB is 272 000 tonnes and 1 400 million herring, a slight increase over the 2013 estimate. In 2013 3 and 4 winter ring fish dominated the age composition of the standing stock and these cohorts have been successfully tracked in 2014 with 4 and 5 winter ring fish comprising 23% and 29% of the TSB, respectively. A large proportion of 1 winter ring fish were also observed in 2014: 66 000 tonnes (18% of TSB) and 1 031 million individuals (38% of total). This lowered the overall maturity ratio to 0.52.

The SSB estimate for the Malin Shelf area (divisions VIaN-S and VIIb,c) is 285 000 tonnes and 1 471 million herring. This is a marginal increase on 2013 and the second lowest SSB estimate in the seven year time-series. The estimate is also dominated by 1, 4 and 5 winter ringed fish. The overall maturity ratio was 0.52. These similarities between the West of Scotland and Malin Shelf indices reflect the fact that so few herring were observed in VIaS and VIIb,c, the lowest in the Malin Shelf time-series.

The Irish Sea survey program is reported separately in the WGIPS report (Section 4.3.2).

The area covered during the individual acoustic surveys is given in Figure 5.1. The spatial distributions of the abundance (numbers and biomass) of autumn spawning herring are shown in Figure 5.2. The distribution of numbers by age is shown in Figure 5.3 for 1, 2 and 3+ ring autumn spawning herring. The survey provides estimates of maturity and weight-at-age: the mean weight-at-age for 1 and 2 ring herring along with the proportions mature for 2 and 3 ring herring are shown in Figure 5.4. The spatial distribution of mature and immature autumn spawning herring is shown in Figures 5.5 and 5.6 respectively. The spatial distributions of the abundance (numbers and biomass) of Western Baltic spring-spawning herring are shown in Figure 5.7. The distribution of numbers by age is shown in Figure 5.8 for 1, 2 and 3+ ring herring. The mean weight-at-age for 1 and 2 ring herring along with the proportion mature for 2 and 3 ring herring are shown in Figure 5.9. The spatial distribution of mature and immature Western Baltic spring-spawning herring is shown in Figures 5.10 and 5.11 respectively.

The time-series of abundance for the four stocks (North Sea autumn-spawners, Western Baltic spring spawners, West of Scotland and Malin Shelf herring) are given in Tables 5.6 – 5.9 and illustrated in Figures 5.12 -5.14, respectively. In each of them, a 3 year running mean is included to show the general trend more clearly.

Sprat in the North Sea and Division IIIa

Sprat data were available from RV "Solea", MRV "Scotia", and RV "Dana". No sprat were observed in the midwestern and northeastern part of the North Sea surveyed by RV "Tridens" and RV "Johan Hjort". In the 2014 acoustic surveys, sprat concentrated in the southern part of the North Sea, with the highest abundances and biomass in an area below 55° N. The southern limit of the surveyed area is at 52° N. There is no indication that the southern limit of the sprat stock distribution has been reached; it is likely that sprat can be found even further south in the English Channel. In the Northern North Sea, sprat were caught in small amounts in three hauls in the Scottish survey by MRV Scotia. The sprat distribution in the North Sea and Division IIIa in terms of abundance and biomass is shown in Figure 5.15. Due to the small numbers of sprat in the Scottish survey, these can't be seen in Figure 5.15, but all rectangles yielding sprat are presented in Figure 5.16. The NASC values attributed to sprat in the Danish and German survey are shown in Figures 5.17 and 5.18

The total abundance of North Sea sprat (Subarea IV) in 2014 was estimated at 88 219 million individuals and the biomass at 728 000 tonnes (Table 5.10). This is the highest estimate ever observed in the time-series, both in terms of abundance and biomass. Compared to the 2009 estimate, the so far largest numbers on record, abundance and biomass have increased by more than 30% (Table 5.11). The 2014 sprat biomass is twice as high as the long-term average for the survey time-series. Most sprat were found to be mature (64%; Table 5.10). The sprat stock in the North Sea is dominated by 1- and 2-year-old fish representing 90% of the biomass.

An age-disaggregated time-series of North Sea sprat abundance and biomass (ICES Subarea IV), as obtained from the acoustic survey, is given in Table 5.11. Note that for 2003, information on the sprat distribution in the North Sea is available from one nation only.

In Division IIIa, sprat were found in the Kattegat and, in smaller amounts, in the Skagerrak area. This is in contrast to 2013, when sprat was only seen in the Kattegat. The abundance is estimated at 913 mill individuals, increased by 71% compared to the 533 million individuals in 2013 (Table 5.13). However, the biomass has decreased by 7% to 10 134 tonnes. This reduction in biomass is due to a change in the stock's age structure, containing more 1-year-old sprat compared to the previous year. 1-year-old sprat now dominate the stock (67% in numbers and 47% in biomass), while in 2013 the 3+ group was the major proportion of the stock. The age-disaggregated time-series of sprat abundance and biomass in Division IIIa is given in Table 5.13.

Quality considerations

Scottish data

Scotland covered the assigned area (VIa and IVa) with interlaced transects using two vessels (MRV Scotia and a commercial charter). Interlacing transects were at 7.5nmi spacing in line with the procedure first adopted in 2011. However, concern was expressed by WGIPS regarding the reliability of data collected from the charter vessel. This was due to a failure of a quadrant in the 38 kHz transducer for the duration of the survey. It was decided, with input from the group, that data from the Scottish charter vessel should be excluded from the analysis until further work has been carried out to warrant its inclusion. Abundance as reported is based solely on data collected from MRV Scotia using a 15nmi transect spacing. The decreased transect resolution (7.5nmi planned, 15nmi achieved), will likely have decreased the precision of the 2014 survey estimates. The precision of this revised estimate has not been calculated but earlier work presented at WGIPS (ICES, 2011, Annex 7) using 7.5 nmi and 15nmi transect resolutions estimated a loss of precision from a Relative Standard Error of 10% (7.5nmi) and 14% (15nmi). The estimate should therefore still satisfy the minimum requirements for the precision of the North Sea survey (RSE<15%) and is deemed acceptable by the group.

Work is underway to investigate options to include the data collected from the charter vessel. If a scientifically robust solution can be found, WGIPS will be provided with a revised estimate in due course. A detailed explanation and discussion of the problem is given in the national report as an addition to Table 1.

Transect spacing

In recent years the centre of distribution of mature herring seem to have stretched further south than previously and out of the areas covered with the highest intensity by the survey. This has the potential to lower the precision of the survey estimates. Work is underway to address this issue by adjusting transect spacing in the affected areas to maintain appropriate survey cover and precision.

Norway pout

In the areas covered by Scotland and Netherlands large increases in the amount of juvenile Norway Pout made scrutiny of echograms challenging in 2014. Norway pout appear in aggregations similar to smaller herring schools encountered in the area and with very similar acoustic characteristics (Fässler *et al.*, 2007). Trawl sampling revealed the presence of juvenile Norway pout in several areas but due to their small size (~7cm) they were poorly retained in the catches and a traditional split of the acoustic backscatter based on trawl composition was not possible. Instead extreme care was taken during scrutiny in areas where Norway pout was present in hauls also containing herring. A precautionary principle was adopted and echotraces which deviated from the expected traditional herring traces as deemed by experienced personnel were discarded. A preliminary analysis of both Scottish and Dutch data indicated some subtle differences between herring and juvenile Norway pout in multifrequency data that may prove useful in future for discriminating between the two. A more detailed analysis is underway and this issue will be taken up at the scrutinising workshop in September 2015 (WKSCRUT 2015).

Blue Whiting

During the Irish component of the Malin Shelf Herring Acoustic Survey a number of very large, dense, midwater schools of 0-group blue whiting were encountered to the northwest of Donegal. These marks exhibited very similar acoustic characteristics to herring marks and a number of fishing operations were required to discern the species composition of marks in the area. The resulting total herring biomass estimate is reliable but is supported by fewer herring hauls due to the time used in collecting juvenile blue whiting.

See the full survey report for more details including echograms (Nolan *et al.*, 2014; oar.marine.ie).

References

Fässler, S. M. M., R. Santos, *et al.* 2007. Multifrequency backscattering properties of Atlantic herring (*Clupea harengus*) and Norway pout (*Trisopterus esmarkii*). Canadian Journal of Fisheries and Aquatic Sciences, 64: 362–374.

ICES. 2011. Report of the Working Group for International Pelagic Surveys (WGIPS), 17–21 January 2011, Bergen, Norway. ICES CM 2011/SSGESST:02. 287 pp.

Tables and Figures

Table 5.2. Total numbers (millions) and biomass (thousands of tonnes) of North Sea autumn spawning herring in the area surveyed in the acoustic surveys June - July 2014 with mean weights and mean lengths by age in winter rings.

Age (ring)	Numbers	Biomass	Maturity	Weight(g)	Length (cm)
0	34864	194	0.00	5.6	9.3
1	11634	512	0.03	44.0	17.3
2	4918	639	0.85	129.9	23.9
3	2827	500	1.00	177.0	26.7
4	2939	572	1.00	194.5	27.4
5	1791	403	1.00	225.2	28.7
6	1236	269	1.00	217.8	28.7
7	669	151	1.00	225.1	29.1
8	211	53	1.00	250.3	29.9
9+	250	61	1.00	246.1	29.7
Immature	**46947**	**744**		**15.8**	**11.4**
Mature	**14392**	**2611**		**181.4**	**26.7**
Total	**61339**	**3354**	**0.23**	**54.7**	**15.0**

Table 5.3. Total numbers (millions) and biomass (thousands of tonnes) of Western Baltic spring-spawning herring in the area surveyed in the acoustic surveys June-July 2014, with mean weights, mean length and fraction mature by age ring.

Age (ring)	Numbers	Biomass	Maturity	weight(g)	Length (cm)
0	314	1	0.00	4.3	9.1
1	513	26	0.01	51.6	18.2
2	415	48	0.68	114.9	23.0
3	176	21	0.73	122.4	24.2
4	248	43	0.98	175.0	26.6
5	28	6	1.00	210.6	28.5
6	37	8	1.00	220.2	28.8
7	26	6	1.00	213.3	28.9
8+	42	11	1.00	244.1	30.3
Immature	1007	42		41.9	16.0
Mature	791	128		161.7	25.8
Total	1,798	170	0.44	94.6	20.3

Table 5.4. Total numbers (millions) and biomass (thousands of tonnes) of autumn spawning West of Scotland herring in the area surveyed in the acoustic surveys July 2014, with mean weights, mean lengths and fraction mature by age ring.

Age (ring)	Numbers	Biomass	Maturity	Weight (g)	Length (cm)
0					
1	1031	66	0	64.4	19.5
2	243	26	0.20	108.1	22.9
3	218	34	0.75	157.4	25.8
4	469	85	0.99	180.4	27.3
5	519	107	1.00	206.0	28.5
6	143	31	1.00	213.8	29.2
7	30	7	1.00	231.1	29.4
8	19	5	1.00	244.3	30.2
9+	11	3	1.00	264.4	30.4
Immature	1284	91		71.2	20.1
Mature	1400	272		194.6	27.9
Total	2684	364	0.52	135.5	24.2

Table 5.5. Total numbers (millions) and biomass (thousands of tonnes) of Malin Shelf herring (VIaN-S, VIIb,c) June-July 2014. Mean weights, mean lengths and fraction mature by age ring.

Age (ring)	Numbers	Biomass	Maturity	Weight (g)	Length (cm)
0					
1	1031	66	0	64.4	19.5
2	281	30	0.18	106.2	22.8
3	243	37	0.73	154.2	25.6
4	502	90	0.99	179.9	27.2
5	534	110	1.00	205.4	28.5
6	148	32	1.00	214.1	29.2
7	33	8	1.00	232.0	29.4
8	19	5	1.00	244.3	30.2
9+	13	3	1.00	259.1	30.1
Immature	1333	96		72.2	20.2
Mature	1471	285		193.6	27.8
Total	2804	381	0.52	135.9	24.2

Table 5.6. Estimates of North Sea autumn spawners (millions) at age from acoustic surveys, 1986–2014. For 1986 the estimates are the sum of those from the Division IVa summer survey, the Division IVb autumn survey, and the Divisions IVc, VIId winter survey. The 1987 to 2014 estimates are from summer surveys in Divisions IVa,b,c and IIIa excluding estimates of Western Baltic spring spawners. For 1999 and 2000 the Kattegat was excluded from the results because it was not surveyed. Total numbers include 0-ringers from 2008 onwards.

Years / Age (rings)	1	2	3	4	5	6	7	8	9+	Total	SSB ('000t)
1986	1,639	3,206	1,637	833	135	36	24	6	8	7,542	942
1987	13,736	4,303	955	657	368	77	38	11	20	20,165	817
1988	6,431	4,202	1,732	528	349	174	43	23	14	13,496	897
1989	6,333	3,726	3,751	1,612	488	281	120	44	22	16,377	1,637
1990	6,249	2,971	3,530	3,370	1,349	395	211	134	43	18,262	2,174
1991	3,182	2,834	1,501	2,102	1,984	748	262	112	56	12,781	1,874
1992	6,351	4,179	1,633	1,397	1,510	1,311	474	155	163	17,173	1,545
1993	10,399	3,710	1,855	909	795	788	546	178	116	19,326	1,216
1994	3,646	3,280	957	429	363	321	238	220	132	13,003	1,035
1995	4,202	3,799	2,056	656	272	175	135	110	84	11,220	1,082
1996	6,198	4,557	2,824	1,087	311	99	83	133	206	18,786	1,446
1997	9,416	6,363	3,287	1,696	692	259	79	78	158	22,028	1,780
1998	4,449	5,747	2,520	1,625	982	445	170	45	121	16,104	1,792
1999	5,087	3,078	4,725	1,116	506	314	139	54	87	15,107	1,534
2000	24,735	2,922	2,156	3,139	1,006	483	266	120	97	34,928	1,833
2001	6,837	12,290	3,083	1,462	1,676	450	170	98	59	26,124	2,622
2002	23,055	4,875	8,220	1,390	795	1,031	244	121	150	39,881	2,948
2003	9,829	18,949	3,081	4,189	675	495	568	146	178	38,110	2,999
2004	5,183	3,415	9,191	2,167	2,590	317	328	342	186	23,722	2,584
2005	3,113	1,890	3,436	5,609	1,211	1,172	140	127	107	16,805	1,868
2006	6,823	3,772	1,997	2,098	4,175	618	562	84	70	20,199	2,130
2007	6,261	2,750	1,848	898	806	1,323	243	152	65	14,346	1,203
2008	3,714	2,853	1,709	1,485	809	712	1,749	185	270	20,355	1,784
2009	4,655	5,632	2,553	1,023	1,077	674	638	1,142	578	31,526	2,591
2010	14,577	4,237	4,216	2,453	1,246	1,332	688	1,110	1,619	43,705	3,027
2011	10,119	4,166	2,534	2,173	1,016	651	688	440	1,207	25,524	2,431
2012	7,437	4,718	4,067	1,738	1,209	593	247	218	478	23,641	2,269
2013	6,388	2,683	3,031	2,895	1,546	849	464	250	592	36,484	2,261
2014	11,634	4,918	2,827	2,939	1,791	1,236	669	211	250	61,339	2,610

Table 5.7. Numbers-at-age (millions) of Western Baltic Spring-spawning herring at age (rings) from acoustic surveys 1992 to 2014. The 1999 survey was incomplete due to the lack of participation by RV "DANA".

Year/Age	1	2	3	4	5	6	7	8+	Total	3+ group
1992	277	2,092	1,799	1,593	556	197	122	20	10,509	4,287
1993	103	2,768	1,274	598	434	154	63	13	5,779	2,536
1994	5	413	935	501	239	186	62	34	3,339	1,957
1995	2,199	1,887	1,022	1,270	255	174	39	21	6,867	2,781
1996	1,091	1,005	247	141	119	37	20	13	2,673	577
1997	128	715	787	166	67	69	80	77	2,088	1,245
1998	138	1,682	901	282	111	51	31	53	3,248	1,428
1999	1,367	1,143	523	135	28	3	2	1	3,201	691
2000	1,509	1,891	674	364	186	56	7	10	4,696	1,295
2001	66	641	452	153	96	38	23	12	1,481	774
2002	3,346	1,576	1,392	524	88	40	18	19	7,002	2,081
2003	1,833	1,110	395	323	103	25	12	5	3,807	864
2004	1,668	930	726	307	184	72	22	18	3,926	1,328
2005	2,687	1,342	464	201	103	84	37	21	4,939	910
2006	2,081	2,217	1,780	490	180	27	10	0.1	6,791	2,487
2007	3,918	3,621	933	499	154	34	26	14	9,200	1,661
2008	5,852	1,160	843	333	274	176	45	44	8,839	1,715
2009	565	398	205	161	82	85	39	65	1,602	638
2010	999	511	254	115	65	24	28	34	2,030	519
2011	2,980	473	259	163	70	53	22	46	4,067	614
2012	1,018	1,081	236	87	76	33	14	60	2,605	505
2013	49	627	525	53	30	12	8	15	1,319	643
2014	513	415	176	248	28	37	26	42	1,798	556

Table 5.8. Numbers-at-age (millions) and SSB of West of Scotland Autumn Spawning herring at age (rings) from acoustic surveys 1993 to 2014. In 1997 the survey was carried out one month early in June as opposed to July when all the other surveys were carried out.

Year/Age	1	2	3	4	5	6	7	8	9+	SSB:
1993	3	750	681	653	544	865	284	152	156	866
1994	494	542	608	286	307	268	407	174	132	534
1995	441	1,103	473	450	153	187	169	237	202	452
1996	41	577	803	329	95	61	77	78	115	370
1997	792	642	286	167	66	50	16	29	24	141
1998	1,221	795	667	471	179	79	28	14	37	376
1999	534	322	1,389	432	308	139	87	28	35	460
2000	448	316	337	900	393	248	200	95	65	500
2001	313	1,062	218	173	438	133	103	52	35	359
2002	425	436	1,437	200	162	424	152	68	60	549
2003	439	1,039	933	1,472	181	129	347	114	75	739
2004	564	275	760	442	577	56	62	82	76	396
2005	50	243	230	423	245	153	13	39	27	168
2006	112	835	388	285	582	415	227	22	59	472
2007	0	126	294	202	145	347	243	163	32	299
2008	48	233	912	669	340	272	721	366	264	788
2009	346	187	264	430	374	219	187	500	456	579
2010	425	489	398	150	143	95	63	48	188	253
2011	22	185	733	451	204	220	199	113	263	458
2012	792	179	729	471	241	107	107	56	105	375
2013	0	137	320	600	162	69	61	24	37	256
2014	1031	243	218	469	519	143	30	19	11	272

Table 5.9. Numbers-at-age (millions) and SSB (thousands of tonnes) of Malin Shelf survey (VIaN-S, VIIb,c) time-series. Age (rings) from acoustic surveys 2008 to 2014.

Year/Age	1	2	3	4	5	6	7	8	9+	SSB:
2008	312	290	998	720	363	331	744	386	274	842
2009	928	265	274	444	380	225	193	500	456	593
2010	300	376	374	242	173	146	102	100	297	366
2011	63	257	900	485	213	228	205	113	264	494
2012	796	548	832	518	249	115	111	57	105	427
2013	0	212	435	672	195	71	61	29	37	282
2014	1031	281	243	502	534	148	33	19	13	285

Table 5.10. Sprat in the North Sea (Subarea IV): Abundance, biomass, mean weight and mean length by age and maturity (i = immature, m = mature) from summer 2014 North Sea acoustic survey (HERAS).

Age	Abundance (million)	Biomass (1000 t)	Mean weight (g)	Mean length (cm)
0i	5,828.0	8.9	1.5	6.2
1i	23,957.3	134.5	5.6	9.2
1m	34,447.4	294.5	8.6	10.5
2i	1,784.5	14.1	7.9	10.3
2m	18,379.7	214.1	11.6	11.7
3m	3,662.3	59.0	16.1	13.1
4m	155.9	3.1	20.1	14.2
5m	4.4	0.1	28.1	15.9
6m	0.0	0.0	-	-
Immature	31,569.8	157.5	5.0	8.7
Mature	56,649.7	570.9	10.1	11.1
Total	88,219.5	728.3	8.3	10.2

Table 5.11. Time-series of sprat abundance and biomass (ICES Subarea IV) as obtained from summer North Sea acoustic survey (HERAS). The surveyed area has expanded over the years. Only figures from 2004 and onwards are broadly comparable. In 2003, information on sprat abundance is available from one nation only.

	Abundance (million)					Biomass (1000 t)				
Year/Age	0	1	2	3+	Sum	0	1	2	3+	Sum
2014	5,828	58,405	20,164	3,823	88,219	9	429	228	62	728
2013	454	9,332	6,273	1,600	17,660	2	71	74	25	172
2012	7,807	21,912	12,541	3,205	45,466	27	177	150	55	409
2011	0	26,536	13,660	2,430	42,625	0	212	188	44	444
2010	1,991	19,492	13,743	798	36,023	22	163	177	14	376
2009	0	47,520	16,488	1,183	65,191	0	346	189	21	556
2008	0	17,165	7,410	549	25,125	0	161	101	9	271
2007	0	37,250	5,513	1,869	44,631	0	258	66	29	353
2006*	0	21,862	19,916	760	42,537	0	159	265	12	436
2005*	0	69,798	2,526	350	72,674	0	475	33	6	513
2004*	17,401	28,940	5,312	367	52,019	19	267	73	6	366
2003*	0	25,294	3,983	338	29,615	0	198	61	6	266
2002	0	15,769	3,687	207	19,664	0	167	55	4	226
2001	0	12,639	1,812	110	14,561	0	97	24	2	122
2000	0	11,569	6,407	180	18,156	0	100	92	3	196

*** re-calculated using FishFrame.**

Table 5.12. Sprat in Division IIIa: Abundance, biomass, mean weight and length by age and maturity from summer 2014 North Sea acoustic survey (HERAS).

Age	Abundance (million)	Biomass (tonnes)	mean weight (g)	mean length (cm)
0i	29.6	118	4.2	8.0
1i	604.9	4 641	7.7	9.8
1m	9.6	117	12.5	11.2
2i	75.6	1 255	16.7	13.2
2m	34.2	564	16.6	13.0
3m+	159.4	3 439	21.7	14.5
Immature	710.1	6 014	8.5	10.1
Mature	203.2	4 120	20.4	14.1
Total	913.3	10 134	11.1	11.0

Table 5.13. Time-series of sprat abundance and biomass (ICES Division IIIa) as obtained from summer North Sea acoustic survey (HERAS).

Abundance (million)						Biomass (1000 t)				
Year/Age	0	1	2	3+	Sum	0	1	2	3+	Sum
2014	29.6	614.5	109.8	159.4	913.3	0.1	4.8	1.8	3.4	10.1
2013	1.4	14.5	68.8	448.6	533.3	0.0	0.2	1.2	9.6	10.9
2012	0.3	123.9	290.1	1,488.0	1,902.3	0.0	1.2	5.0	31.4	37.6
2011	0.0	45.4	546.9	981.9	1,574.2	0.0	0.5	9.1	17.8	27.5
2010	0.0	836.1	343.8	376.3	1,556.2	0.0	7.3	4.9	6.4	18.6
2009	0.0	169.5	432.4	1,631.9	2,233.8	0.0	1.8	6.5	28.3	36.6
2008	0.0	23.0	457.8	291.2	772.0	0.0	0.2	6.3	5.8	12.3
2007	0.0	5,611.9	323.9	382.9	6,318.7	0.0	47.9	3.8	6.5	58.2
2006	86.0	61.3	1451.9	653.0	2,252.2	0.3	0.6	21.2	11.5	33.6

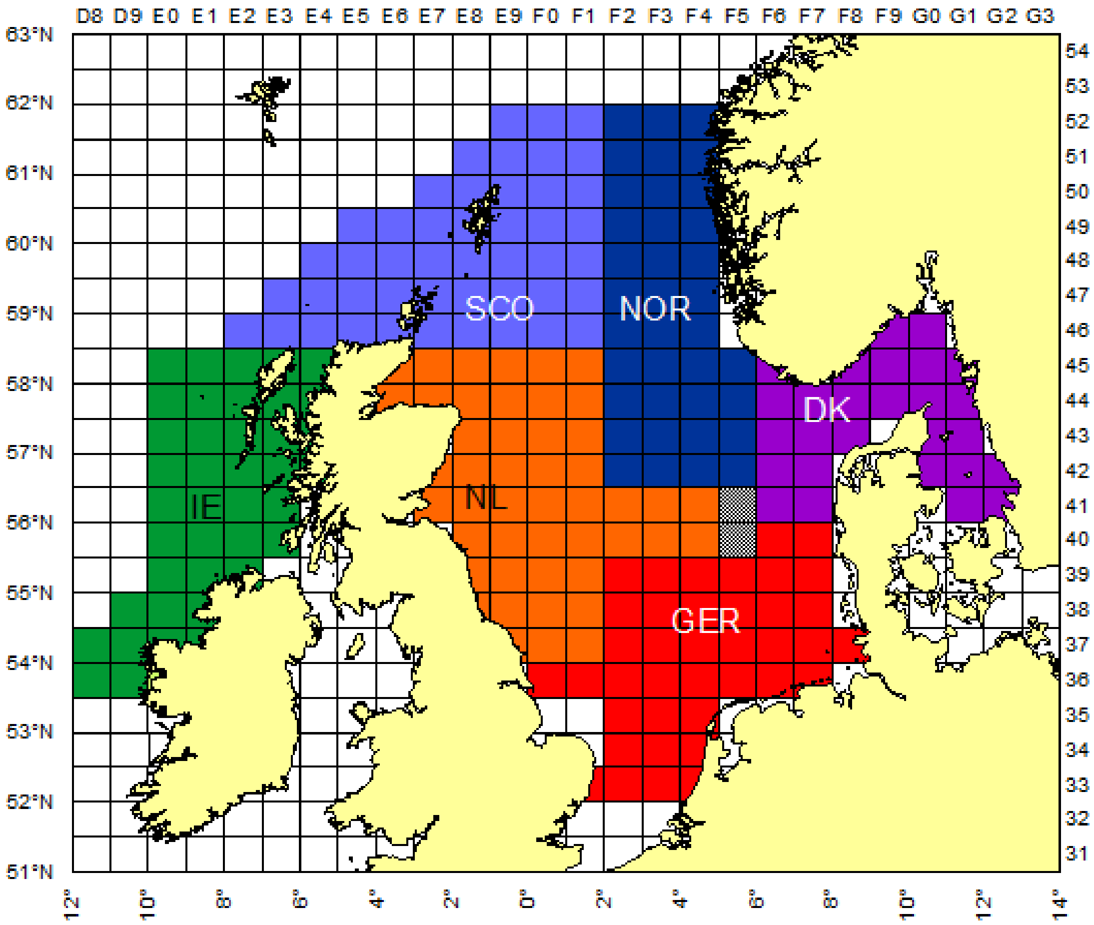

Figure 5.1. Survey area coverage in the pelagic acoustic surveys in 2014, by rectangle and nation (IR = Celtic Explorer; SCO = Scotia and chartered vessel; NOR = Johan Hjort; DK = Dana; NL = Tridens; GER = Solea). The grey rectangles 40F5 and 41F5 were not surveyed.

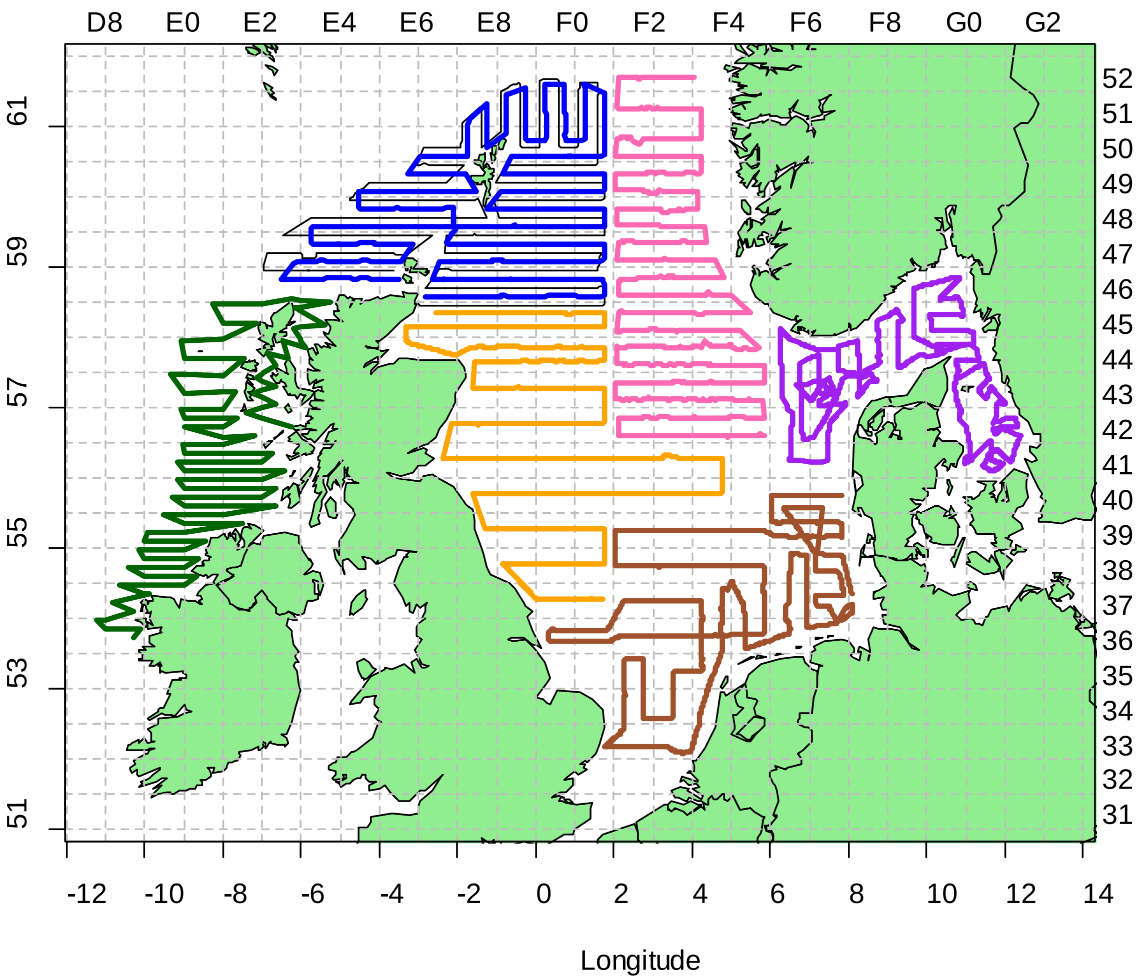

Figure 5.1b. Cruise tracks from individual vessels participating in the herring acoustic surveys 2014. The thin black track interlacing with the blue represents the track of the Scottish chartered vessel. The data from this was not used in the calculations of the 2014 estimates.

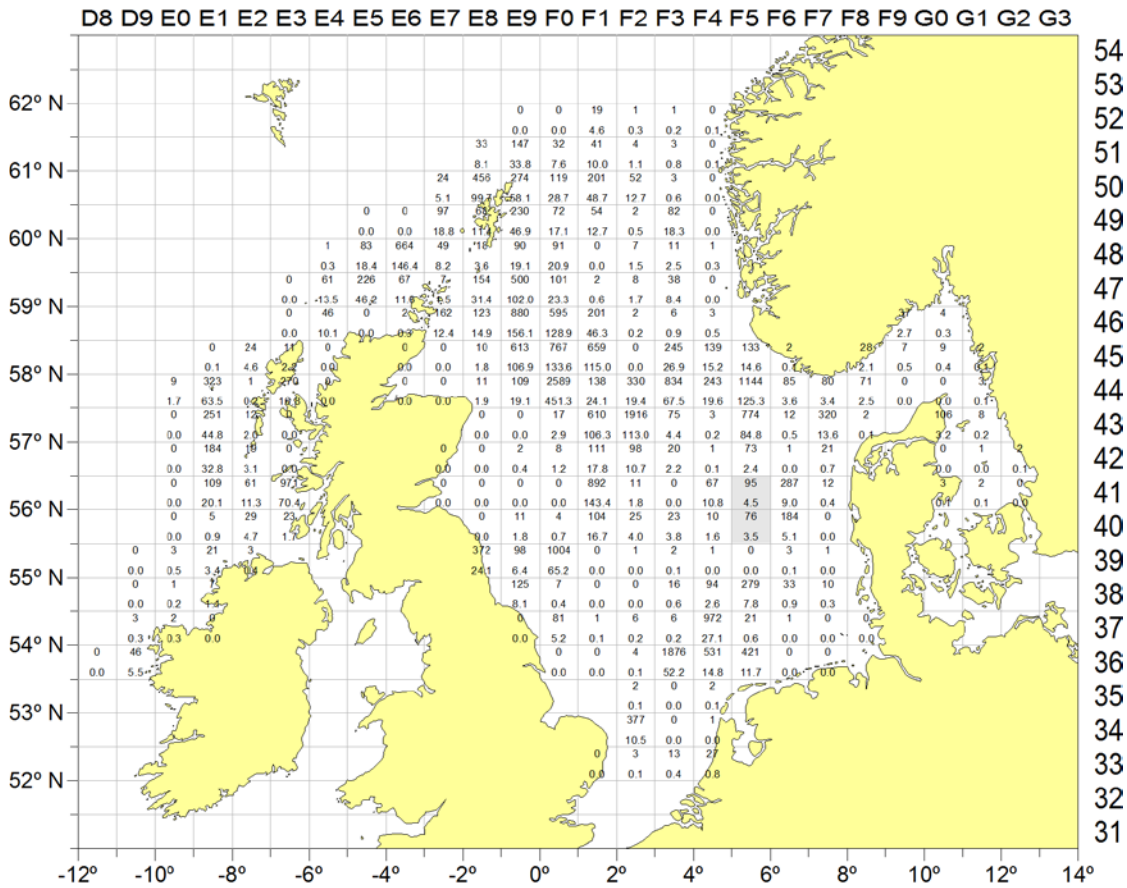

Figure 5.2. Abundance of autumn spawning herring (winter ring 1–9+) from the combined acoustic survey in June-July 2014. Numbers (millions, upper figure) and biomass (thousands of tonnes, lower figure). Light grey rectangles were not surveyed and values represent interpolations.

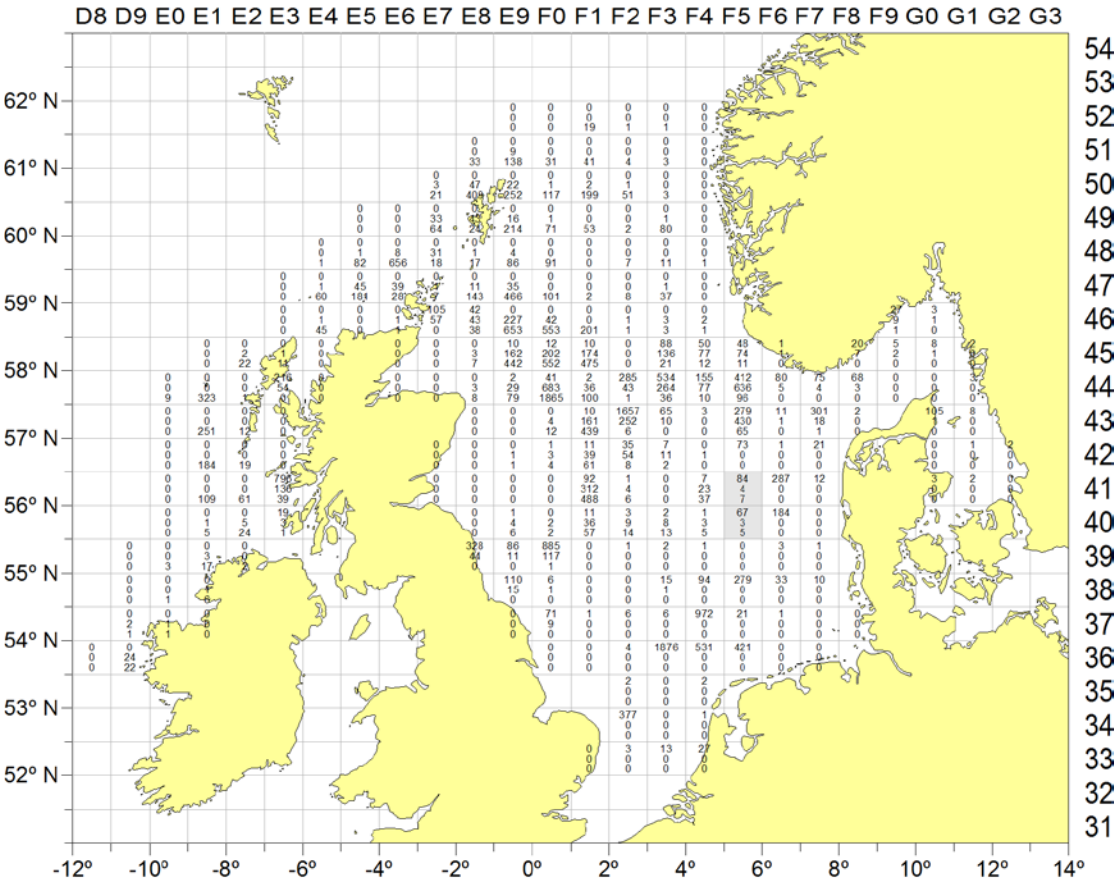

Figure 5.3. Numbers (millions) of autumn spawning herring from combined acoustic survey June – July 2014. 1 winter ring (upper figure), 2 ring (centre figure), 3+ (lower figure). Light grey rectangles were not surveyed and values represent interpolations.

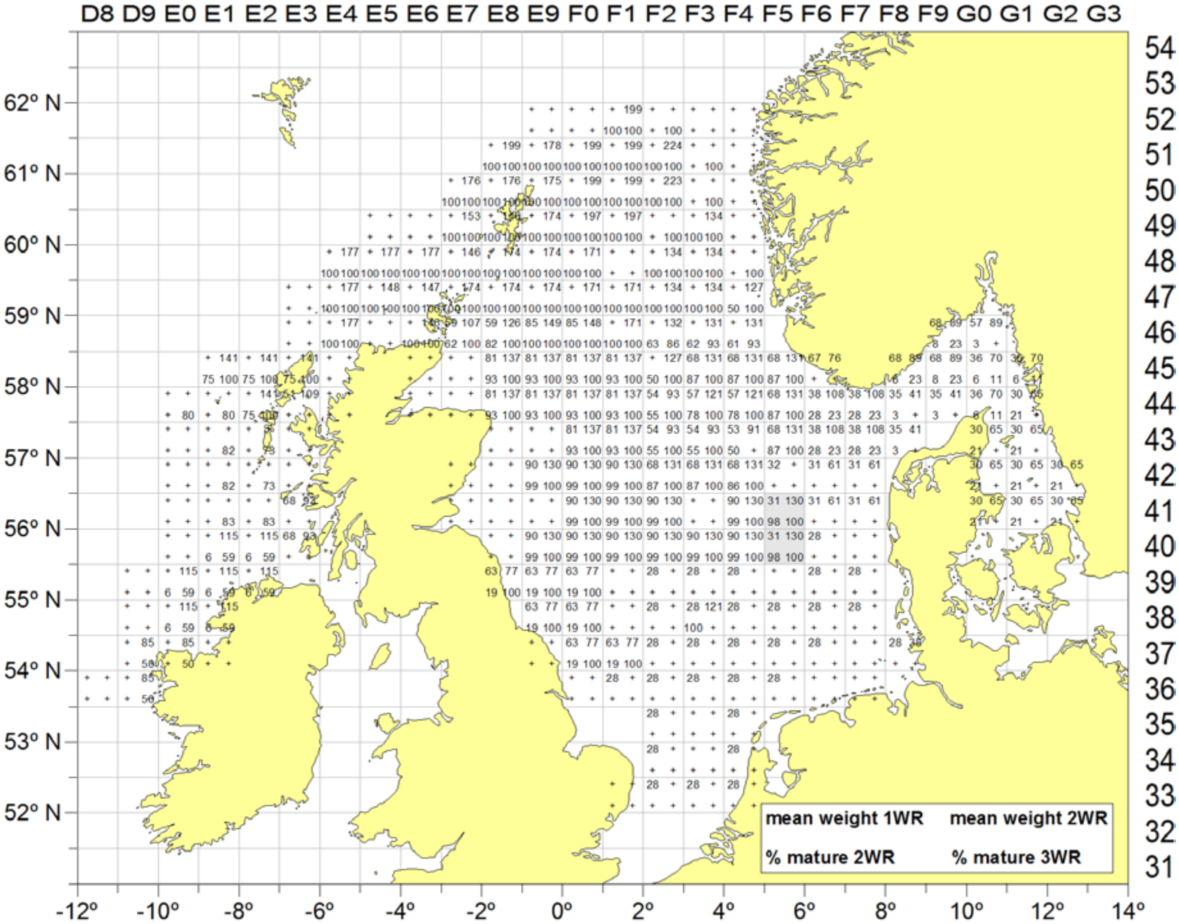

Figure 5.4. Mean weight and maturity of autumn spawning herring from combined acoustic survey June – July 2014. Four values per ICES rectangle, percentage mature of 2 ring (lower left) and 3 ring fish (lower right), mean weights (grams) of 1 ring (upper left) and 2 ring fish (upper right). Light grey rectangles were not surveyed and values represent interpolations.

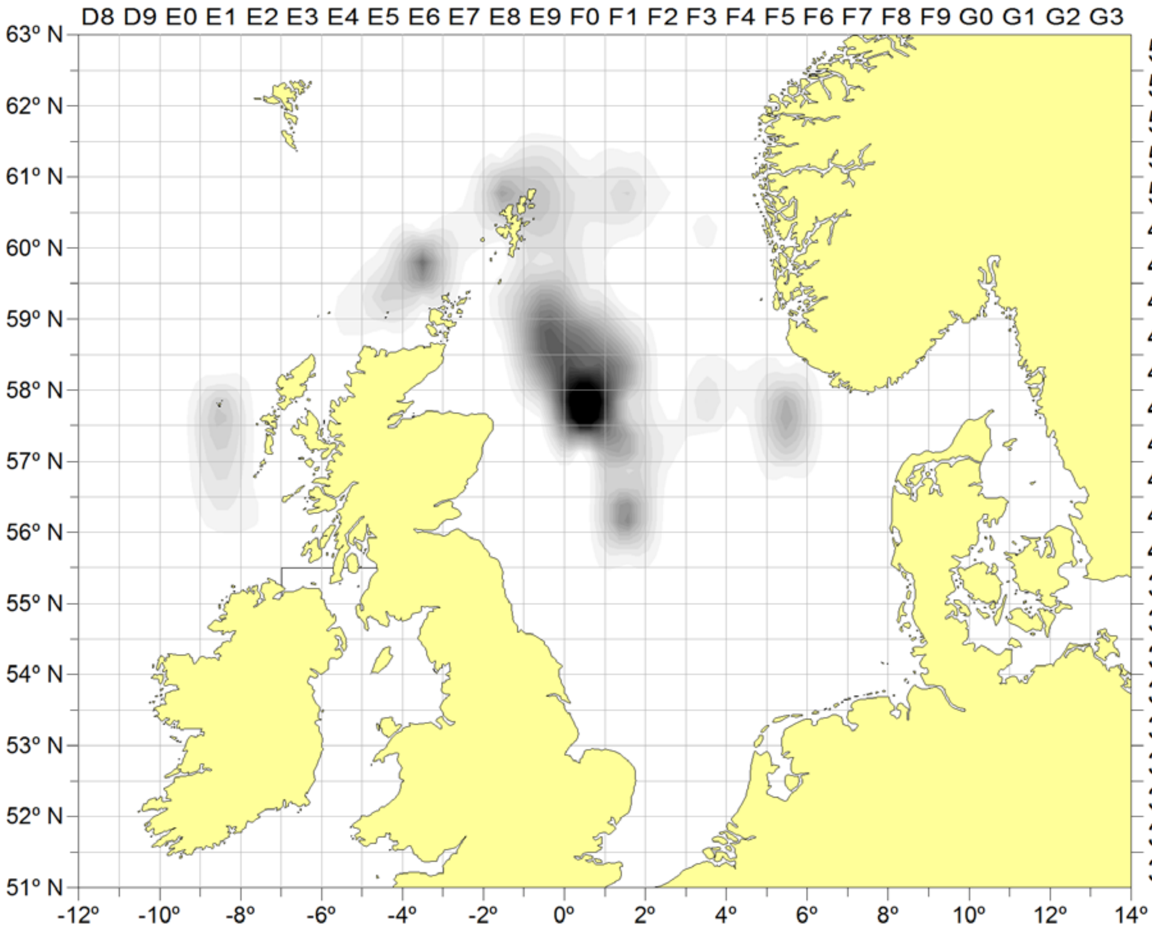

Figure 5.5. Biomass of mature autumn spawning herring from the combined acoustic survey in June – July 2014 (maximum value = 443 537).

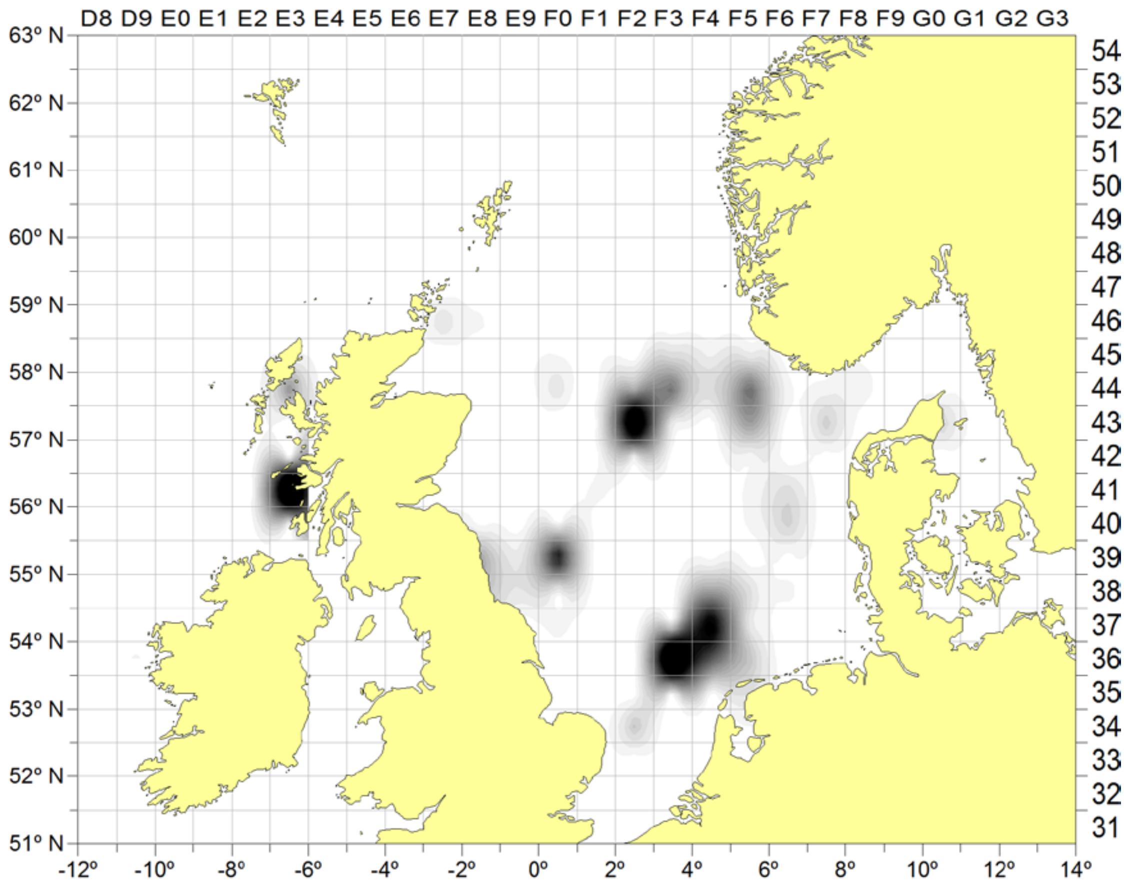

Figure 5.6. Biomass of immature autumn spawning herring from the combined acoustic survey in June – July 2014 (maximum value = 115 135).

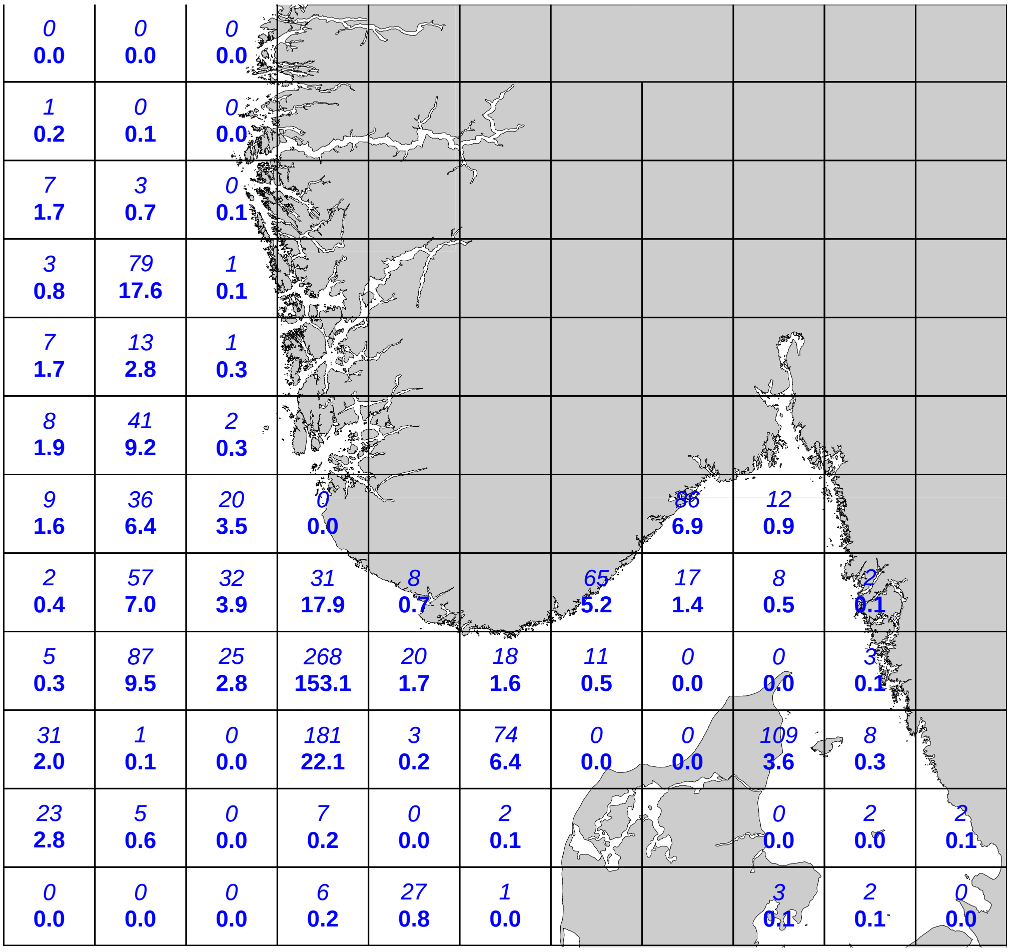

Figure 5.7. Abundance of western Baltic spring-spawning herring 1–9+ from combined acoustic survey July 2014. Numbers (millions, upper figure) and biomass (thousands of tonnes, lower figure).

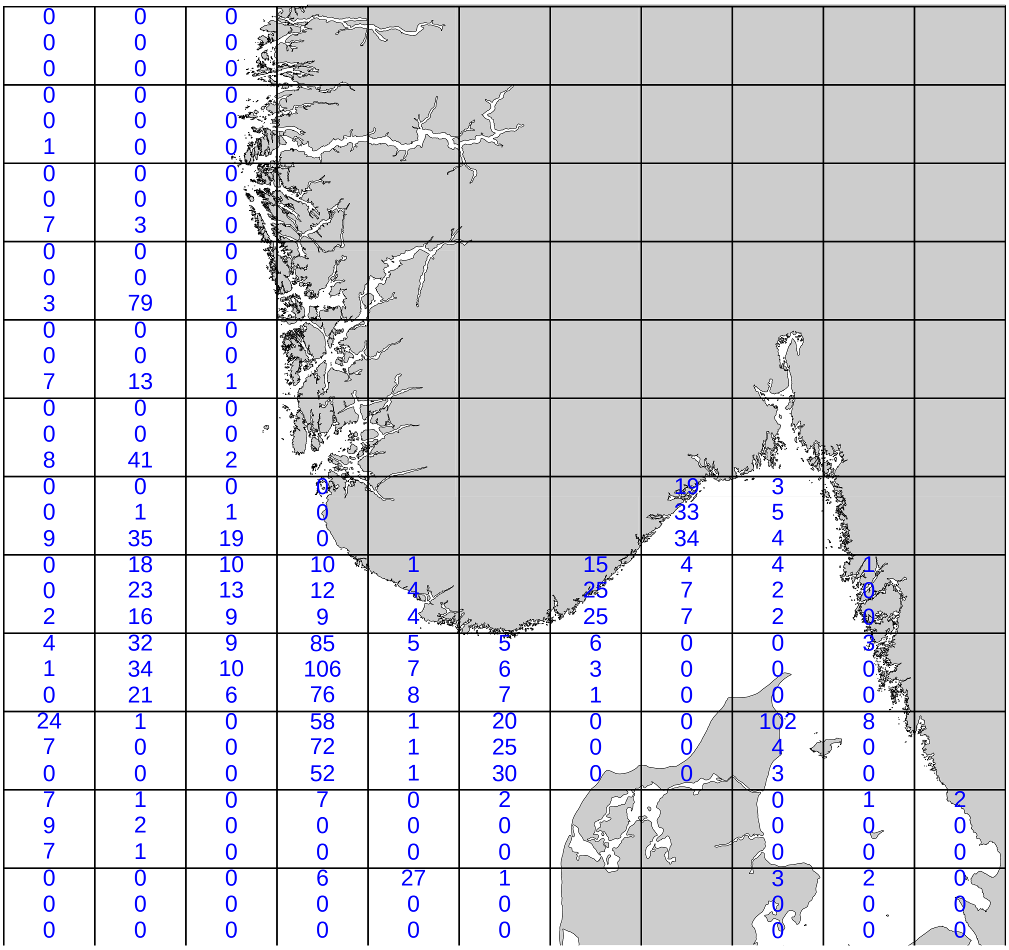

Figure 5.8. Numbers (millions) of western Baltic spring-spawning herring from combined acoustic survey June – July 2014. 1 ring (upper figure), 2 ring (centre figure), 3+ (lower figure).

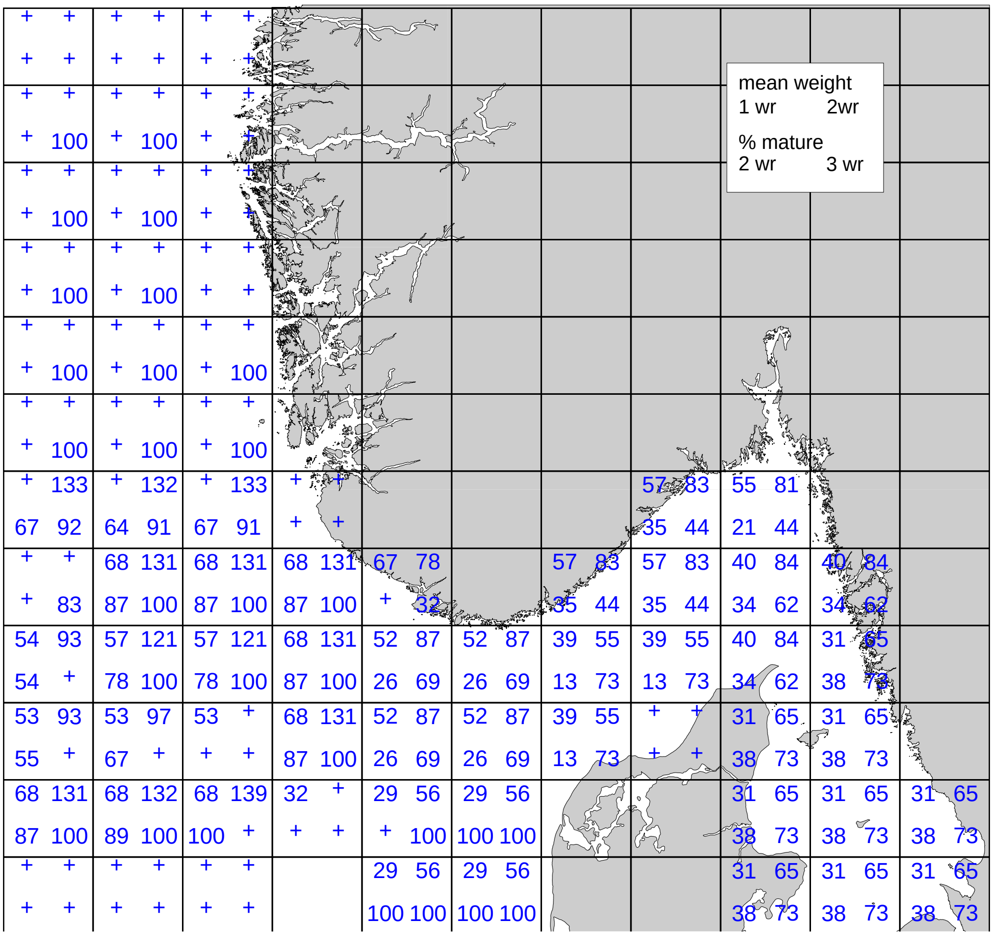

Figure 5.9. Mean weight and maturity of western Baltic spring-spawning herring from combined acoustic survey June – July 2014. Four values per ICES rectangle, percentage mature of 2 ring (lower left) and 3 ring fish (lower right), mean weights gram of 1 ring (upper left) and 2 ring fish (upper right), + indicates surveyed with zero abundance, blank indicates an unsurveyed rectangle.

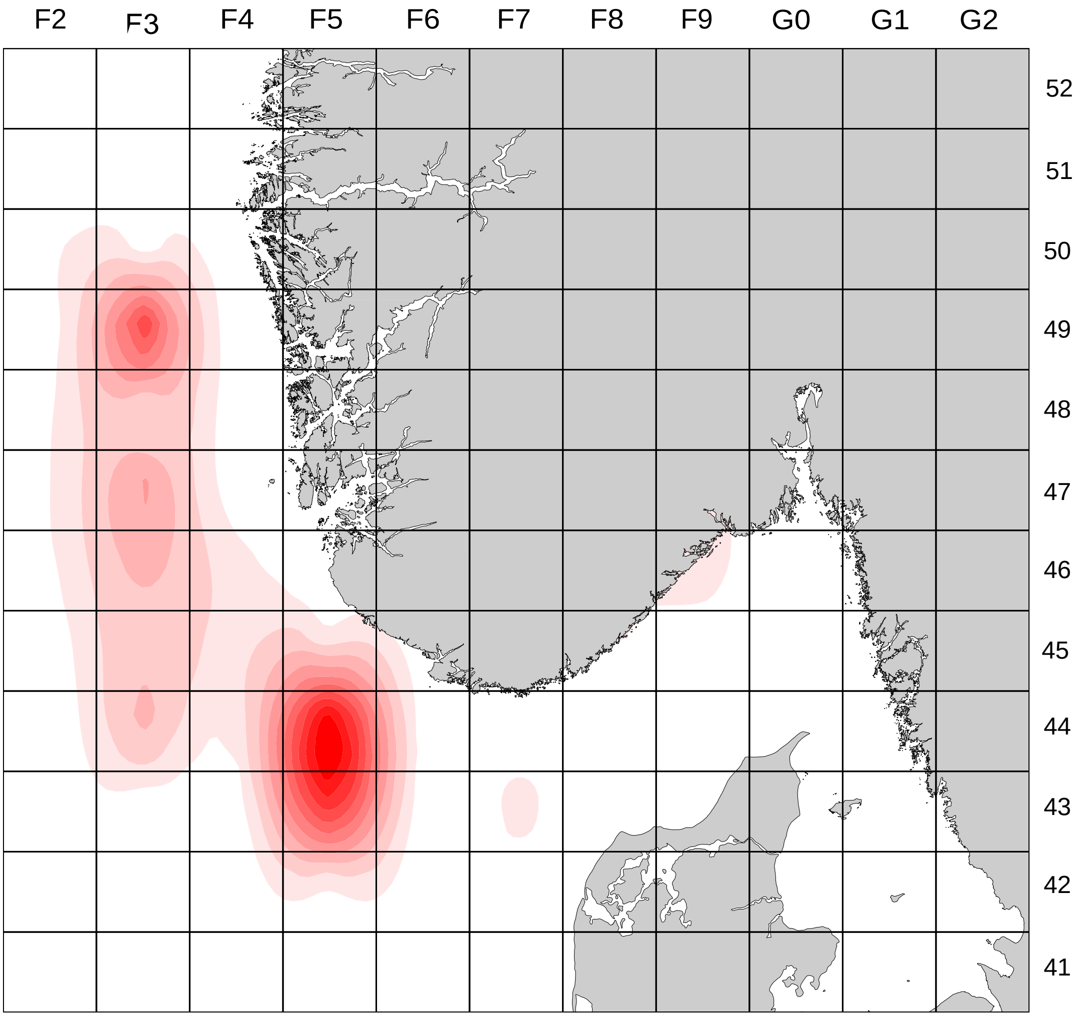

Figure 5.10. Biomass of mature western Baltic spring-spawning herring from combined acoustic survey in June – July 2014 (maximum = 20 000 t).

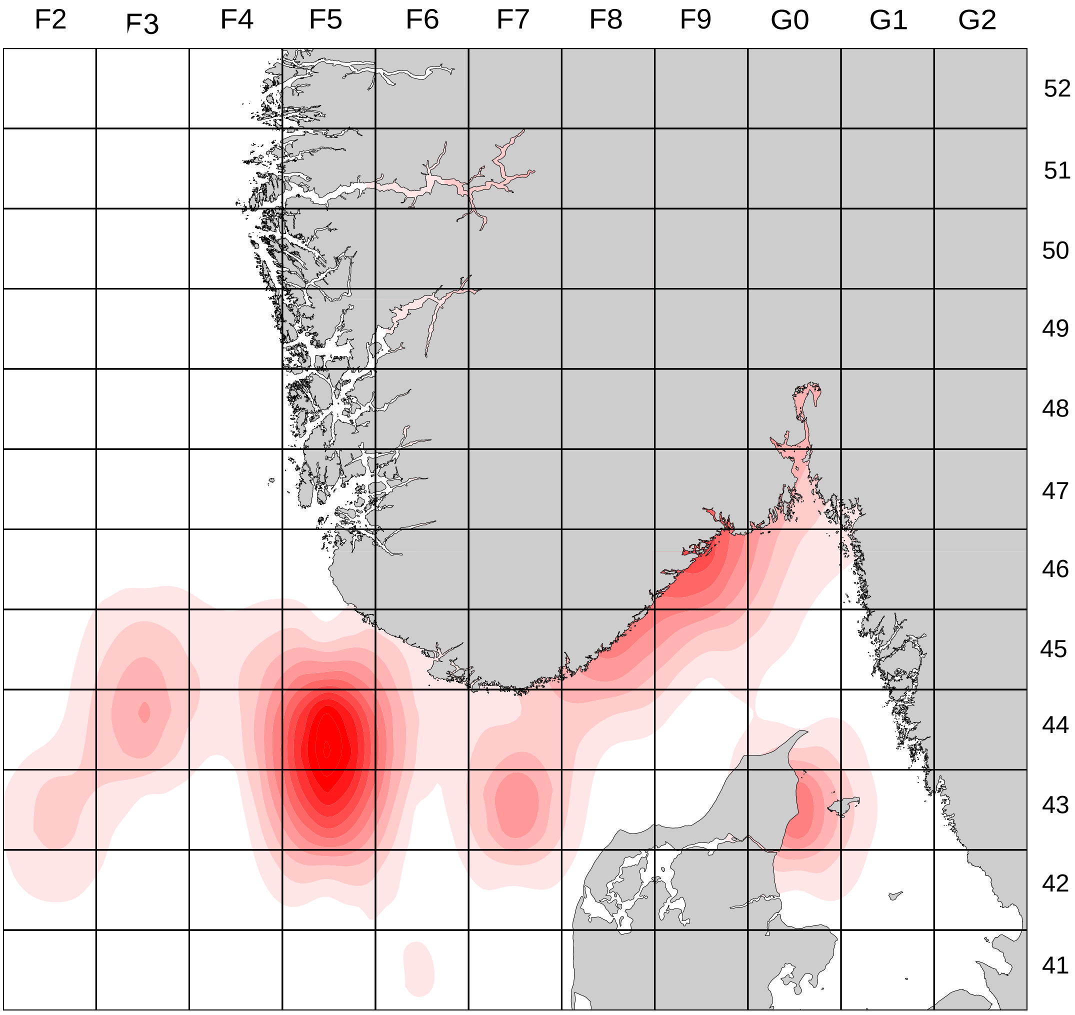

Figure 5.11. Biomass of immature western Baltic spring-spawning herring from combined acoustic survey in June – July 2014 (maximum = 6 000 t).

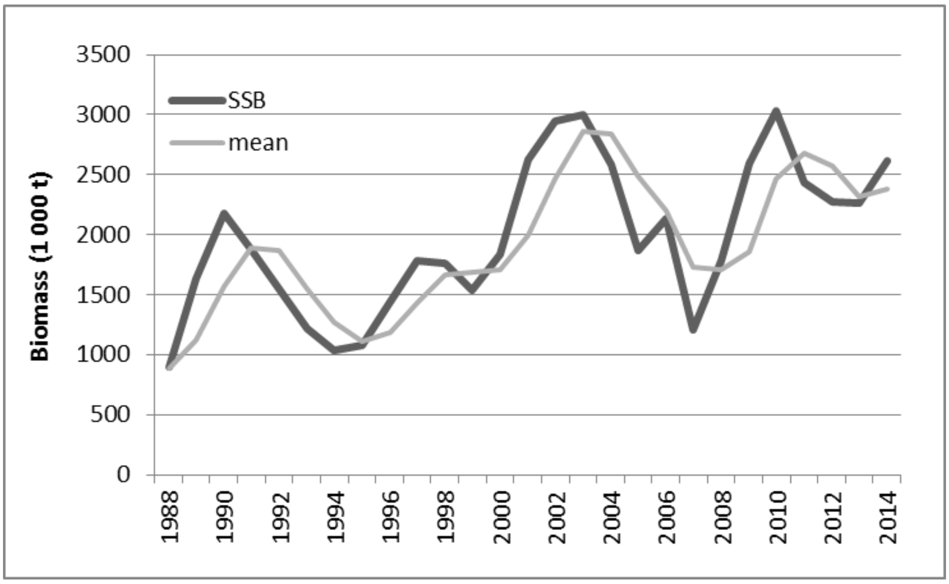

Figure 5.12. Time-series of SSB of North Sea autumn spawning herring with three year running mean.

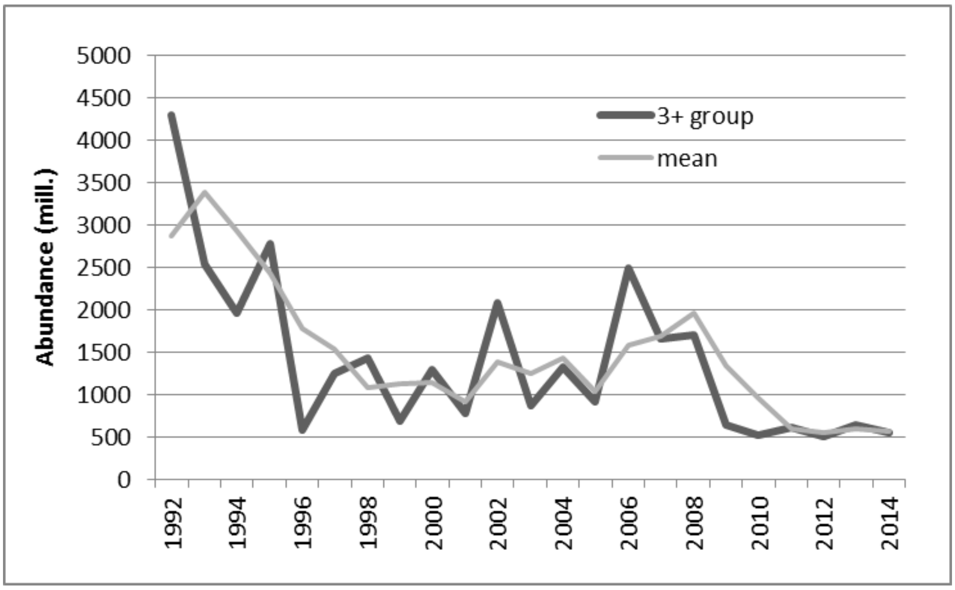

Figure 5.13. Time-series of 3+ abundance of Western Baltic spring-spawning herring with three year running mean.

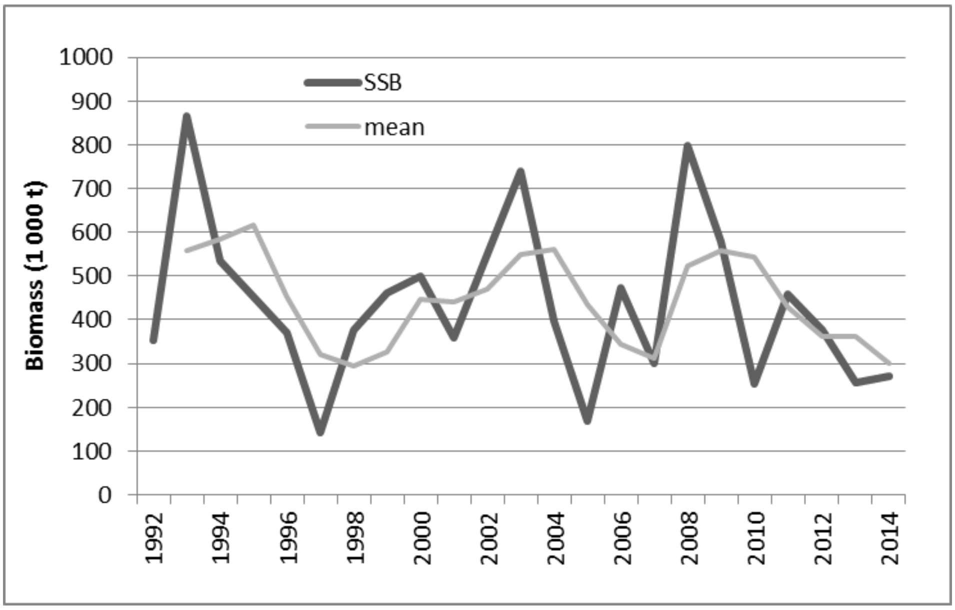

Figure 5.14. Time-series of SSB of West of Scotland herring with three year running mean.

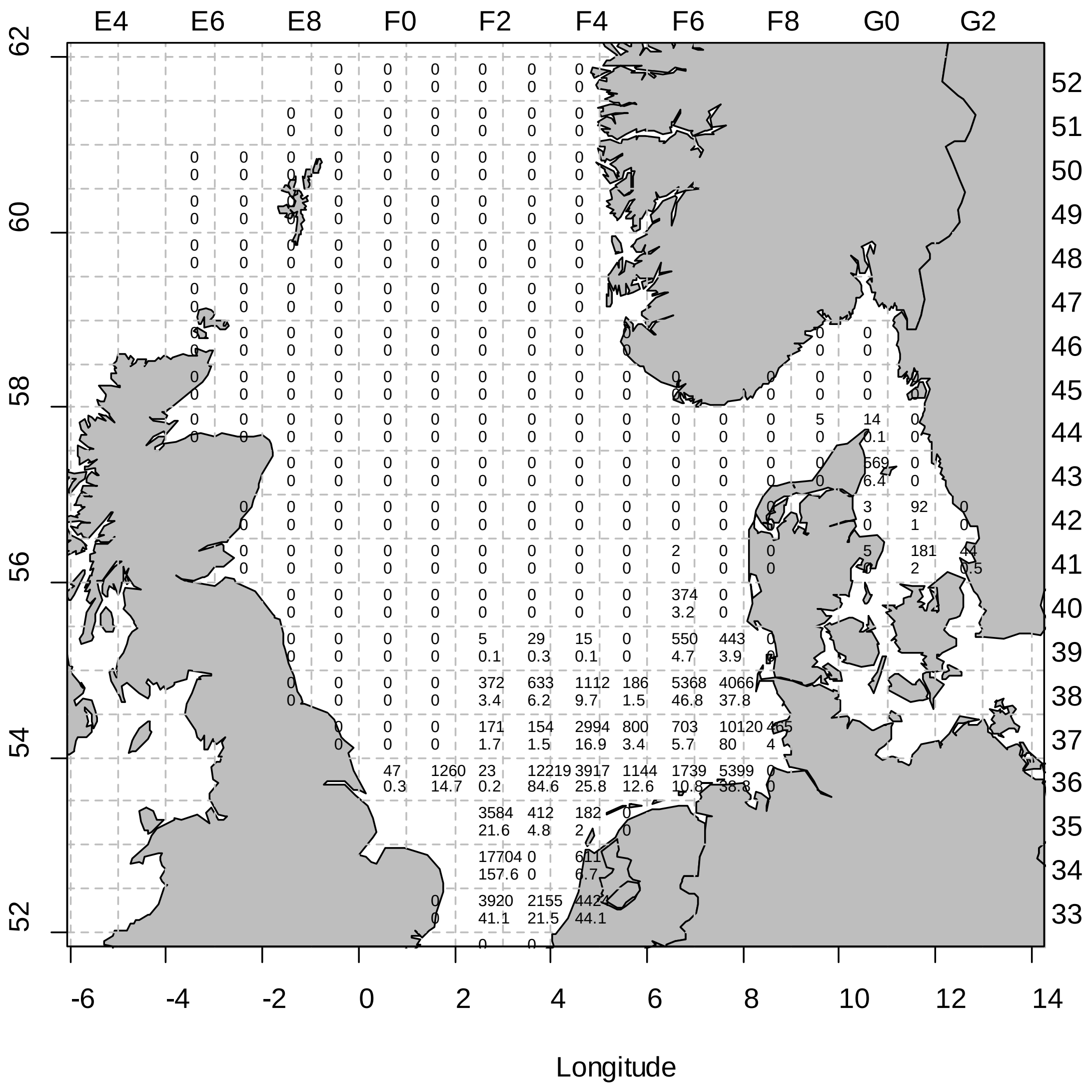

Figure 5.15. North Sea Sprat. Abundance (upper figure, in millions) and biomass (lower figure, in 1000 t) per ICES statistical rectangle.

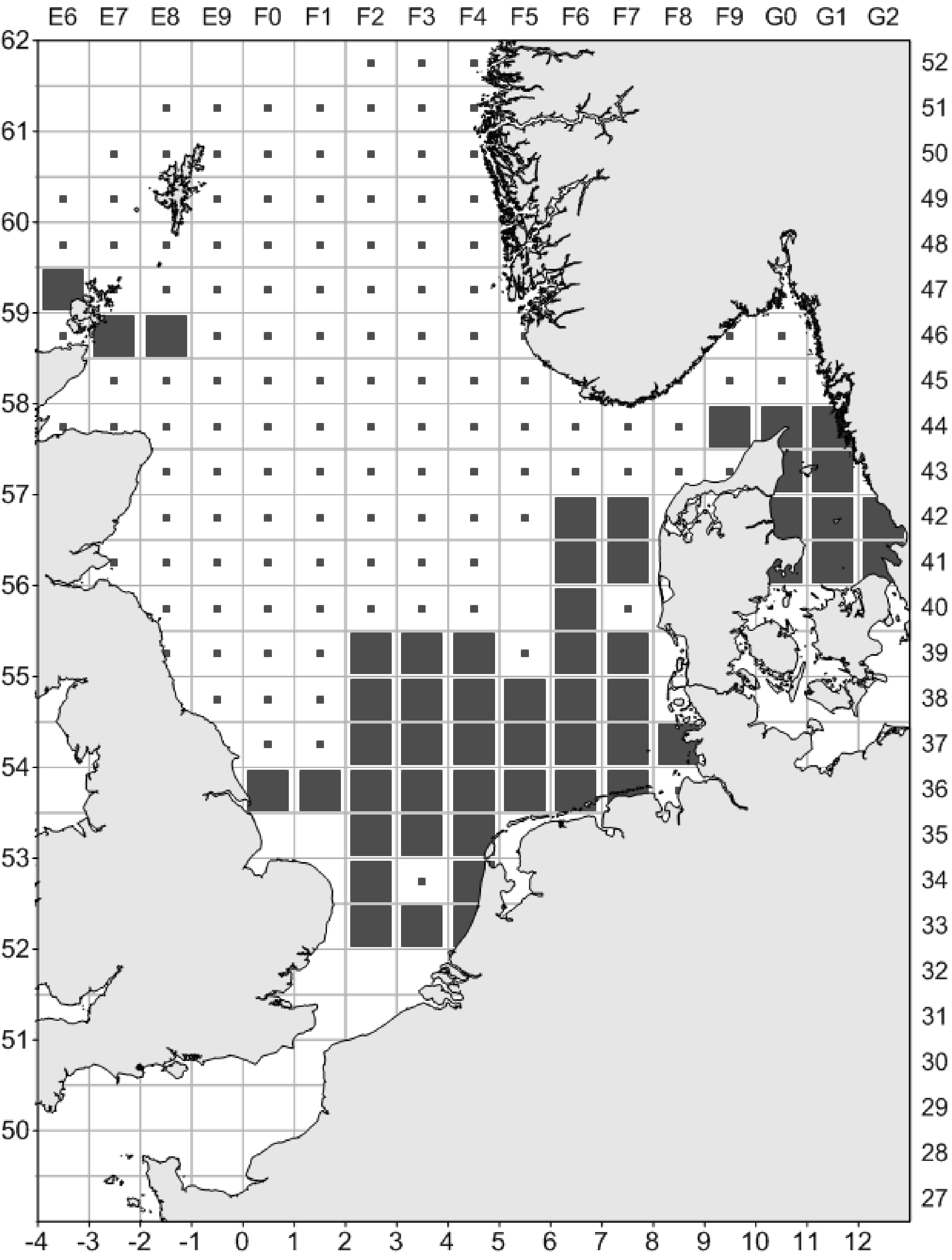

Figure 5.16. Presence or absence of sprat in the North Sea in 2014. Rectangles with sprat present are in filled in grey, rectangles without sprat are in white with a small dot, unsurveyed rectangles are left blank.

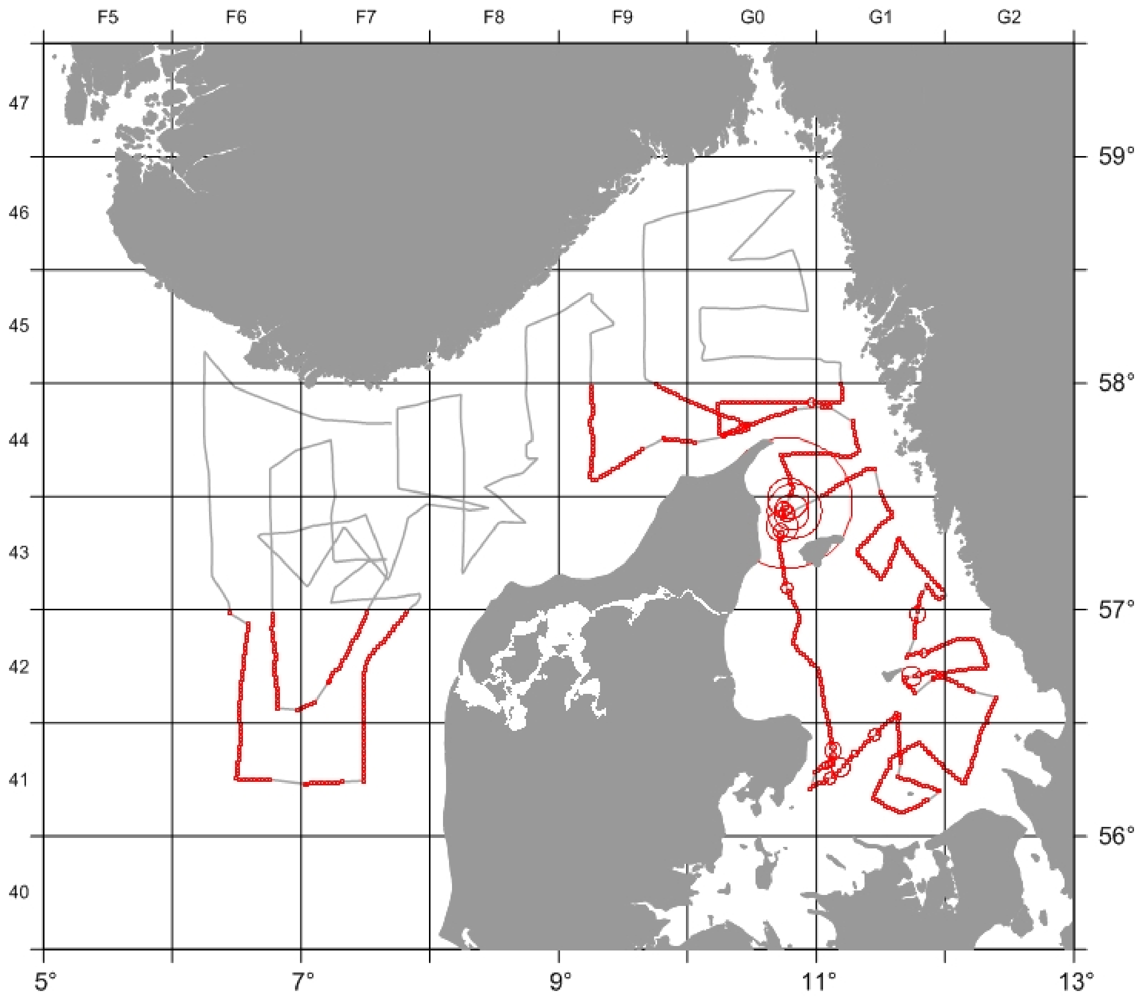

Figure 5.17. Relative sprat density (in numbers per nm²) along the track of the Danish survey with. Red circles indicate relative density of sprat per ESDU calculated as total abundance in the square splitted by the total NASCs.

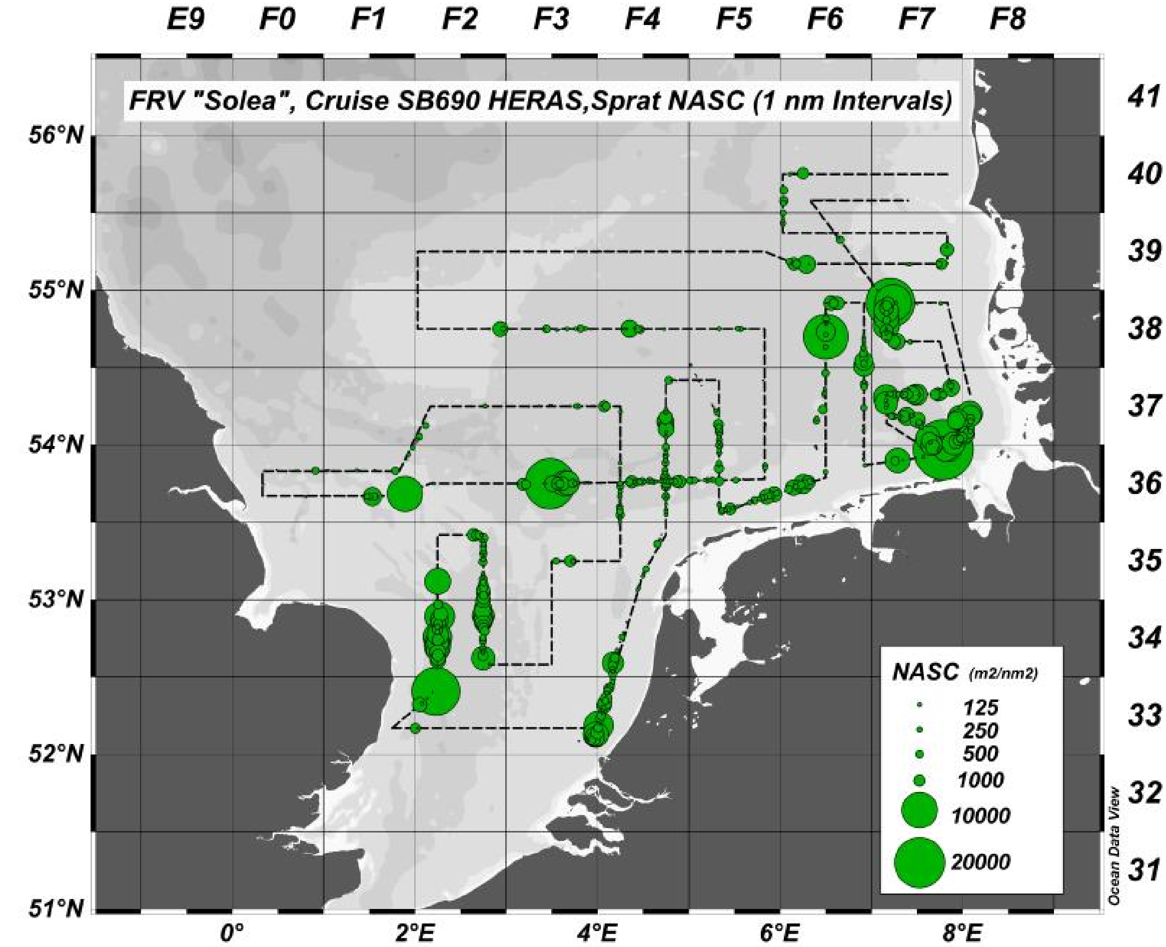

Figure 5.18. NASCs attributed to sprat from the German survey. It is not possible to disentangle clupeid target strength by species. Thus the NASCs are split according to the percentages by species and according scattering properties (length based) as obtained from the trawl hauls.

Annex 5d:Coordinated Nordic Seas ecosystem survey (IESSNS)

Working Document to:

ICES Working Group on Widely distributed Stocks (WGWIDE), ICES Headquarters, Copenhagen, Denmark, 26 August – 1 September 2014
and

ICES Working Group on International Pelagic Surveys (WGIPS), ICES Headquarters, Copenhagen, Denmark, 19 – 23 January 2015

Cruise report from the coordinated ecosystem survey (IESSNS) with M/V ”Brennholm”, M/V “Vendla”, M/V “Finnur Fríði” and RV “Árni Friðriksson” in the Norwegian Sea and surrounding waters, 2 July – 12 August 2014

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Abstract

The international coordinated ecosystem survey in the Norwegian Sea and adjacent areas (IESSNS) was performed during 2 July to 12 August 2014 on four vessels from Norway (2), Iceland (1) and Faroes (1). Greenland leased the Icelandic vessel for 12 days to cover the East Greenland area. A standardized pelagic trawl swept-area method was used to estimate abundance of NEA mackerel in the Nordic Seas in recent years.

One of the main objectives of the IESSNS is to provide reliable and consistent age-disaggregated abundance indices of NEA mackerel. The WKPELA meeting held at ICES in Copenhagen in February 2014 benchmarked the assessment of mackerel in the Northeast Atlantic (ICES, 2014c). It was agreed during the meeting to include age-disaggregated indices for age-group 6+ scaled by the coverage each year from the IESSNS into the assessment.

The total swept-area estimate of NEA mackerel in summer 2014 was 9.0 million tonnes distributed over an area of 2.45 million square kilometres in the Nordic Seas from about 58°30'N up to 76°10'N and from 22°E on the Norwegian coast to 43°W in the Irminger Sea south of Cape Farewell in Greenland waters. The 2011-year class contributed with 32.0% in number followed by the 2010-year class with 21.1%. The 2007, 2008 and 2009 year classes contributed then to around 11% each. Altogether 66.2% of the estimated number of mackerel was less than 6 years old. The internal consistency plot for age-disaggregated year classes has greatly improved since 2013 especially for younger year classes. There is now good internal consistency between year classes 1–10 years old, except between the less abundant 5 and 6 year old. The improved consistency in younger year classes for NEA mackerel in the IESSNS survey should be taken into consideration by ICES, specifically by including also younger mackerel 1–5 years of age, and not only age 6+ mackerel, into the tuning series as input on abundance of NEA mackerel to the assessment.

Mackerel was observed in most of the surveyed area, and the zero boundaries were found in most areas, except in the southwestern border of the East Greenland zone. Approximately 8% of the mature mackerel sampled during the survey had not yet spawned based on maturity on each trawl haul and all the vessels.

The geographical coverage and survey effort was 2.45 million km^2 in 2014 which was very similar to 2013 (2.41 million km^2). The area coverage in 2013 and 2014 is larger than previous years mapping from 2007 to 2012.

Norwegian spring-spawning (NSS) herring was measured acoustically during the survey and the total biomass came to 4.6 million tonnes. The 2004 and 2005 year classes were most abundant in the survey. The NSS herring was mainly found in the southwestern and western part of the Norwegian Sea; i.e. from north of the Faroe Islands and to the east and north off Iceland. Small concentrations were found in the northern and eastern areas, while herring was mostly absent in the mid Norwegian Sea. The biomass estimate is considerably lower than from the 2013 survey (8.6 million tonnes). This is partly due to insufficient coverage north of Iceland and west of Jan Mayen, and partly due to the very shallow distribution in the Jan Mayen area, with apparently large proportions of NSS herring being in the acoustic dead zone above the transducers.

The spatio-temporal overlap between NEA mackerel and NSS herring in July-August 2014 was highest in the southern and southwestern part of the Norwegian Sea. Herring was most densely aggregated in areas where zooplankton concentrations where high.

Mackerel, on the other hand, was found in most of the surveyed area, and in areas with varying zooplankton concentrations.

No deep trawl hauls were taken on acoustic registrations of blue whiting, and acoustic registrations deeper than 200 m were not scrutinized in part of the survey area in 2014. Thus the results of the survey can neither be used to quantify nor map the distribution of blue whiting in the Nordic Seas in summer 2014.

The surface temperatures in the Nordic Seas in July-August 2014 were generally higher in all areas compared to July-August 2013. The SST anomaly map showed considerably higher average surface temperatures in July 2014 or 1–3°C higher compared to the average temperature in July during the last 20 years. This is thought to be due to the unusual calm weather conditions during this summer.

The average concentration of zooplankton in the Nordic Seas in July-August 2014 was at the same level as in 2013, 8.3 g/m² and 8.6 g/m², respectively. However, in the western areas, i.e. west of 14 degrees west (Iceland and East Greenland areas), the zooplankton biomass was markedly lower in 2014.

Whale observations were done by the two Norwegian vessels during the survey. The number of marine mammal sightings was generally very low in the central and eastern part of the Norwegian Sea but considerably larger numbers, especially of fin whales, were observed in the northern Norwegian Sea and into the Barents Sea. Many groups of killer whales were observed in central and northern Norwegian Sea feeding on mackerel, whereas fin whales where mainly observed near Jan Mayen, Bear Island and the southwestern part of the Barents Sea and off the coast of Finnmark.

All vessels that participated in the IESSNS 2014 used the same pelagic sampling trawl design (Multpelt 832) and followed the protocol agreed upon in Hirtshals in February 2013 for both rigging and operation (ICES 2013). Systematic underwater video recordings of mackerel swimming behaviour in relation to the catching process were also conducted. Results from those exercises are not available yet.

Introduction

In July-August 2014, four vessels; the chartered trawler/purse-seiners M/V "Brennholm" and M/V "Vendla" from Norway, and M/V "Finnur Fríði" from Faroe Islands, and the research vessel RV "Arni Friðriksson" from Iceland, participated in the joint ecosystem survey (IESSNS) in the Norwegian Sea and surrounding waters. The five weeks coordinated survey from 2 July to 11 August 2014 is part of a long-term project to collect updated and relevant data on abundance, distribution, aggregation, migration and ecology of Northeast Atlantic mackerel and other major pelagic species. Major aims of the survey were to quantify abundance, spatio-temporal distribution, aggregation and feeding ecology of Northeast Atlantic mackerel in relation to distribution of other pelagic fish species such as Norwegian spring-spawning herring, oceanographic conditions and prey communities. Whale observations were conducted on the Norwegian vessels in order to collect data on distribution and aggregation of marine mammals in relation to potential prey species and the physical environment. The pelagic trawl survey was initiated by Norway in the Norwegian Sea at the beginning of the 1990's. Faroe Islands and Iceland have been participating on the joint mackerel-ecosystem survey since 2009, but the Icelandic survey results for 2009 were not included in a joint cruise report that year.

The main objective of the IESSNS survey in relation to quantitative assessment purposes is to provide reliable and consistent age-disaggregated abundance indices of NEA mackerel. WKPELA meeting was held in ICES HQ in Copenhagen from the 21–27 February 2014, to benchmark the assessment of mackerel in the Northeast Atlantic. In the case of NEA mackerel the previous assessment was not considered to give a reliable estimate of the development of the stock, and this assessment was limited by lack of independent age-structured indices. There was an agreement during the benchmark meeting to include age-structured indices on adults from the IESSNS swept-area trawl survey. It was decided that an age-disaggregated time-series for analytical assessment should be restricted to adult mackerel at age 6 years and older for the years 2007, 2010–2013. We furthermore aim to extend the existing time-series with annual updates from 2014 on abundance indices from the IESSNS swept-area trawl survey as input to the analytical assessment on NEA mackerel. Based on results on coefficient of correlation from updated internal consistency plots in the age-disaggregated data between year classes when extending the time-series, we will test whether younger year classes (2, 3, 4 and 5 year olds) can be included in the age-disaggregated time-series from the IESSNS survey.

It must be noted that even if the IESSNS covers the spatial distribution of blue whiting adequately no dedicated deep trawl hauls were taken on likely acoustic registrations of blue whiting and acoustic registrations deeper than 200m were not scrutinized in part of the survey area. Thus the results of the survey can neither be used to quantify nor map the distribution of blue whiting in the Nordic Seas in summer 2014.

Material and methods

Coordination of the survey was done by correspondence during spring and summer 2013 and in relation to the international ICES WKNAMMM workshop in February 2013 in Hirtshals, Denmark and input and recommendations from the mackerel benchmark in February 2014 (ICES, 2014c). The participating vessels together with their effective survey periods are listed in Table 1.

In general, the weather conditions were predominantly very calm with good survey conditions for the two Norwegian vessels “Brennholm” and “Vendla” related to oceanographic monitoring, plankton sampling, acoustic registrations and pelagic trawling. The same was the case with the Faroese chartered vessel “Finnur Fridi” experiencing very good weather conditions in Faroese waters. Although “Arni Fridriksson” experienced some bad weather in the northwestern part of the Iceland at the beginning of the survey, and a few days in Greenland waters at the end of the survey the weather conditions did not affect the quality to any extent of the various scientific data collection during the survey for the involved survey vessels. Only a few plankton stations could not be taken due to bad weather.

During this year’s survey the special designed pelagic trawl, Multpelt 832, was used by all four participating vessels for the third consecutive year. This trawl is a product of a cooperation of participating institutes in designing and construction of a standardized sampling trawl for this survey in future for all participants. The work lead by trawl gear scientist John Willy Valdemarsen, Institute of Marine Research (IMR), Bergen, Norway, has been in good progress for four years. The design of the trawl was finalized during meetings of fishing gear experts and skippers at meetings in January and May 2011. Further discussions on modifications in standardization between the rigging and operation of Multpelt 832 was done during a trawl expert meeting in Copenhagen 17–18 August 2012, in parallel with the post-cruise meeting for the joint ecosystem survey, and then at the WKNAMMM workshop and tank experiments on a prototype (1:32) of the Multpelt 832 pelagic trawl, conducted as a sequence of trials in Hirtshals, Denmark from 26 to 28 February 2013 (ICES, 2013). The standardization and quantification of catchability from the Multpelt 832 pelagic trawl was further discussed during the mackerel benchmark in Copenhagen in February 2014. Recommendations and requests coming out of the mackerel benchmark have further been implemented and improved on all the four vessels involved during the IESSNS survey in July-August 2014.

Table 1. Survey effort by each of the four vessels in the July-August survey in 2014.

Vessel	Effective survey period	Length of cruise track (nmi)	Trawl stations	CTD stations	Plankton stations
Arni Friðriksson	11/7–12/8	6080	117	117	108
Finnur Fríði	10/7- 21/7	2247	33	33	32
Brennholm	2/7–28/7	4283	77	77	77
Vendla	2/7–28/7	3462	55	54	55
Total	2/7–12/8	16072	282	281	272

Hydrography and Zooplankton

The hydrographical and plankton stations by all vessels combined are shown in Figure 2. Arni Fridriksson was equipped with a SEABIRD CTD sensor with a water rosette that was applied during the entire cruise. Finnur Fríði was equipped with a mini SEABIRD SBE 25+ CTD sensor, and Brennholm and Vendla were equipped with a SAIV SD200 CTD sensor, recording temperature, salinity and pressure (depth) from the surface down to 500 m, or when applicable as linked to maximum bottom depth.

All vessels collected and recorded also oceanographic data from the surface either applying a thermosalinograph (temperature and salinity) placed at approximately 6 m depth underneath the surface or a thermograph logging temperatures continuously near the surface throughout the survey.

Zooplankton was sampled with a WP2-net on all vessels. Mesh sizes were 180 µm (Brennholm and Vendla) and 200 µm (Arni Fridriksson and Finnur Fríði). The net was hauled vertically from a depth of 200 m (or bottom depth at shallower stations) to the surface at a speed of 0.5 m/s. All samples were split in two, one half preserved for species identification and enumeration, and the other half dried and weighed. Detailed description of the zooplankton and CTD sampling is provided in the survey manual (ICES, 2014b).

The number of stations taken by the different vessels is provided in Table 1. The smaller number of plankton stations in comparison to the trawl and CTD stations (e.g. on Árni Friðriksson) is usually due to bad weather preventing plankton sampling.

Trawl sampling

Trawl catches were sorted and weighed; fish were identified to species level, when possible, and other taxa to higher taxonomic levels. The full biological sampling at each trawl station varied between nations and is presented in Table 2. On Finnur Fríði, trawl hauls were subsampled, 100 kg to 300 kg, and the same sample processing protocol follow as used on the other three vessels. Smaller subsample (approximately 100 kg) was taken when either mackerel or herring was visible in catch but if both species were in catch a large subsample is taken (300 kg).

Table 2. Summary of biological sampling in the survey from 2 July to 11 August 2014 by the four participating countries. Numbers denote the maximum number of individuals sampled for each species for the different determinations.

	Species	Faroes	Iceland	Norway
Length measurements	Mackerel	100*	100	100
	Herring	100*	200	100
	Blue whiting	100*	100	100
	Other fish sp.	0	50	25
Weighed, sexed and maturity determination	Mackerel	15	50	25
	Herring	15	50	25
	Blue whiting	15	50	25
	Other fish sp.	10	10*	0
Otoliths/scales collected	Mackerel	15	25	25
	Herring	15	50	25
	Blue whiting	50	50	25
	Other fish sp.	0	0	0
Stomach sampling	Mackerel	10	10	10
	Herring	10	10	10
	Blue whiting	10	10	10
	Other fish sp.	0	0	10*
Tissue for genotyping	Mackerel	210	400	1125

*are also weighted.

All vessels used the Multpelt 832 pelagic trawl aimed for further strict standardization of fishing gear used in the survey (see ICES, 2013; ICES, 2014c). Standardization and documentation/quantification on effective trawl width, trawl depth and catch efficiency was improved according to requests during the mackerel benchmark (ICES, 2014c). The most important properties of the Multpelt 832 trawls during the survey and their operation were as shown in Table 3.

Table 3. Trawl settings and operation details during the international mackerel survey in the Nordic Seas in July-August 2014. The column for influence indicates observed differences between vessels likely to influence performance. Influence is categorized as 0 (no influence) and + (some influence).

Properties	Brennholm	Arni Fridriksson	Vendla	Finnur Fríði	Influence
Trawl producer	Egersund Trawl AS	Tornet/Hampiðjan (50:50)	Egersund Trawl AS	Vónin	0
Warp in front of doors	Dyneema – 32 mm	Dynex-34 mm	Dyneema -32 mm	Dynex – 34mm	+
Warp length during towing	350 m	350 m	350 m	350 m	0
Difference in warp length port/starboard	0–4 m	3–12 m	0–4 m	5–12 m	0
Weight at the lower wing ends	400 kg	400 kg	300 kg	400 kg	0
Setback in metres	6 m	6 m	6 m	6 m	+
Type of trawl door	Seaflex adjustable hatches	Jupiter	Seaflex adjustable hatches	Injector F-15	0
Weight of traw door	2000 kg	2200 kg	1700 kg	2000 kg	+
Area trawl door	9 m^2 75% hatches (effective 6.5m^2)	7 m^2	7.5 m^2 25% hatches (effective 6.5m^2)	6 m2	+
Towing speed (GPS) in knots	4.8 (4.5–5.2)	5.0 (4.5–5.5)	4.8 (4.5–5.2)	4.9 (4.1–5.1)	+
Trawl height	28–35	27–30	29–35	~ 35	+
Door distance	110–117 m	110–114 m	110–117 m	105–110	+
Trawl width*	-	-	-	-	+
Turn radius	5–8 degrees turn	5–10 degrees turn	5–8 degrees turn	5–10 degrees turn	+
A fish lock in front end of codend	Yes	Yes	Yes	Yes	+
Trawl door depth (port and starboard)	5–15, 7–17 m	8–13, 10–15 m	5–15, 8–18 m	5–15 m	+
Headline depth	0–1 m	0–1 m	0–1 m	0–1 m	+
Float arrangements on the headline	Kite +2 buoys on each wing	Kite + 2 buoys on wings	Kite + 2 buoys on each wingtip	Kite + 2 buoys on wings and 1 in middle	+
Weighing of catch	All weighted	All weighted	All weighted	All weighted	+

Marine mammal observations

Observations of marine mammals were conducted by trained scientific personnel and crew members from the bridge between 2nd and 28th of July 2014 onboard the Norwegian chartered vessels M/V “Brennholm” and M/V “Vendla” respectively. The priority periods of observing were during the transport stretches from one trawl station to another. Observations were done 24 h per day if the visibility was sufficient for marine mammal sightings. Digital filming and photos were taken whenever possible on each registration from scientists onboard.

Underwater camera observations during trawling

All vessels employed an underwater video camera (GoPro HD Hero 3 Black Edition, www.gopro.com) or high definition Sony camera in the trawl to observe mackerel behaviour during trawling. The camera was put in a waterproof box which tolerated pressure to 40 m or 60 m, and mounted on a small steel frame (approximately 20 cm by 30 cm, weight < 1 kg) with protective bars preventing entanglement of camera in trawl (see Photo 1 and 2). The small and light frame enabled camera employment at many different locations in trawl. The camera was employed inside (except at one station) the trawl where the steel frame was tied to trawl using a rope. It proved a quick and secure method of attaching frame to trawl.

The goal video recordings was to observe and assess: if the fish lock successfully prevents mackerel/herring from escaping the codend when effective trawl time ends and speed slows below 5 nmi, and escapement of mackerel/herring at meshes from 16 m to 8 cm (Table 9). No light source was employed with camera, hence, recordings were limited to day light hours. Video recordings were collected at 30% of trawl stations from eleven different locations in the trawl.

Photo 1. GoPro camera inside a waterproof box, mounted on steel frame and ready for employment in trawl on Finnur Fríði.

Photo 2. GoPro camera attached to inside of trawl by fish lock on Finnur Fríði. The steel frame was tied to trawl, at the each corner using a rope.

Acoustics

Multifrequency echosounder

The acoustic equipment onboard Brennholm and Vendla were calibrated 30th of June and 1st of July 2014 for 18, 38, 70, 120, 200 and 333 kHz. Arni Fridriksson was also calibrated on 31st of March 2014 for all frequencies 18, 38, 120 and 200 kHz, whereas Finnur Fridi was calibrated on 9th July 2014 for 38, 120 and 200 kHz prior to the cruise. All vessels used standard hydroacoustic calibration procedure for each operating frequency (Foote, 1987). CTD measurements were taken in order to get the correct sound velocity as input to the echosounder calibration settings.

Generally, acoustic recordings were scrutinized on daily basis using the software LSSS onboard Vendla, Brennholm and Arni Fridriksson, and Echoview onboard Finnur Friði. Species were 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.

The survey was based on scientific echosounders using 38 kHz frequency as the main frequency for the abundance estimate. Also 200 kHz was used as frequency for acoustic registrations of NEA mackerel. A summary of acoustic settings is given in Table 4.

Acoustic estimates of herring and blue whiting abundance were obtained during the surveys in a same way as e.g. done in the International ecosystem survey in the Nordic Seas in May (ICES, 2014a) and detailed in the manual for the surveys (ICES, 2014b).

Table 4. Acoustic instruments and settings for the primary frequency in the July/August survey in 2014.

	M/V Brennholm	RV Arni Friðriksson	M/V Vendla	M/V Finnur Friði
Echosounder	Simrad EK60	Simrad EK 60	Simrad EK 60	Simrad EK 60
Frequency (kHz)	18, 38, 70, 120, 200	18, 38, 120, 200	18, 38, 70, 120, 200	38,120, 200
Primary transducer	ES38B	ES38B	ES38B	ES38B
Transducer installation	Drop keel	Drop keel	Drop keel	Hull
Transducer depth (m)	9	8	9	5
Upper integration limit (m)	15	15	15	12
Absorption coeff. (dB/km)	9.9	10	9.9	9.7
Pulse length (ms)	1.024	1.024	1.024	1.024
Bandwidth (kHz)	2.43	2.425	2.425	2.43
Transmitter power (W)	2000	2000	2000	2000
Angle sensitivity (dB)	21.9	21.9	21.9	21.9
2-way beam angle (dB)	-21.1	-20.9	-20.6	-20.7
TS Transducer gain (dB)	24.87	24.64	23.27	24.37
sA correction (dB)	-0.60	-0.84	-0.65	-0.63
alongship:	6.89	7.31	7.01	7.06
athw. ship:	6.87	6.95	7.11	7.16
Maximum range (m)	500	750	500	500
Post-processing software	LSSS	LSSS	LSSS	Sonardata Echoview 5.1

Multibeam sonar

M/V "Brennholm" and M/V "Vendla" were equipped with the Simrad fisheries sonars SX90 (frequency range: 111.5–115.5 kHz), with a scientific output incorporated which allow the storing of the beam data for post-processing. One of the objectives in this survey was to continue the test of the software module "Processing system for fisheries omnidirectional sonar, PROFOS" in LSSS at the Institute of Marine Research in Norway. The first test was done during the 2010 survey, and the basic processing was described in the cruise report (Nøttestad *et al.*, 2010). The PROFOS module is in a late development phase and for this survey, functionalities for school enhancement by image processing techniques and for automatic school detection have been incorporated (Nøttestad *et al.*, 2012; 2013).

Acoustic Doppler current profiler (ADCP)

M/V "Brennholm" are equipped with a scientific ADCP, RDI Ocean surveyor, operating at 75 kHz and/or 150 kHz. The data collected during the survey will be quality checked and used for later analysis.

Intercalibration of Multpelt 832 pelagic trawl

No intercalibration of the Multpelt 832 pelagic trawl was performed during the 2014 survey.

Cruise tracks

M/V "Brennholm", M/V "Vendla", M/V "Finnur Friði" and RV "Arni Fridriksson" followed predetermined survey lines with preselected pelagic trawl stations (Figure 1). An adaptive survey design was also adopted although to a small extent, due to uncertain geographical distribution of our main pelagic planktivorous schooling fish species. The cruising speed was between 10–12.0 knots if the weather permitted otherwise the cruising speed was adapted to the weather situation.

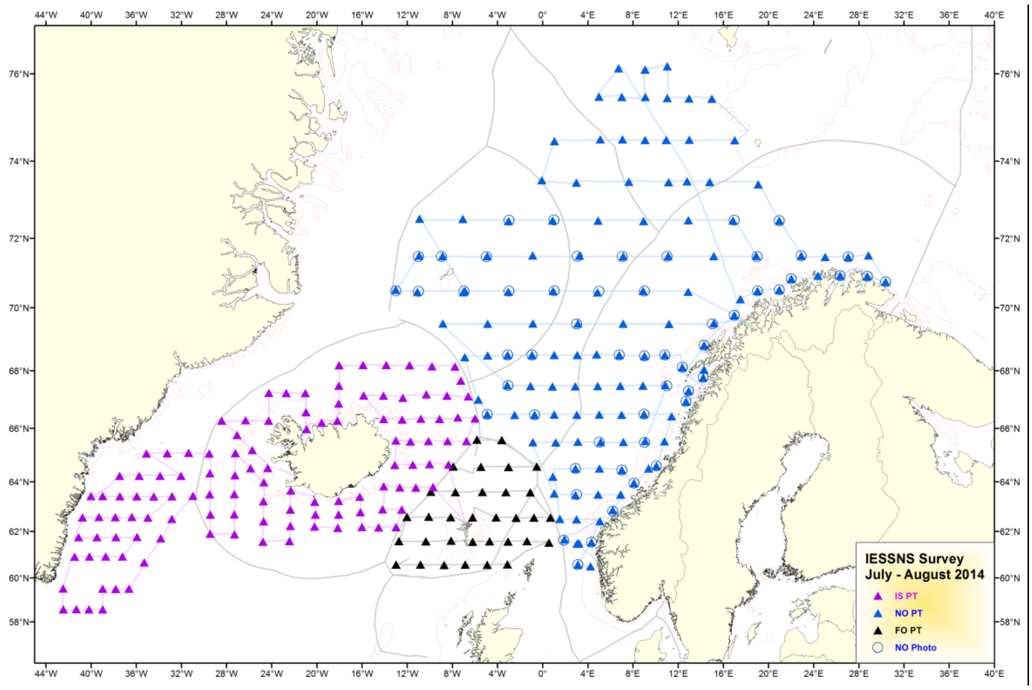


Figure 1. Cruise tracks and pelagic trawl stations shown for M/V "Brennholm" and "Vendla" (Norway) in blue, M/V "Finnur Friði" (Faroe Islands) in black and RV "Arni Fridriksson" (Iceland/Greenland) in purple within the covered areas of the Norwegian Sea and surrounding waters from 2 July to 11 August 2014.

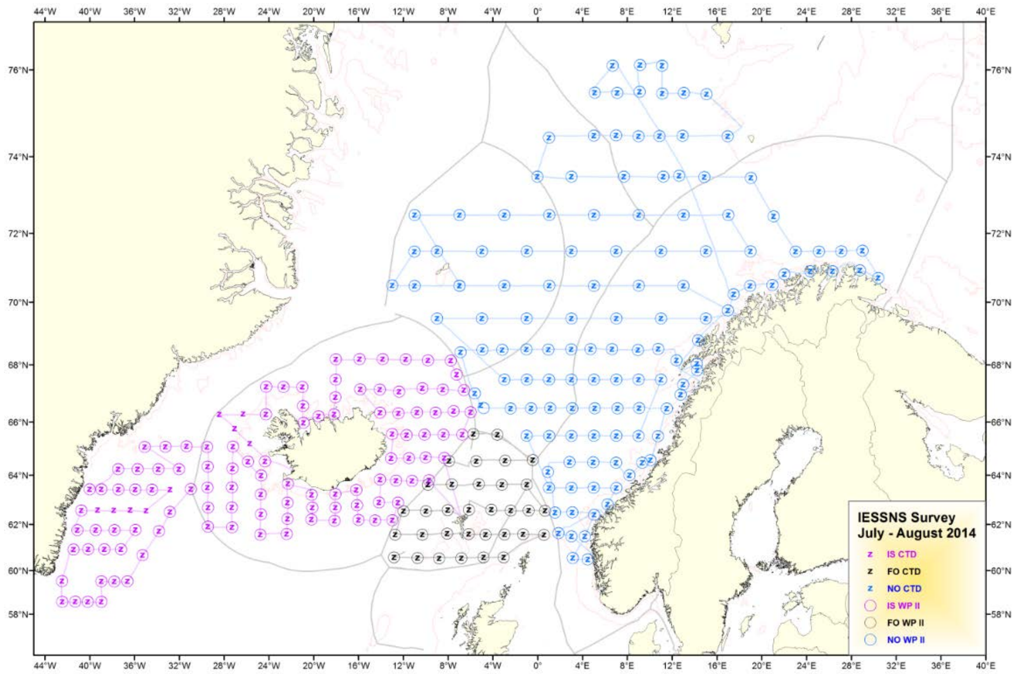


Figure 2. CTD stations (0–500 m) using SEABIRD SBE 37 (Arni Fridriksson) SEABIRD SB 25+ (Finnur Friði) and SAIV SD200 (Brennholm and Vendla) CTD sensors and WP2 plankton net samples (0–200 m depth). These were taken systematically on every pelagic trawl station on all four vessels

Swept-area index and biomass estimation

The swept-area estimate is based on catches in the whole area covered in the survey, or between 58°N and 77°N and 43°W and 22°E. Rectangle dimensions were 1° latitude by 2° longitude as in the estimates from previous years. Allocation of the biomass to exclusive economic zones (EEZs) was done in the same way as in 2010–2013 (see Annex 1).

In order to calculate a swept-area estimate, the horizontal width of the trawl opening is required. It is assumed that no mackerel is distributed below the groundrope (vertical opening of the trawl). Average trawl door spread, vertical trawl opening and tow speed were sampled on each vessel for all stations. Two different kinds of data are available, manually reported values from logbooks (one value per station) and digitally recorded data from trawl sensors. The digitally recorded data were analysed as follows: Average door spread and vertical opening were calculated for each station, then the average values per station were used to calculate mean, maximum (max), minimum (min) and standard deviation (st.dev.) for each vessel. Horizontal opening of the trawl was calculated by a formula using average values of trawl door horizontal spread and tow speed for each vessel. The results of the measurements and estimations for the four vessels are given in Table 5. Based on these results average horizontal trawl opening used in the swept-area calculations was set at the following vessel specific values given as 'Horizontal trawl opening (m)' in Table 5.

Table 5. Descriptive statistics for trawl door spread, vertical trawl opening and tow speed for each vessel. Two different kinds of data were analysed, manually reported values from logbooks (one value per station) and digitally recorded data from trawl sensors (*). Digitally recorded data were filtered prior to calculations; for trawl door spread all values < 80 m and > 140 m were deleted, and for opening vertical spread all values < 20 m and > 50 were deleted. Next, average door spread and vertical opening was calculated for each station, then the average values per station were used to calculate overall mean, maximum (max), minimum (min) and standard deviation (st.dev.) for each vessel. Number of trawl stations used in calculations is also reported. For Árni Friðriksson, trawl door spread is reported both for logbook data and digital trawl sensor data (*). Horizontal trawl opening (**) was calculated using average vessel values for trawl door spread and tow speed (details in Table 6).

	Finnur Fríði	RV Árni Friðriksson		Brennholm	Vendla
Trawl doors horizontal spread (m)					
Number of stations	31*	44*	110	76	56
mean	109*	113*	113	117	117
max	116*	118 *	120	133	127
min	102*	102*	97	100	110
st. dev.	3*	3*	3	4	4
Vertical trawl opening (m)					
Number of stations	27*	110		77	56
mean	35*	31		33	33
max	43*	38		40	41
min	27*	30		24	29
st. dev.	3*	2		2	5
Horizontal trawl opening (m) **					
mean	63	65		65	66
Speed (over ground, nmi)					
Number of stations	33	115		77	56
mean	5	5.0		4.7	4.8
max	5.5	5.4		5.7	6.0
min	4.6	4.5		4.0	4.2
st. dev.	0.2	0.2		0.2	0.2

Horizontal trawl opening was calculated using average vessel values for trawl door spread and tow speed (Table 6). The estimates in the formulae were based on a flume tank simulations in 2013 (Hirtshals, Denmark) where formulas were developed from the for the horizontal trawl opening as a function of door spread, for two towing speeds, 4.5 and 5 knots:

Towing speed 4.5 knots: Horizontal opening (m) = 0.441 * Doorspread (m) + 13.094

Towing speed 5.0 knots: Horizontal opening (m) = 0.3959 * Doorspread (m) + 20.094

Table 6. Horizontal trawl opening as a function of trawl door spread and towing speed. Relationship based on simulations of horizontal opening of the Multpelt 832 trawl towed at 4.5 and 5 knots, representing the speed range in the 2014 survey, for various door spread. See text for details.

Door	Towing speed (knots)					
spread (m)	4.5	4.6	4.7	4.8	4.9	5
100	57.2	57.7	58.2	58.7	59.2	59.7
101	57.6	58.1	58.6	59.1	59.6	60.1
102	58.1	58.6	59.0	59.5	60.0	60.5
103	58.5	59.0	59.5	59.9	60.4	60.9
104	59.0	59.4	59.9	60.3	60.8	61.3
105	59.4	59.9	60.3	60.8	61.2	61.7
106	59.8	60.3	60.7	61.2	61.6	62.1
107	60.3	60.7	61.2	61.6	62.0	62.5
108	60.7	61.1	61.6	62.0	62.4	62.9
109	61.2	61.6	62.0	62.4	62.8	63.2
110	61.6	62.0	62.4	62.8	63.2	63.6
111	62.0	62.4	62.8	63.2	63.6	64.0
112	62.5	62.9	63.3	63.7	64.0	64.4
113	62.9	63.3	63.7	64.1	64.4	64.8
114	63.4	63.7	64.1	64.5	64.9	65.2
115	63.8	64.2	64.5	64.9	65.3	65.6
116	64.3	64.6	65.0	65.3	65.7	66.0
117	64.7	65.0	65.4	65.7	66.1	66.4
118	65.1	65.5	65.8	66.1	66.5	66.8
119	65.6	65.9	66.2	66.6	66.9	67.2
120	66.0	66.3	66.6	67.0	67.3	67.6

Results

Hydrography

The surface layer in the northeastern part of the North Atlantic was warm in July 2014, as seen from the SST anomaly (one week in mid July 2014 relative to a 20 year average, Figure 3). The SST was more than 3°C warmer north of Iceland and between 2–2.5°C warmer in the central Norwegian Sea. This is in contrast to 2013 when the surface layer was close to the long-term average (Figure 4). The anomaly pattern in 2014 resembles that of 2012 with the exception that in 2012 the Irminger Sea was considerably (more than 3°C) warmer than the average.

It must be mentioned that the NOAA sea surface temperature measurements (SST) are sensitive to the weather condition (i.e. wind and cloudiness) prior to and during the observations and do therefore not necessarily reflect the oceanographic condition of the water masses in the areas, as seen when comparing detailed features of SSTs between years (Figures 3 and 4). However, since the anomaly is now based on averages values over whole July, it should give representative results of the surface temperature.

The upper layer (< 20 m depth) in the southern and mid area surveyed, i.e. from East Greenland extending to the Norwegian coast, was 1–2°C warmer in 2014 compared to

2013 (Figures 5–6). In the northern part of the surveyed area (Jan Mayen towards the northern Norwegian coast) the temperatures was at the 2013 level (Figures 5–6). One exceptional feature of the upper layer in 2014 is the very low signal of the cold East Icelandic Current (EIC) north of Iceland. The usual cool water of the EIC originating in the East Greenland Current (EGC) extending in a southeasterly direction was very weak (Figures 5–6). The temperature was up to 2°C warmer in the surface portion of the EIC in 2014 compared to 2013. The temperature distribution at 50 m depth was similar to the surface layers but with cooler water (Figure 7).

In the deeper layers (below 100 m depth), however, the hydrographic features in the area were similar to those in 2013, with a very clear signal of the EIC extending progressively farter eastwards with depth, towards the Norwegian coast at 400 m depth (Figures 8–10).

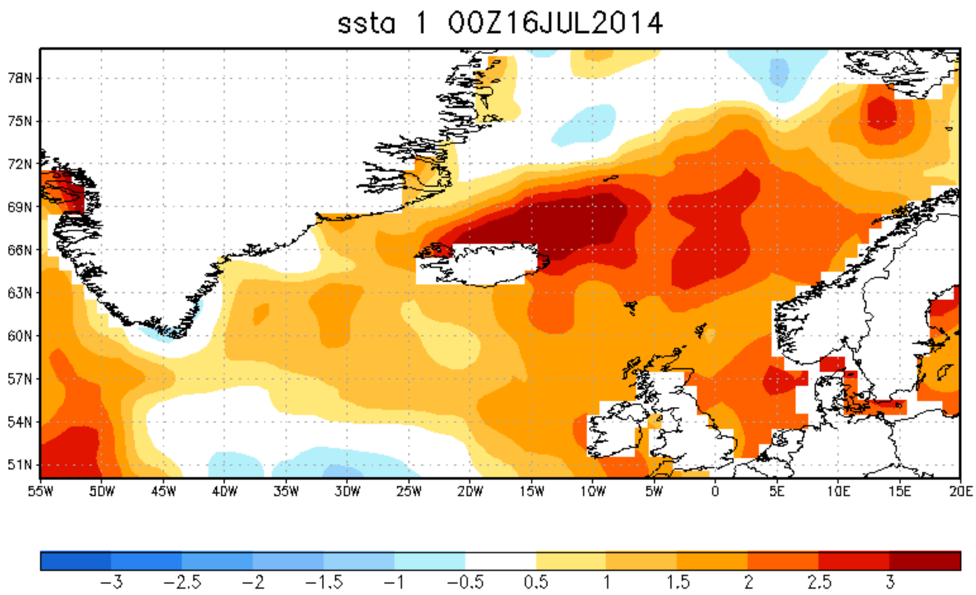


Figure 3. Sea surface temperature anomaly in July (°C; centered for mid July 2014) showing warm and cold conditions in comparison to a 20 year average.

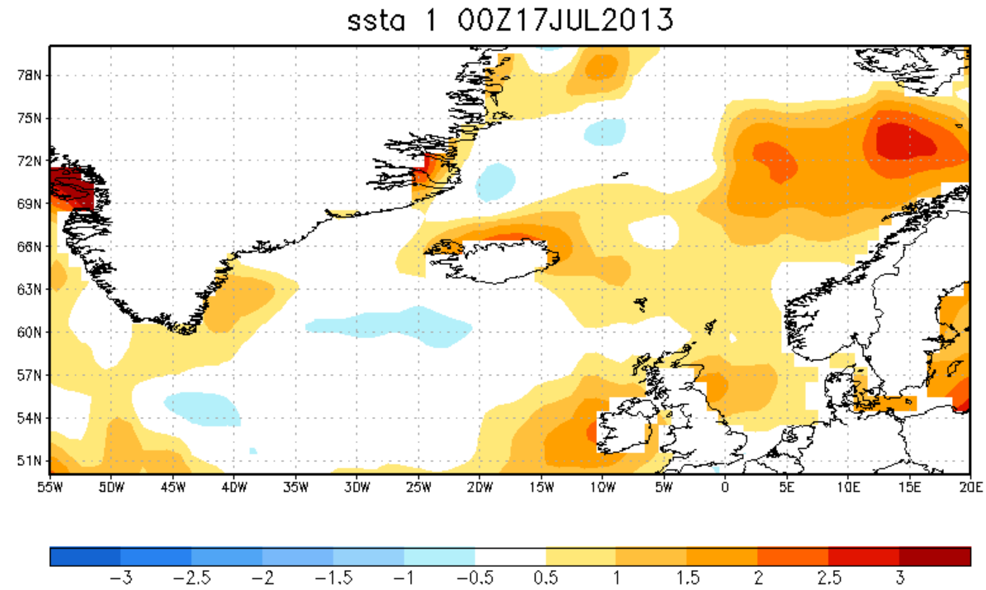


Figure 4. Sea surface temperature anomaly in July (°C; centered for mid July 2013) showing warm and cold conditions in comparison to a 20 year average.

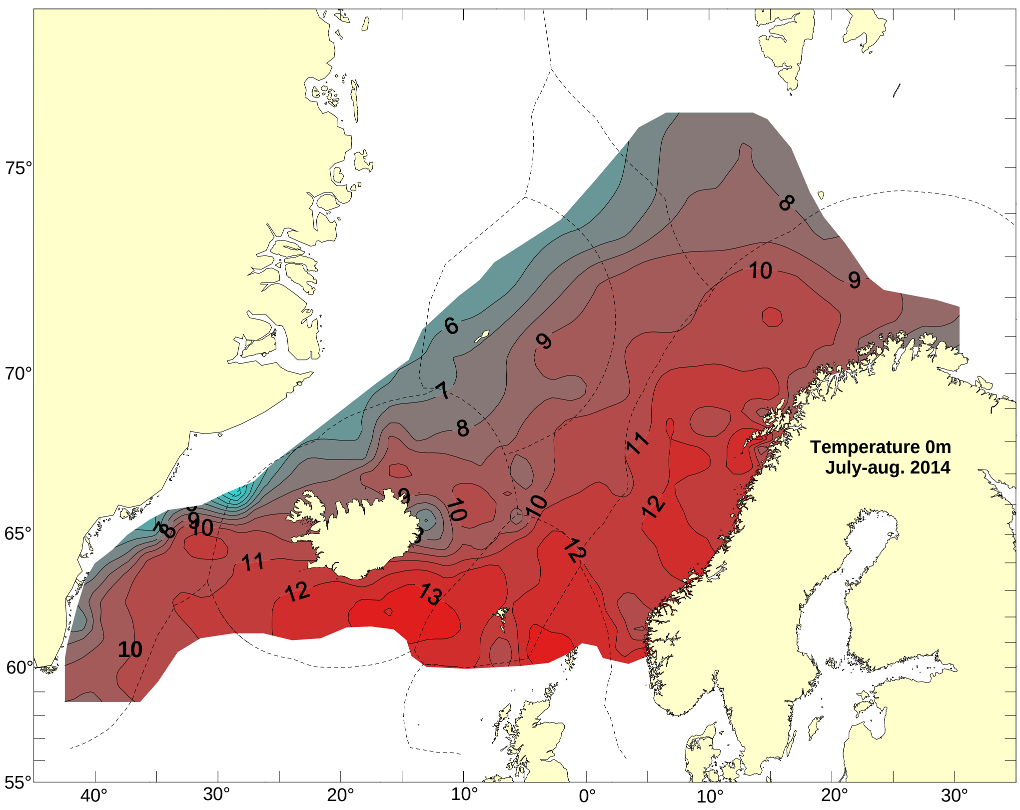


Figure 5. Temperature (°C) at 10 m depth in the Norwegian Sea and surrounding waters in July/August 2014.

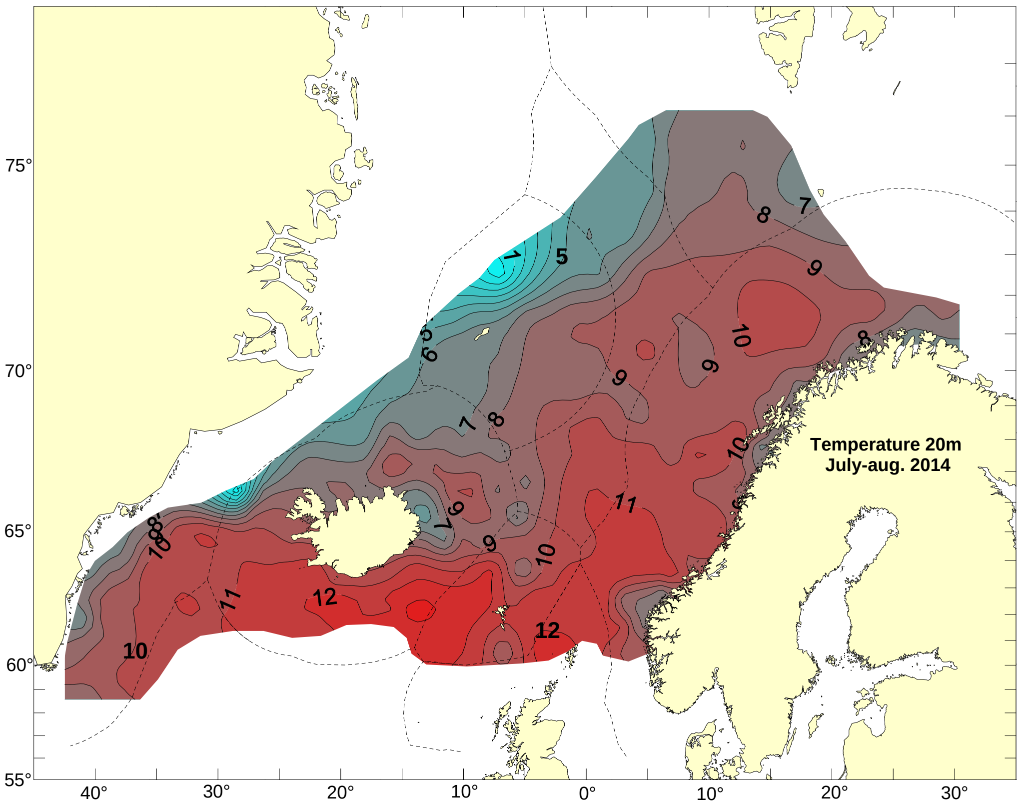


Figure 6. Temperature (°C) at 20 m depth in the Norwegian Sea and surrounding waters in July/August 2014.

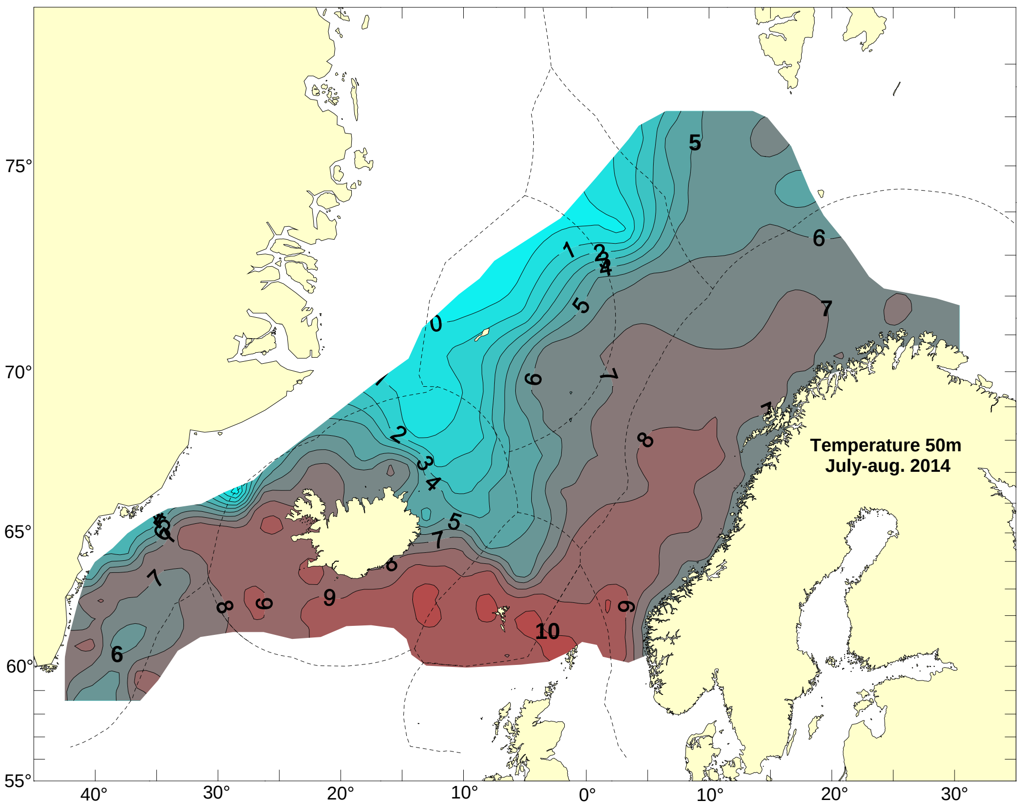


Figure 7. Temperature (°C) at 50 m depth in the Norwegian Sea and surrounding waters in July/August 2014.

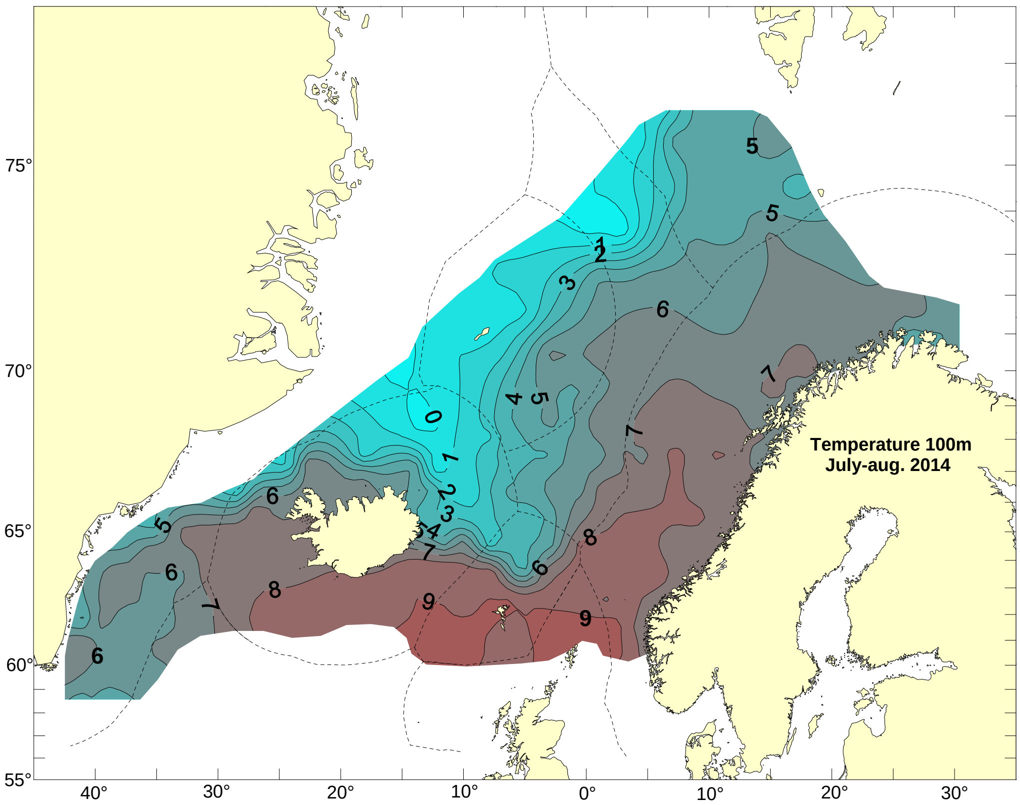


Figure 8. Temperature (°C) at 100 m depth in the Norwegian Sea and surrounding waters in July/August 2014.

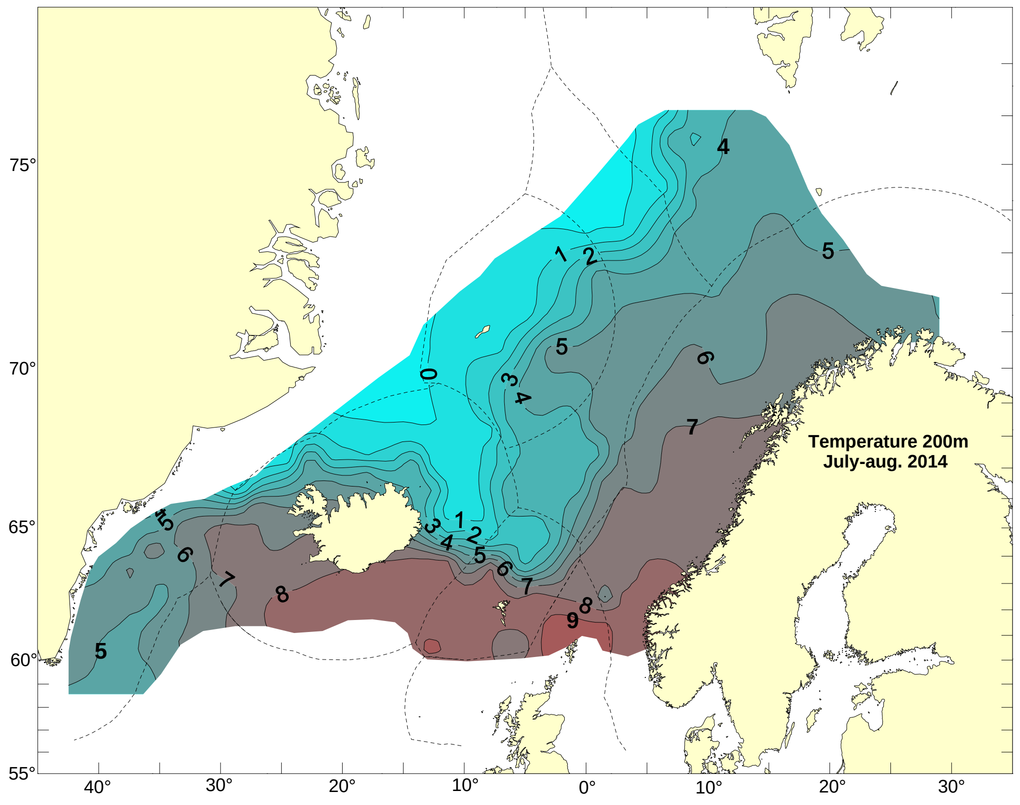


Figure 9. Temperature (°C) at 200 m depth in the Norwegian Sea and surrounding waters in July/August 2014.

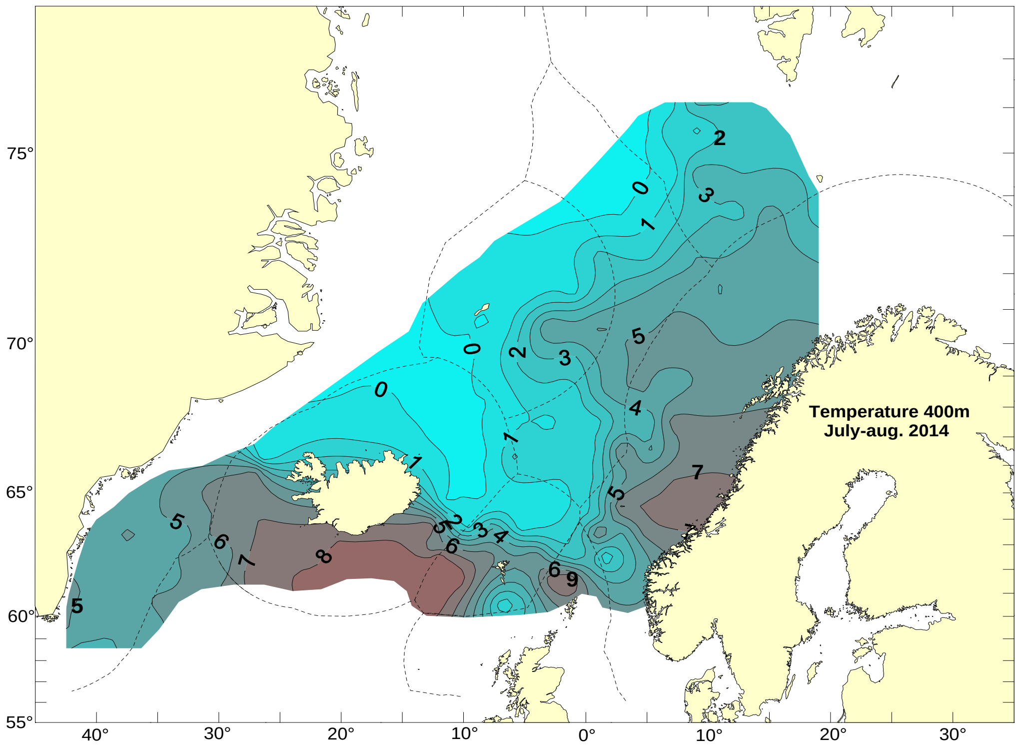


Figure 10. Temperature (°C) at 400 m depth in the Norwegian Sea and surrounding waters in July/August 2014.

Zooplankton

The average plankton biomass in the Norwegian Sea (north of 61°N and between 14°W and 17°E) in July-August was at the same level in 2014 as in 2013 or 8.4 g/m² and 8.2 g/m² respectively (Table 7). This is a substantial increase from 2012 when the average biomass was 6 g/m². The plankton concentrations were high in the northeastern part of the Icelandic area and the northern part of the Faroese area, as in 2013 (Figure 11). However, in 2014 the concentrations in the central part of the Norwegian Sea were higher than in 2013, as well as in the northeastern part (Svalbard area; Figure 11).

In 2014 the average zooplankton concentration the Icelandic area (between 14°W and 30°W) was only 4.8 g/ m², or only half of the biomass observed in 2013 (Table 7).

This year additional and extensive area in East Greenland waters was surveyed. The area was first surveyed in a limited area east of Greenland in 2013 (between 62–66°N). In 2014 this survey was expanded to cover the area from 65°30′ N to 58°30′ N. The average plankton biomass in this area was 13.8 g/m² in 2013 and only 5.3 g/ m² in 2014. This is considerably lower than last year, but the area covered in 2014 was extending much farther south in East Greenland waters, and therefore cannot be compared directly. The level in East Greenland waters is at the same levels as in the Icelandic area. Overall, the impression is that the concentration in the western part of the surveyed area is lower than last year.

The zooplankton samples for species identification have not been examined in detail.

The increased biomass of zooplankton in the Norwegian Sea is in agreement with the increase that has been observed in the zooplankton biomass in the area in the May survey from 2010 to 2014 (ICES, 2014a) after a decade with a decreasing trend in zooplankton biomass. These data need nevertheless to be treated with some care, due to various amounts of phytoplankton between years and areas in the samples influencing the total amount of zooplankton (g dry weight/m^2) which is relevant and valuable as available food for pelagic planktivorous fish.

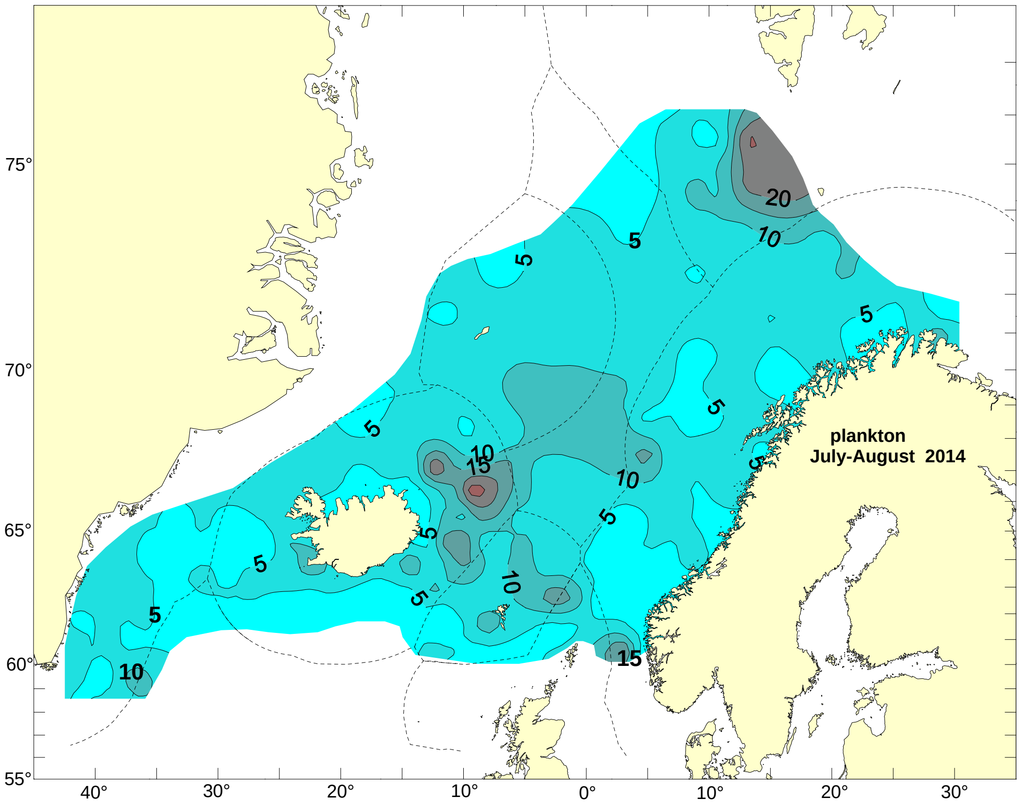


Figure 11. Zooplankton biomass (g dw/m^2, 0–200 m) in the Norwegian Sea and surrounding waters, 2 July -9 August 2014.

Table 7. The time-series of zooplankton dry weight in IESSNS during 2010 to 2014 for Norwegian Sea (between 17°E and 14°W and north of 61°N), Icelandic waters (between 14°W and 30°W) and Greenlandic waters (west of 30°W). The number of samples is given in parentheses.

	Dry weight of zooplankton (mg/m2)		
Year	Norwegian Sea	Icelandic waters	Greenlandic waters
2010	4911 (167)	9276 (8)*	
2011	4622 (110)	7058 (61)	
2012	6033 (134)	5926 (55)	10086 (2)
2013	8360 (163)	9990 (49)	13787 (14)
2014	8242 (167)	4834 (47)	5308 (33)

***No plankton samples on the Icelandic vessel, only by Norwegian vessel north off Iceland.**

Pelagic fish species

Mackerel

The total mackerel catches (kg) taken during the joint mackerel-ecosystem survey with the Multpelt 832 quantitative sampling trawl is presented in standardized rectangles in Figure 12. The map is showing different concentrations of mackerel from zero catch to more than 5000 kg.

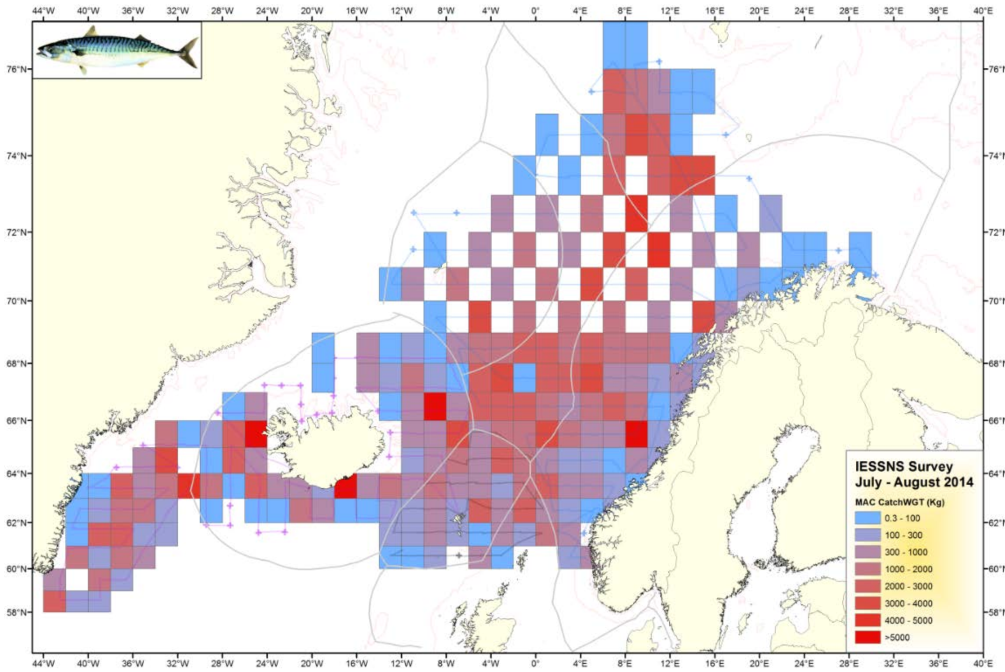


Figure 12. Catches of mackerel in kg represented in standardized rectangles. Light blue represents small catches (0.3–100 kg), while dark red represents catches of more than 5000 kg mackerel after 30 min standardized towing with the Multpelt 832 pelagic trawl. Vessel tracks are shown as continuous lines. Trawl stations are marked as small crosses for each vessel. Empty rectangles surrounded by three or more were interpolated in the calculations on biomass/abundance and density indices.

The length distribution of NEA mackerel during the joint ecosystem survey showed a pronounced length- dependent distribution pattern both with regard to latitude and longitude. The largest mackerel were found in the northernmost and westernmost part of the covered area in July-August 2014 (Figure 13).

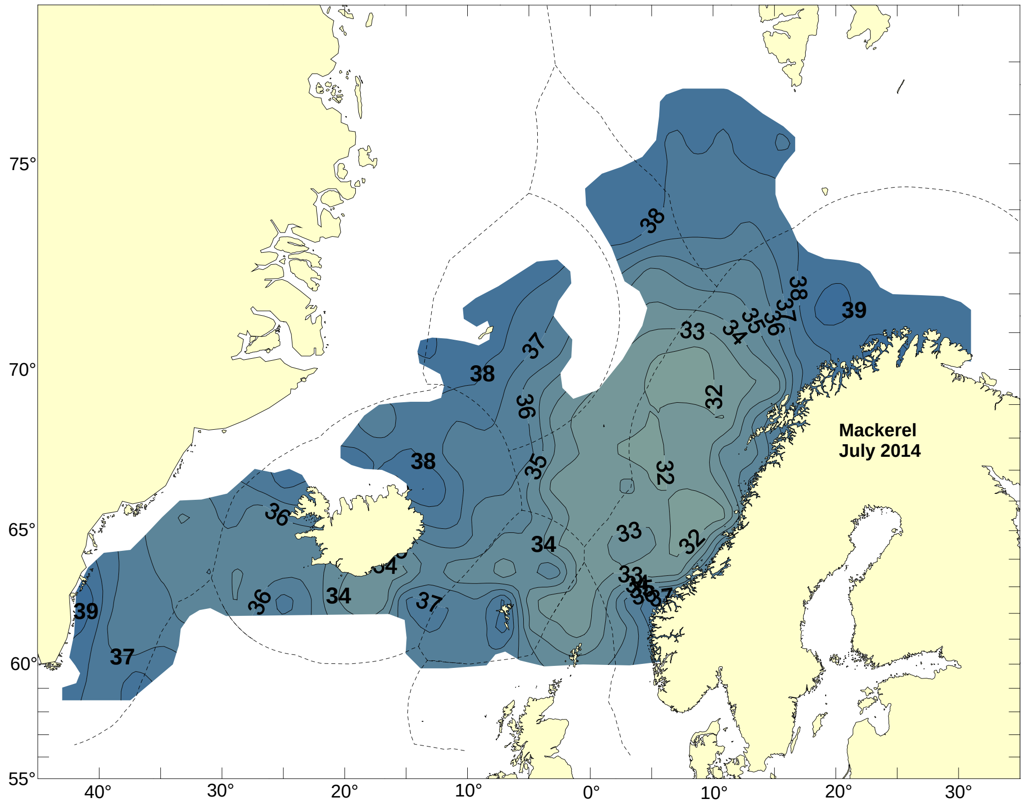


Figure 13. Average length distribution of NEA mackerel from the joint ecosystem survey with M/V "Brennholm", M/V "Vendla", M/V "Finnur Friði" and RV "Arni Fridriksson" in the Norwegian Sea and surrounding waters between 2 July and 12 August 2014.

Mackerel caught in the pelagic trawl hauls on the four vessels varied from 24 cm to 46 cm in length with the individuals between 30–33 cm and 35–38 cm dominating in the abundance. The mackerel weight (g) varied between 180 to 820 g (Figure 14). Very few juvenile mackerel were caught in 2014.

The spatial distribution and overlap between the major pelagic fish species from the joint ecosystem survey in the Nordic Seas according to the catches are shown in Figure 15.

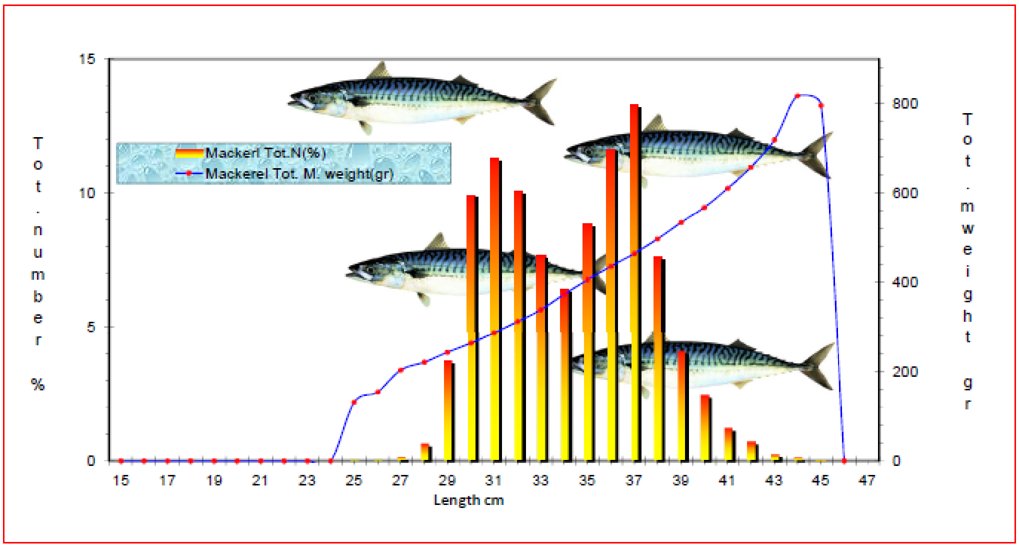


Figure 14. Length (cm) and weight (g) distribution in percent (%) for mackerel sampled in the trawl catches. Note that these values are not weighed with catch or area size and can therefore divide from the estimation of length distribution in the stock (not provided).

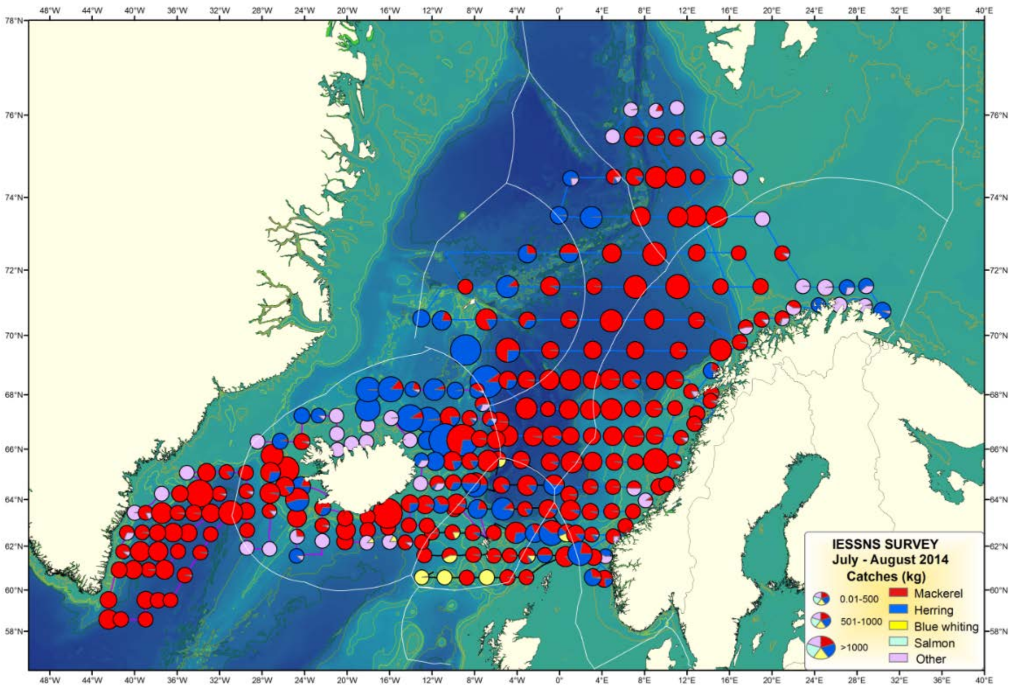


Figure 15. Distribution and spatial overlap between mackerel (red), herring (blue), blue whiting (yellow) and salmon (violet) from joint ecosystem surveys conducted onboard M/V "Brennholm" and M/V "Vendla" (Norway), M/V "Finnur Friði" (Faroe Islands) and RV "Arni Fridriksson" (Iceland) in the Norwegian Sea and surrounding waters between 2 July and 12 August 2014. Vessel tracks are shown as continuous lines.

Swept-area analyses from standardized pelagic trawling with Multpelt 832

The swept-area estimates of mackerel biomass in July-August 2014 were based on average catches of mackerel within rectangles of 1° latitude and 2° longitude and measurements of horizontal opening of the trawls (Table 5), which gave catch indices (kg/km²; Figure 16). An interpolation for rectangles not covered on the edges of area covered was only done for those that had adjacent rectangles with one or more tows on three or four sides. Total number of rectangles interpolated was 38 (Figure 17). The interpolation was done by taking the average values of all adjacent rectangles. The swept-area estimates for the different rectangles is shown in Figure 17 and in a different graphical way in Figure 18. The total biomass estimate came to 9.0 million tons, which was allocated to the different EEZs as in previous years (Annex 1). This estimate was based on the standard method using the average horizontal trawl opening by each participating vessel (around 65 m, see Table 5). A further assumption was that all mackerel inside the trawl opening are caught, i.e. no escape through the meshes.

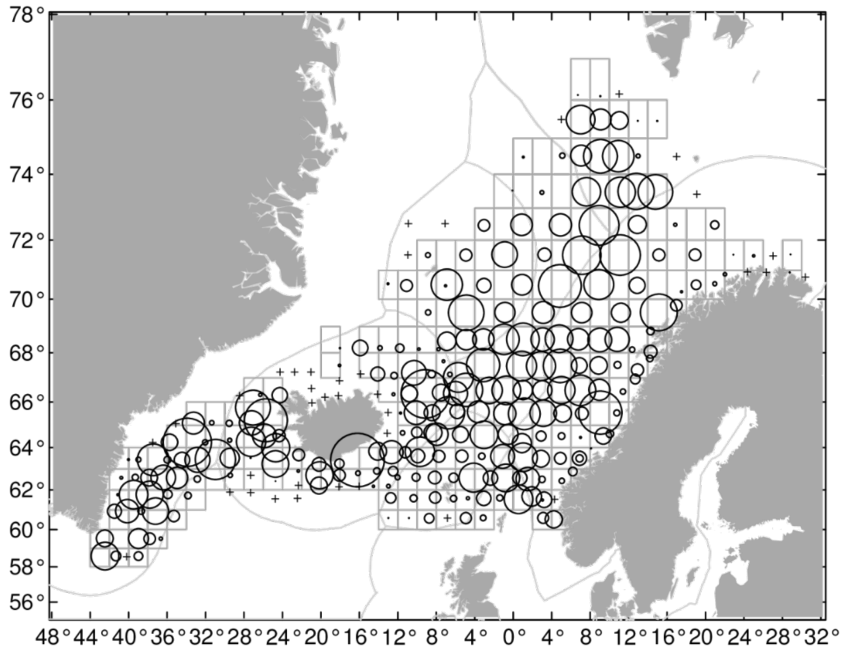


Figure 16. Stations and catches of mackerel in July/August 2014 where the circles size is proportional to square root of catch (kg/km²) and stations with zero catches are denoted with +.

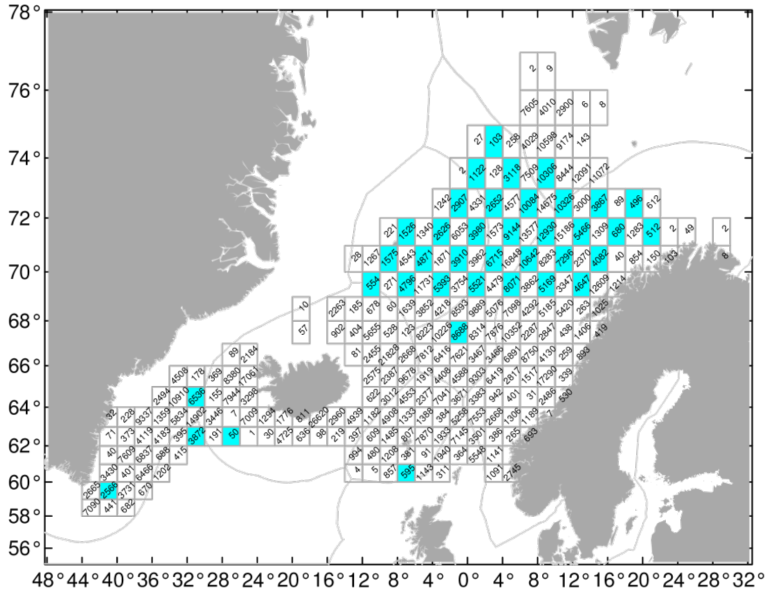


Figure 17. Standardized mackerel catch rates (kg/km²) in 1° lat. by 2° lon. rectangles from swept-area estimates in July/August 2014 where interpolated rectangles are denoted with blue shading.

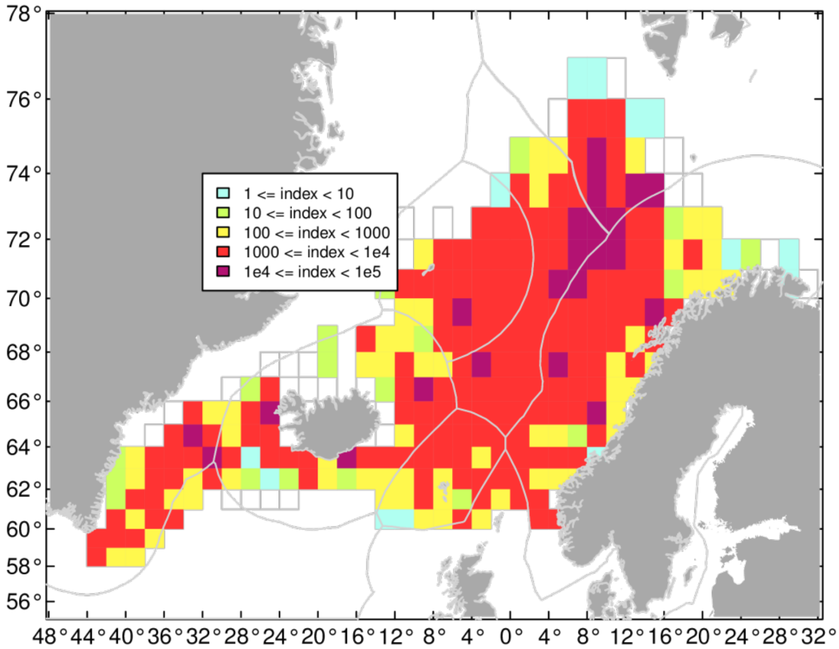


Figure 18. Standardized mackerel catch rates (kg/km²) for mackerel in the July/August 2014 survey represented graphically. Colouring of levels is the same as in the 2013 IESSNS survey report (Nøttestad *et al.*, 2013).

Age-disaggregated indices from IESSNS obtained using the swept-area methodology were first estimated and introduced in the Benchmark assessment of the mackerel stock in 2014 (Nøttestad *et al.*, 2014). The same methodology was used now and the series updated with the 2014 data to be used in the analytical assessment of the stock (Table

8). The 2014 results show that 2011-year class contributed with 32.0% in number followed by the 2010-year class with 21.1% (Figure 19). The 2007, 2008 and 2009 year classes contributed then to around 11% each. Altogether 66.2% of the estimated number of mackerel was less than 6 years old. The consistency between years for the different age groups is shown in Figure 20. A good consistency was observed for all age groups from age 1–10, except for age 5. That might be explained by that the 2009 year class (age 5) is a rather weak and has a similar low strength in abundance as the 2008 year class (age 6) providing low contrast in the consistency plot, compared to many of the surrounding very strong year classes (2005, 2006, 2010, 2011), and could be more difficult to track over time compared to the much stronger year classes within the mackerel stock.

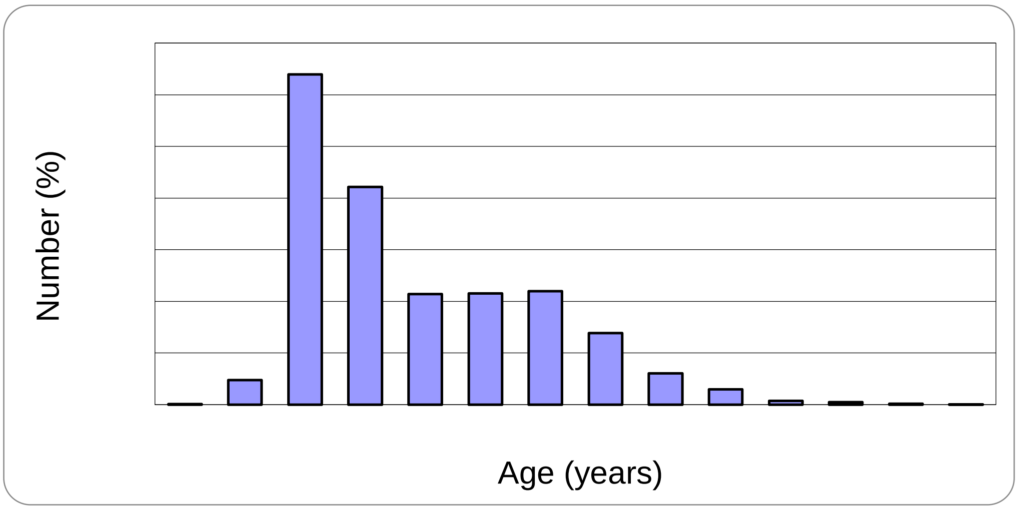


Figure 19. Age distribution in percent (%) of Atlantic mackerel scaled to the total catches, in the Norwegian Sea and surrounding waters from 2 July to 12 August 2014.

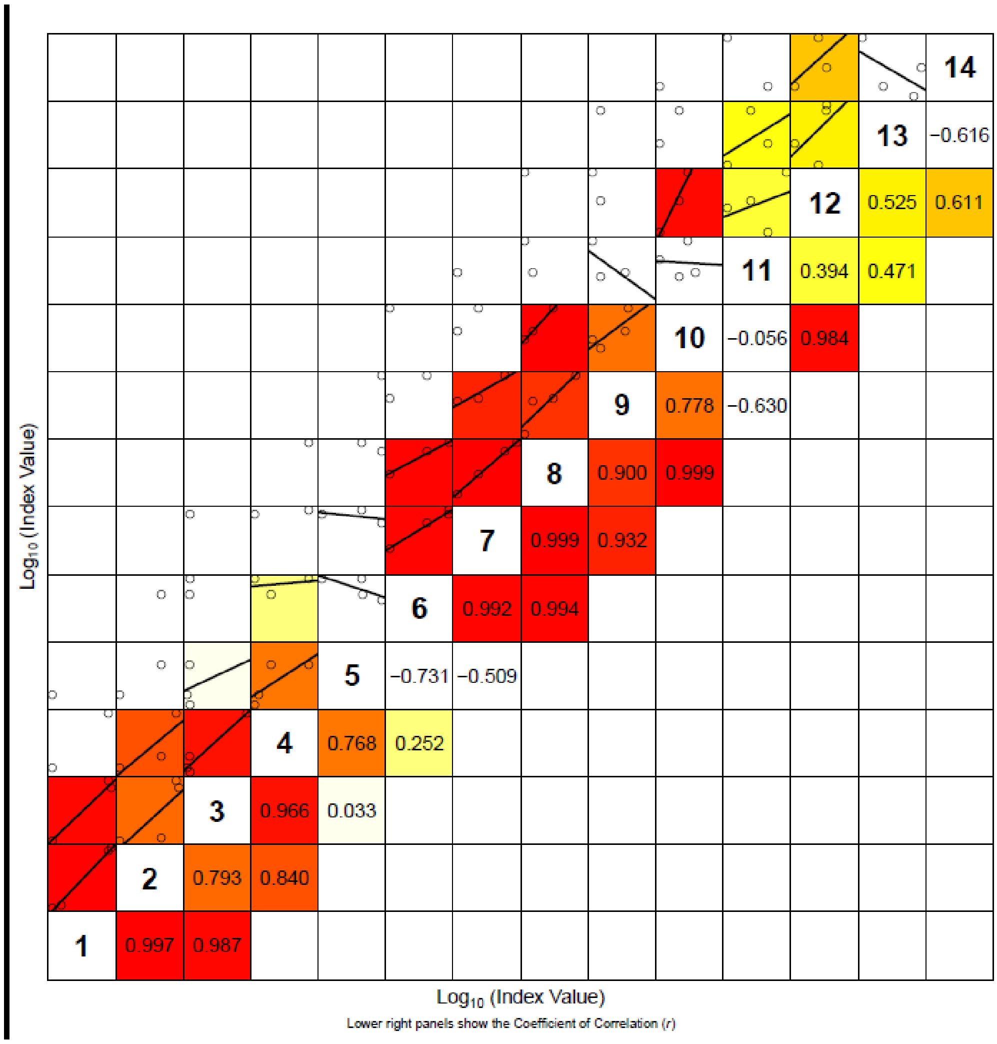


Figure 20a. Consistency plot of mackerel from the July/August 2014 survey (IESSNS).

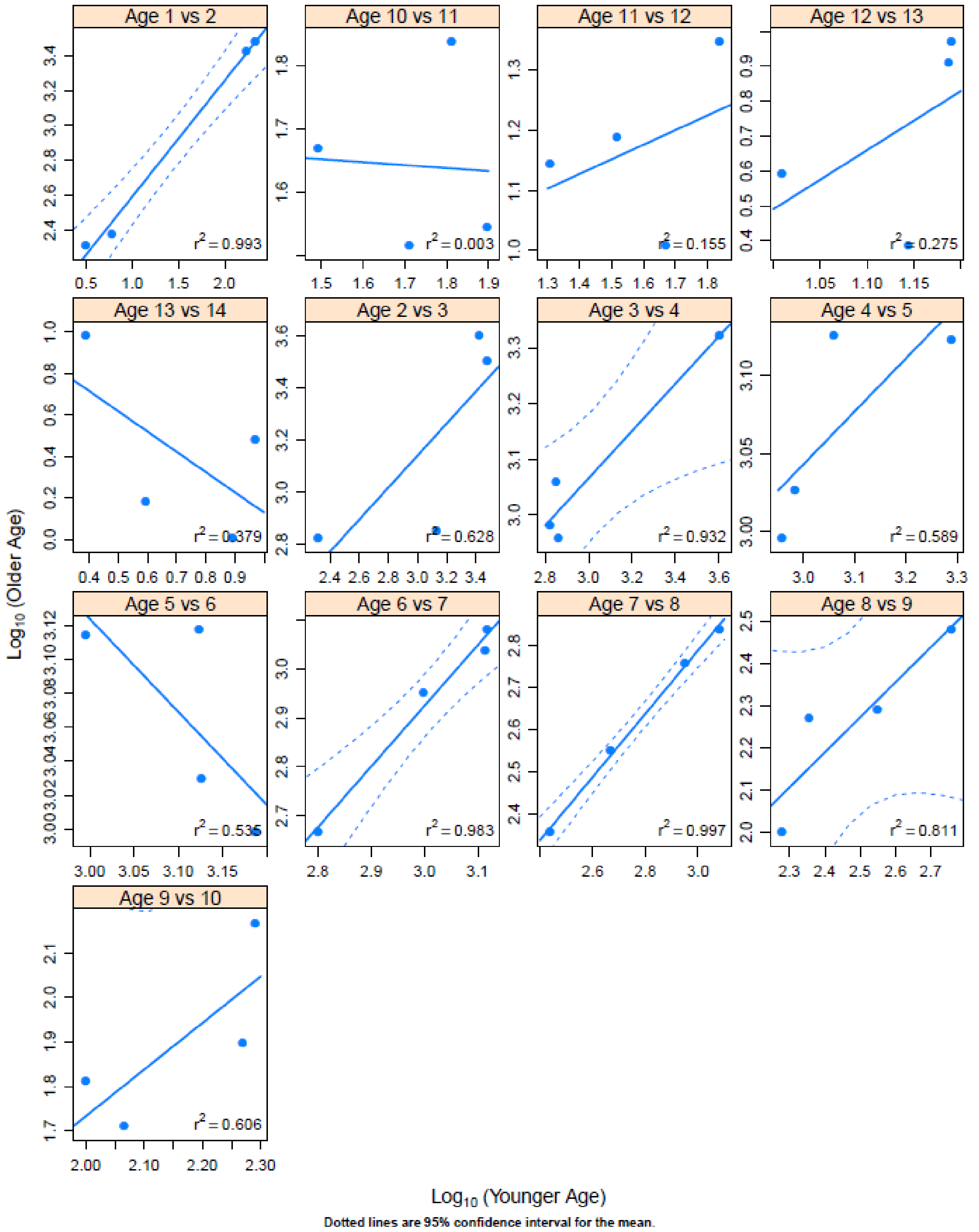


Figure 20b. Consistency plot (Log$_{10}$ transformed on the x- and y axis) for each year class 1–14+. The correlation is given as r^2 for each year class. Dotted lines are 95% confidence interval for the mean.

Table 8. Time-series of the IESSNS showing (a) age-disaggregated abundance indices of mackerel, (b) survey area covered where each age class is observed, and (c) swept-area density index (km^{-2}), which is applied in the analytical assessment of mackerel (limited to age 6+).

(a) Number of individuals (billions)														Habitat range (mill. km^2)
Year\Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14(+)	
2007	1.331	1.861	0.896	0.238	1.000	0.16	0.055	0.039	0.029	0.011	0.009	0.003	0.011	0.002	0.99
2010	0.019	2.768	1.485	3.954	3.123	1.277	0.555	0.385	0.236	0.063	0.041	0.031	0.016	0.005	1.75
2011	0.209	0.251	0.861	1.103	1.616	1.211	0.564	0.276	0.121	0.062	0.057	0.017	0.011	0.001	1.20
2012	0.497	4.991	1.223	2.111	1.822	2.415	1.642	0.652	0.342	0.119	0.067	0.019	0.006	0.006	1.50
2013	0.064	7.776	8.987	2.137	2.906	2.874	2.679	1.266	0.451	0.192	0.161	0.042	0.008	0.022	2.41
2014	0.008	0.579	7.795	5.138	2.605	2.624	2.673	1.686	0.739	0.360	0.086	0.054	0.020	0.004	2.45
(b) Area covered where an age class is observed (km^2)															
2007	0.832	0.832	0.832	0.832	0.832	0.830	0.831	0.829	0.820	0.847	0.865	0.720	0.834	0.788	
2010	6.128	2.059	2.052	2.034	2.032	2.028	2.030	2.027	2.032	2.034	2.023	2.002	2.050	2.039	
2011	1.217	1.216	1.218	1.217	1.217	1.217	1.216	1.219	1.212	1.208	1.223	1.220	1.182	0.992	
2012	2.330	1.892	1.846	1.845	1.842	1.842	1.844	1.842	1.842	1.838	2.041	1.861	2.463	1.974	
2013	10.748	2.596	2.255	2.224	2.175	2.209	2.228	2.210	2.313	2.438	2.344	2.730	2.048	2.302	
2014	2.450	2.450	2.450	2.450	2.450	2.450	2.450	2.450	2.450	2.450	2.450	2.450	2.450	2.450	
(c) Density index (millions per km^2)															
2007	1.599	2.236	1.077	0.286	1.202	0.193	0.066	0.047	0.035	0.013	0.010	0.004	0.013	0.003	
2010	0.003	1.345	0.724	1.944	1.537	0.630	0.273	0.190	0.116	0.031	0.020	0.015	0.008	0.002	
2011	0.172	0.206	0.707	0.907	1.328	0.995	0.464	0.226	0.100	0.051	0.047	0.014	0.009	0.001	
2012	0.213	2.637	0.663	1.144	0.989	1.311	0.890	0.354	0.186	0.065	0.033	0.010	0.002	0.003	
2013	0.006	2.995	3.985	0.961	1.336	1.301	1.202	0.573	0.195	0.079	0.069	0.015	0.004	0.010	
2014	0.003	0.236	3.182	2.097	1.063	1.071	1.091	0.688	0.302	0.147	0.035	0.022	0.008	0.002	

Underwater camera observations

Video recordings have not been quantitatively analysed. However, all recordings have been qualitatively evaluated with regards to research questions stated for employment of camera at each trawl location (Table 9). Quantitative analysis is here defined as viewing of video tape at recorded speed (no stopping and zooming in on details, etc.), and writing down comments on fish abundance, swimming direction and escapement. The results of qualitative analysis are that the fish lock is successful in preventing mackerel from escaping the codend when the towing ends and trawl speed declines to values below 5 knots. Trawl mesh sizes from 8 cm to 16 m were observed. The only location reporting escapement of fish was at the 4 m mesh, herring was confirmed escaping but the video recordings need more detailed analysis before escapement of mackerel can be confirmed.

Table 9. Location of video camera in trawl, number of stations camera was employed and type of video tape analyses completed to date for each vessel. All vessels used a GoPro camera and Árni Friðriksson also used high definition Sony camera. All analyses are qualitative not quantitative.

Vessel	Location of camera	Number of stations	Qualitative results
Finnur Fríði	Junction of 9cm/18cm meshes: facing codend	3	Mackerel swam in direction of towing and no escapement observed. Herring falling back towards codend, hence, not swimming with trawl.
	Fish lock: facing codend	5	Negligible amount of mackerel observed escaping but large numbers observed trapped in codend by the fish lock at the end of effective tow time.
	Headline	2	Turbulence, no fish observed.
Brennholm	8 m meshes: facing trawl opening	29	No escapement of mackerel observed.
Vendla	8 m meshes: facing trawl opening	27	No escapement of mackerel observed.
Árni Friðriksson	Fish lock: facing codend or trawl opening	5	No escapement of mackerel observed.
	16 m mesh	3	Lots of turbulence.
	4 m mesh	2	Lots of escaping fish observed, herring confirmed escaping but no mackerel confirmed escaping, needs further analysis.
	2 m mesh	4	Fish observed swimming in direction of trawling, and possible escapement of fish observed in 1 of 4 stations.
	40 cm mesh	1	Few fish seen.
	20 cm mesh	1	Mackerel swam direction of trawl, avoided panels and no escaping observed.
	8 cm mesh (mounted outside trawl)	1	No fish observed.
	Headline	1	No fish observed.
	Footrope	1	No fish observed.

Multibeam sonar recordings

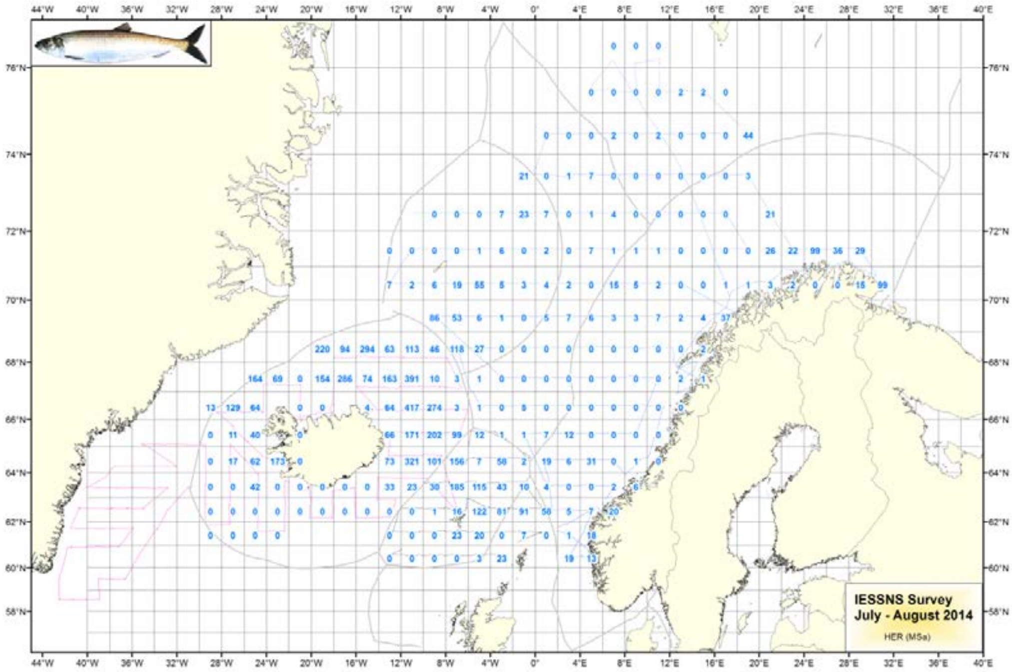
The mackerel schools detected were of small size, predominantly with low density and appeared in the upper 20–30 m of the water column throughout the day, on Simrad SH80 and Simrad SX90 operated within large geographical areas. Only small and loose mackerel schools were recorded on the multibeam sonars at all onboard M/V "Brennholm" and M/V "Vendla". Further quantitative sonar analyses on NEA mackerel will be done in the months ahead. Even if we maximized the ping rate on both the multibeam sonars and multifrequency echosounders, the mackerel were practically invisible for the multibeam sonars. The main reason is probably due to very loose aggregations/shoals close to the surface thereby providing extremely low detection probability on any acoustic instrumentation including multifrequency echosounder and high and low frequency multibeam sonars. We could sometimes detect nothing or very little on the sonars but still got medium to high catches of mackerel during surface trawling with the Multpelt 832 pelagic sampling trawl, also suggesting very dispersed mackerel concentrations.

Norwegian spring-spawning herring

Norwegian spring-spawning herring (NSS) was recorded in the eastern part of the area surveyed. The western boundary of its distribution was at 14°W south of Iceland and 20°W north of Iceland. The herring observed west of these boundaries belonged to the Icelandic summer-spawning herring according to trawl samples. The acoustic values indicated that NSS herring had the highest density in the western periphery of its distribution, or north of the Faroes and east and north of Iceland (Figure 21). The concentrations were low in the northern and eastern areas, and herring was relatively absent from the mid Norwegian Sea. The periphery of the distribution of NSS herring towards north were probably not reached between 20°W and 8°E, as in the years 2012 and 2013 (Figure 21 and 15).

The biomass estimate of NSS herring came to 4.6 million tons in July-August 2014 based on the acoustic recordings using the primary frequency of 38 kHz and the biological measurements of herring caught in the trawl tows. Herring was in the surface waters in most area feeding and possibly above the transducer (acoustic dead zone) and therefore not fully represented in the acoustic measurements.

(a)



(b)

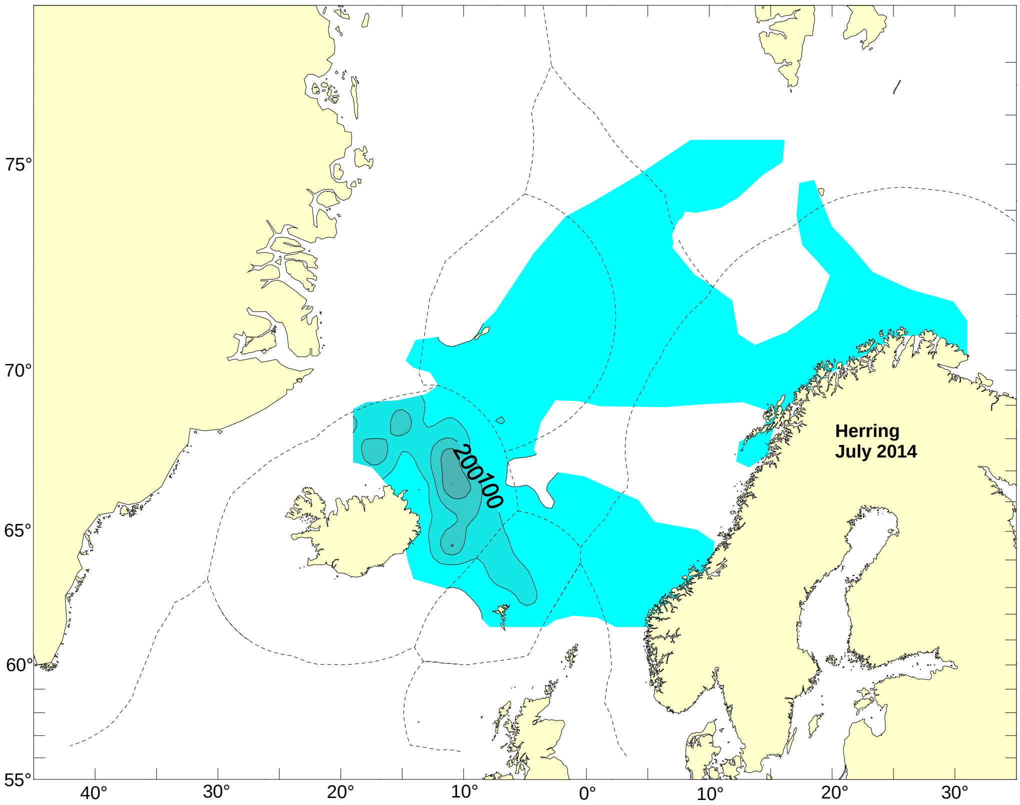


Figure 21. The sA/Nautical Area Scattering Coefficient (NASC) values of herring along the cruise track, 2 July to 12 August 2014 (a) within a rectangles and (b) shown on a contour plot.

Norwegian spring-spawning herring had a length distribution from 18–39 cm with a peak at 35 cm and weighed mean length of 33.4 cm. The weighed mean weight was 329.6 g

The age distribution in NSS herring shows dominance of the 2004 year class with about 22% in numbers of the acoustic estimate, followed by the 2005 year class (16%; Figure 22).

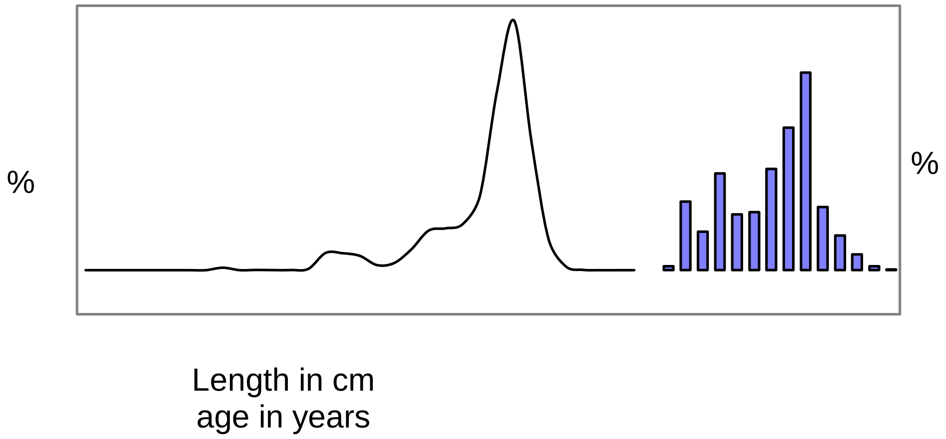


Figure 22. Age and length distribution of Norwegian spring-spawning herring from 2 July to 11 August 2014.

The length distribution measured on herring showed overall a pronounced length dependent migration pattern, with the largest individuals (>35 cm) swam furthest west and northwest (Figure 23). The large herring observed on the west side of Iceland were Icelandic summer-spawners and the large herring in the Lofoten area were Norwegian autumn-spawners, which are, different from the Icelandic summer-spawners assessed with NSS herring.

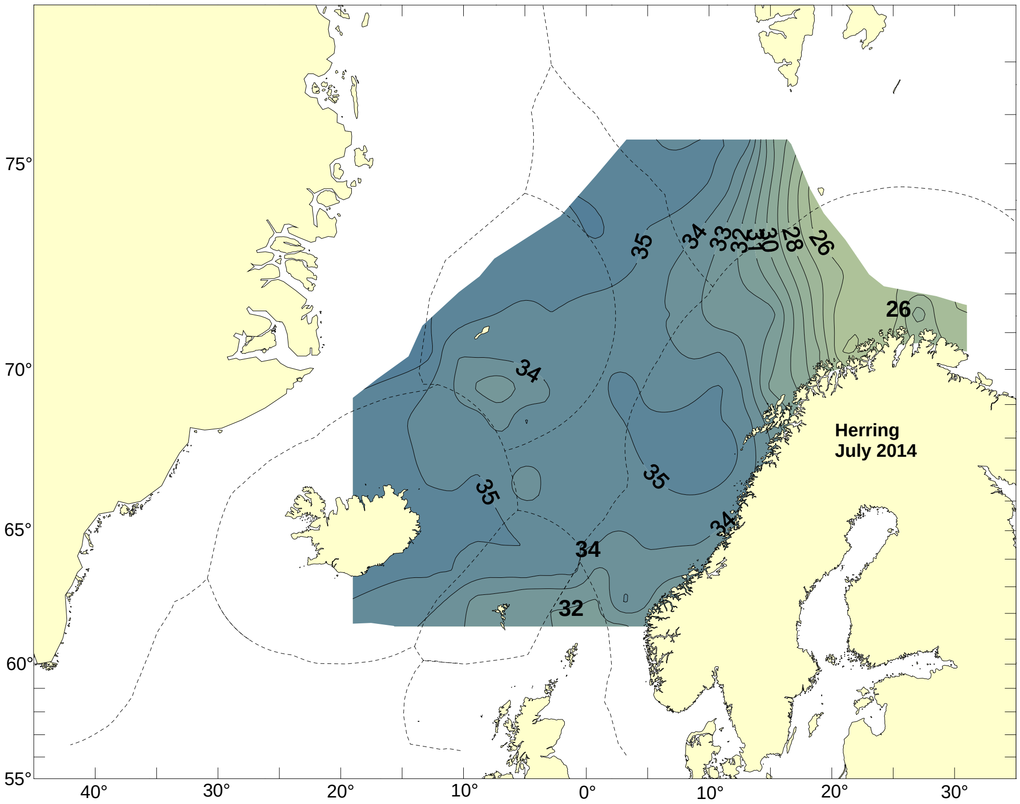


Figure 23. Length distribution of Norwegian spring-spawning herring during the coordinated ecosystem survey 2 July to 12 August 2014.

Blue whiting

No results are presented for blue whiting in 2014 because no dedicated deep trawl hauls were taken on acoustic registrations of blue whiting. See an explanation in the Introduction chapter.

Lumpfish (*Cyclopterus lumpus*)

Lumpfish was caught in 69% of trawl stations (Figure 24). Of stations with mackerel present, 60% of stations had catches < 10 kg. The other 40s% of stations had catches from 25 kg to 95 kg. There was a north–south pattern in lumpfish occurrence. Lumpfish was present at majority of stations north of 65°N, whereas lumpfish was scarce south of 65°N, excluding Greenland waters. Of note, total trawl catch at each trawl station were processed on board Árni Friðriksson, Brennholm and Vendla whereas a subsample of 100 kg to 300 kg was processed on Finnur Fríði. Therefore, small catches (< 10 kg) of lumpfish might be missing from the survey track of Finnur Fríði (black crosses). However, it is unlikely that larger catches of lumpfish would have gone unnoticed by crew during subsampling of catch on Finnur Fríði.

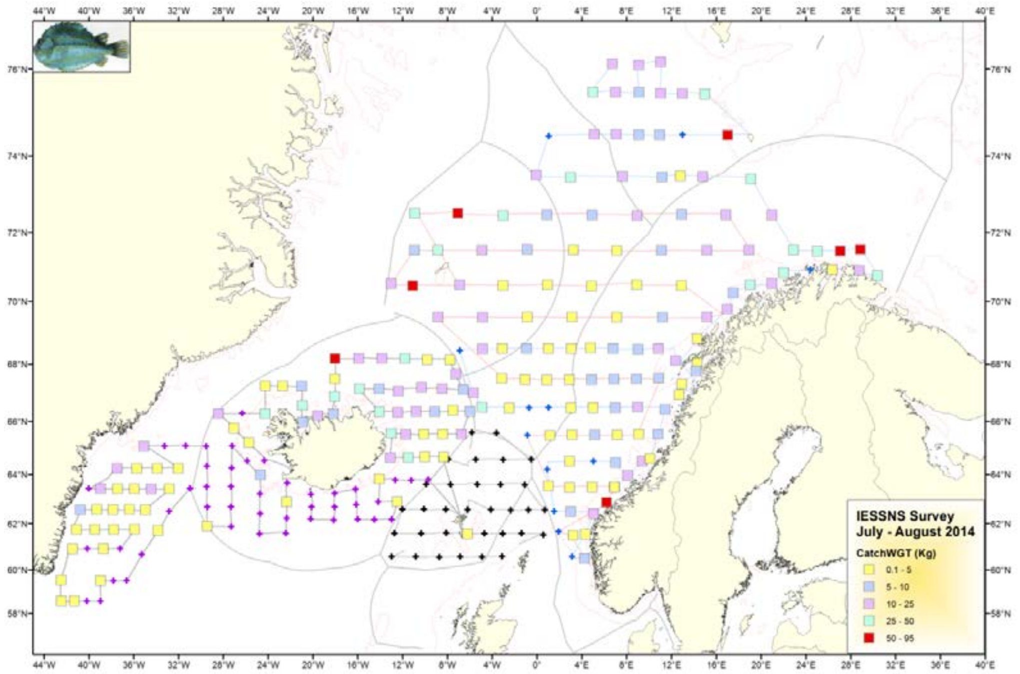


Figure 24. Lumpfish catches at surface trawl stations during the IESSNS survey in July and August 2014.

Marine Mammal Observations

Totally 227 marine mammals and 8 different species were observed onboard M/V "Brennholm" and M/V "Vendla" from 2 – 28 July 2014. Altogether 13 groups of killer whales with average group size of 6.6 individuals (N=86, stdev = 8.9) were found in the central and northern part of the Norwegian Sea in close association with small widely distributed shoals of NEA mackerel. A total number of 7 sightings of 9 minke whales were observed east just south of Jan Mayen, in outer part of Vestfjorden and in the central and northern part of the Norwegian Sea. Altogether 10 sightings of 15 fin whales where found concentrated in the northeastern part of the Norwegian Sea and along the coast of Finnmark, just south of Jan Mayen and between Bear Island and Svalbard. Altogether 12 groups of white beaked dolphins with average group size of 7.9 individuals (stdev = 5.2) appeared together with the fin whale observations and in several groups south of Bear Island. Only 2 sightings of 3 humpback whales were mainly found in the northern part of the Norwegian Sea. Very few marine mammals were sighted in the southern part of the covered area including the northern part of the North Sea, and central Norwegian Sea south of 67°N (Figure 25).

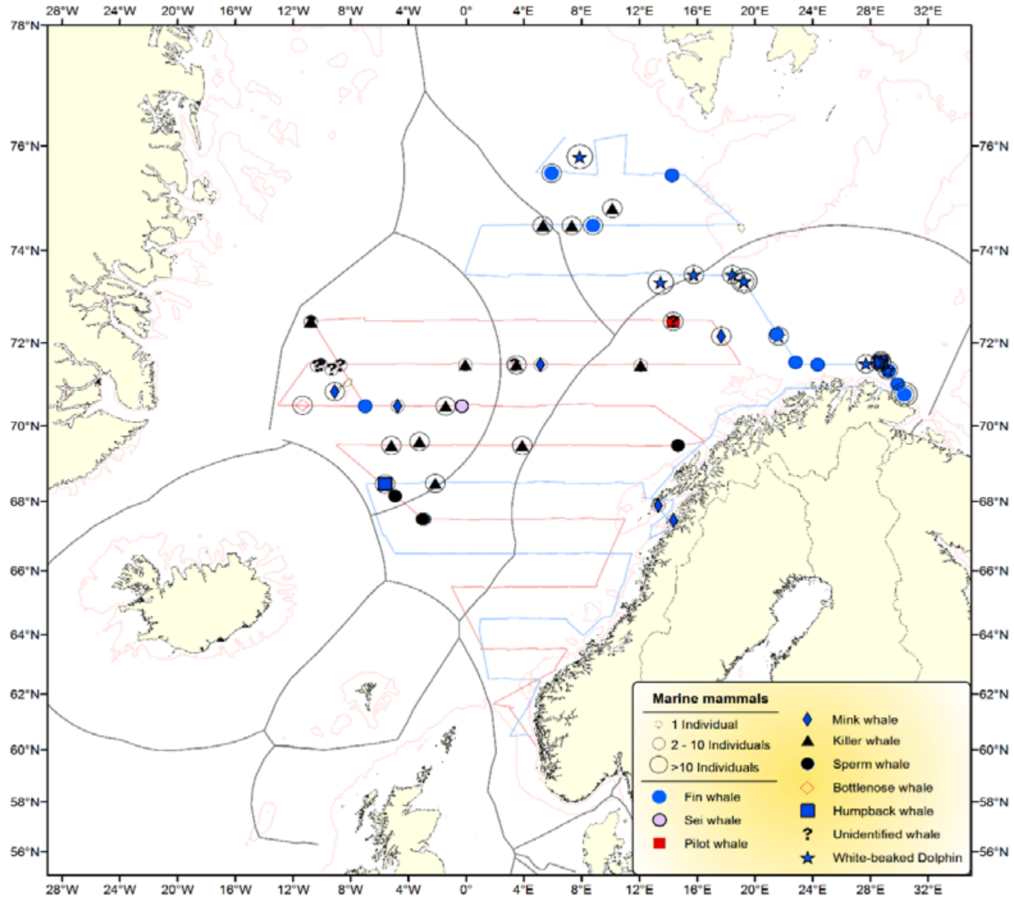


Figure 25. Overview of all marine mammals sighted onboard M/V "Brennholm" and M/V "Vendla" in the Norwegian Sea and surrounding waters from 2 – 28 July 2014. No marine mammal sightings were done onboard the Icelandic and Faroese vessels.

Discussion

The international coordinated ecosystem survey in the Norwegian Sea and adjacent areas (IESSNS) was performed during 2 July to 12 August 2014 by four vessels from Norway (2), Iceland (1) and Faroese (1), beside that the Icelandic vessel was rented by Greenland to cover Greenlandic waters. In this year the survey coverage was extended further into Greenlandic waters than in previous years. Furthermore, the area south of 60°N in the eastern part was not covered, including the northern part of North Sea, as in 2013. Otherwise the survey is comparable to previous years and the same protocol was followed (ICES, 2014b). A major part of the survey is a standardized surface trawling at predefined locations, which has been used for a swept-area abundance estimation of NEA mackerel since 2007, although not in all years. The method is analogous to the various bottom trawl surveys run for many demersal stocks.

The total swept-area estimate of mackerel in summer 2014 was 9.0 million tonnes based on a coverage of more than 2.45 million square kilometres in the Nordic Seas from about 58 degrees up to 76 degrees north and from the Norwegian coast in east and west to the Greenlandic continental shelf. This represents average density of 3.66 tonnes/km^2 which is almost identical with last year's estimate of 3.65 tonnes/km^2. Mackerel was distributed over most of the surveyed area, and the zero boundaries for mackerel were not reached towards south and east in the Greenland waters, west of the southernmost tip of Greenland (Cape Farwell) and towards south in the southeastern part of the survey area.

The 2011-year class contributed with 32.0% in number followed by the 2010-year class with 21.1%. The 2007, 2008 and 2009 year classes contributed then to around 11% each. Altogether 66.2% of the estimated number of mackerel was less than 6 years old. The overlap between mackerel and NSS herring was highest in the southwestern part of the Norwegian Sea (Faroe and east Icelandic area) according to the catch compositions in the survey (Figure 15), which is similar to 2013 and 2012. However, the overlap is less pronounced now than in the previous two years. In the areas where herring and mackerel overlap an interspecific competition for food between the species can be expected. According to Langøy *et al.* (2012), Debes *et al.* (2012), and Oskarsson *et al.* (2012) the herring may suffer in this competition, the mackerel had higher stomach fullness index than herring and the herring stomach composition is different from previous periods. Langøy *et al*. (2012) and Debes *et al.* (2012) also found that mackerel target more prey species compared to herring and mackerel may thus be a stronger competitor and more robust in periods with low zooplankton abundances.

The biomass index of Norwegian spring-spawning herring of 4.6 million tonnes is only 53% of the biomass index in July/August 2013 (8.6 million tonnes). There are two likely explanations for the drop in the biomass index in 2014. First, the survey did probably not cover the whole distribution area of the stock, especially north of Iceland between 20°W and 8°E, as in 2012 and 2013 (Figure 21 and 15). Second, there is a strong indication that herring were in the acoustic dead-zone above the transducer or in the surface 10–15m. An example is the Jan Mayen area where the trawl catches at surface was high (Figure 15) but the acoustic registrations were low (Figure 21).

The surface temperatures in the Nordic Seas in July-August 2014 were generally higher in all areas compared to July-August 2013. The SST anomaly map showed considerably higher average surface temperatures in July 2014 or 1–3°C higher compared to the average temperature in July during the last 20 years. This is thought to be due to the unusual calm weather conditions during this summer.

The concentrations of zooplankton was at the same level in 2014 as in 2013 (8.6 g dry weight/m^2 in July-August 2013 to 8.3 g/m^2 in July-August 2014) after more than a decade of decreasing trend in plankton concentrations.

During the 2014 survey, light intensity was measured to meet a request from the mackerel benchmark (ICES 2014c). The request was to use solar elevation angle as measure of daytime instead of a simple two state parameter as used at the benchmark, to test possible diel effects on catch rates of mackerel. A further request was to compare weather conditions (wind and wave height) in relation catch rates.

Environmental data were collected on all vessels during the 2014 IESSNS and results will be reported to the next mackerel benchmark.

Whale observations were done by the two Norwegian vessels during the survey. The number of marine mammal sightings was generally very low in the central and eastern part of the Norwegian Sea but with considerable larger numbers of especially fin whales in the northern Norwegian Sea and into the Barents Sea. Groups of killer whales were mostly observed in central Norwegian Sea, whereas fin and humpback whales where mainly observed near Jan Mayen, Bear Island and the southwestern part of the Barents Sea and off the coast of Finnmark.

The swept-area estimate was as in previous years based on the standard method using the average horizontal trawl opening by each participating vessel (around 65 m), assuming that all mackerel inside the trawl opening are caught, i.e. no escape through the meshes. Further, that no mackerel is distributed below the trawl. Uncertainties in such a method include e.g. possible escape of fish through the meshes leading to an underestimation of the estimate. If, on the other hand, mackerel is herded into the trawl paths by the trawl doors and bridles, the method overestimates the abundance.

The internal consistency plot for age-disaggregated year classes has improved since 2013 especially for younger year classes. There is now good internal consistency for year classes 1–10 years old, except for age 5. The reason for the low consistency around age 5 is unknown. However, the 2009 year class (age 5) is a rather weak year class and has a similar low strength in abundance as the 2008 year class (age 6) providing low contrast in the consistency plot, compared to many of the surrounding very strong year classes (2005, 2006, 2010, 2011), and could be more difficult to track over time compared to the much stronger year classes within the mackerel stock.

The improved consistency in younger year classes for NEA mackerel in the IESSNS survey should be taken into consideration by ICES WGWIDE, specifically by including also younger mackerel 1–5 years of age, and not only age 6+ mackerel, into the tuning series as input on abundance of NEA mackerel to the assessment.

Since altogether 66.2% of the estimated number of mackerel was less than 6 years old and the internal consistency plot for younger year classes has greatly improved in 2014, the value of the assessment would improve considerably by including these consistent and valid density indices for all year classes 1–14+ years old as input data series to the assessment.

Recommendations

General recommendations

Recommendation	To whom
Increase the survey effort in Greenlandic and international waters in the western part of the survey area to cover the NEA mackerel stock completely during the summer feeding.	Greenland
Develop a method that can sample the mackerel representatively in the Northwest European shelf Seas south of 58.5N, where mackerel tend to dive under surface trawls to cover the NEA mackerel stock completely during the summer feeding.	EU
The age disaggregated indices from IESSNS are considered to give a valid signal about year class sizes from age 1–10 as indicated by the consistency plots (Figure 20). Therefore it is recommended that WGWIDE consider extending the tuning data from the survey to include younger age groups in future analytical assessment of the mackerel stock.	WGWIDE
We recommend that observers collect sighting information of marine mammals and birds on all vessels.	Norway, Faroe Island, Iceland, Greenland

Survey participants

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Guðmundur J. Óskarsson, Marine Research Institute, Reykjavík, Iceland
Haraldur Einarsson, Marine Research Institute, Reykjavík, Iceland
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Mala Broberg, Greenland Institute of Natural Resources, Nuuk, Greenland
Hauke Bietz (guest from Germany)

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Annex 1: Swept-area biomass estimates in the different exclusive economical zones (EEZs)

Allocation of the total swept-area estimate of mackerel biomass to exclusive economic zones (EEZs) given in Table A1 was done in R with a selection of spatial packages (see 'Task View: Spatial' on http://cran.r-project.org). These included notably 'rgeos' for polygon clipping, and package 'geo' (http://r-forge.r-project.org), i.e. for rectangle manipulation and graphical presentation (R Development Core Team 2014, Bivand and Rundel 2014, Björnsson *et al.*, 2014). EEZs in the Northeast Atlantic were taken from shape files available on http://marineregions.org (low resolution version, downloaded in late 2012 as: World_EEZ_v7_20121120_LR.zip). Figure A1 shows the steps taken in establishing the framework. The shapefiles did not include the outlines of the EEZ of Svalbard, these were taken from a text file used in NEAFC work (pers. comm. Þorsteinn Sigurðarson, MRI, Iceland). A slight discrepancy between the two is shown in Figure A2, but it was left for later to correct this and get authoritative EEZ boundaries according to international agreements.

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Table A1. Swept-area estimates of NEA mackerel biomass in the different Exclusive Economic Zones (EEZs) according to the international coordinated ecosystem (IESSNS) survey in July-August 2014. Area calculated from rectangles where mackerel was present. Note that area calculations in the 2013 were incorrect (included covered rectangles without mackerel).

Exclusive economic zone / international area	Area (in thous. km2)	Biomass (in thous. tonnes)	Biomass (%)
EU	78	226	2.5
Norwegian	640	2267	25.2
Icelandic	478	1593	17.7
Faroese	268	549	6.1
Jan Mayen	222	732	8.2
International north	275	1759	19.6
International west	52	83	0.9
Greenland	335	1164	13.0
Spitsbergen	105	611	6.8
Total	2453	8984	100.0

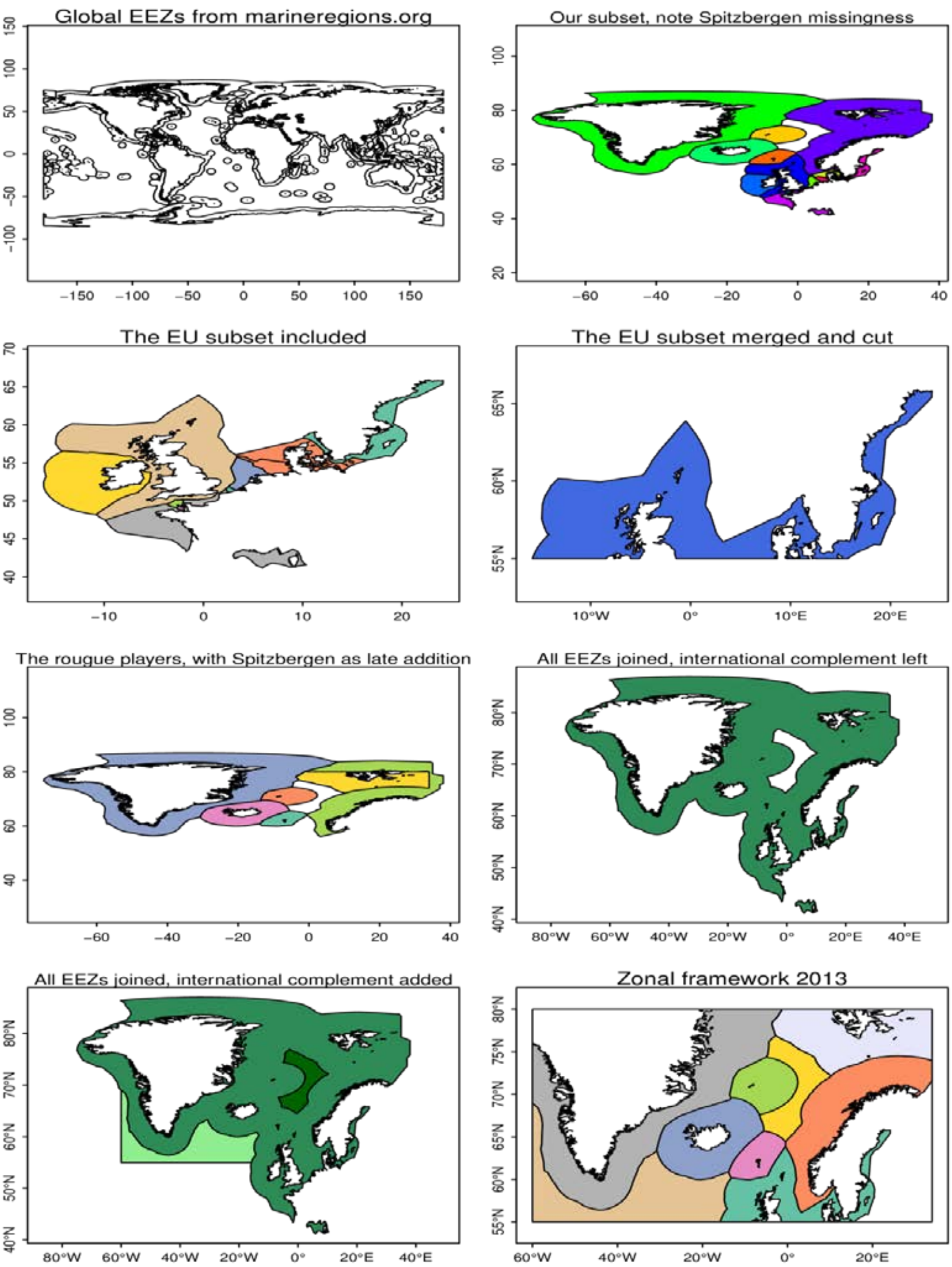

Figure A1. Zonal framework developed and used in 2013, extended and used again in 2014.

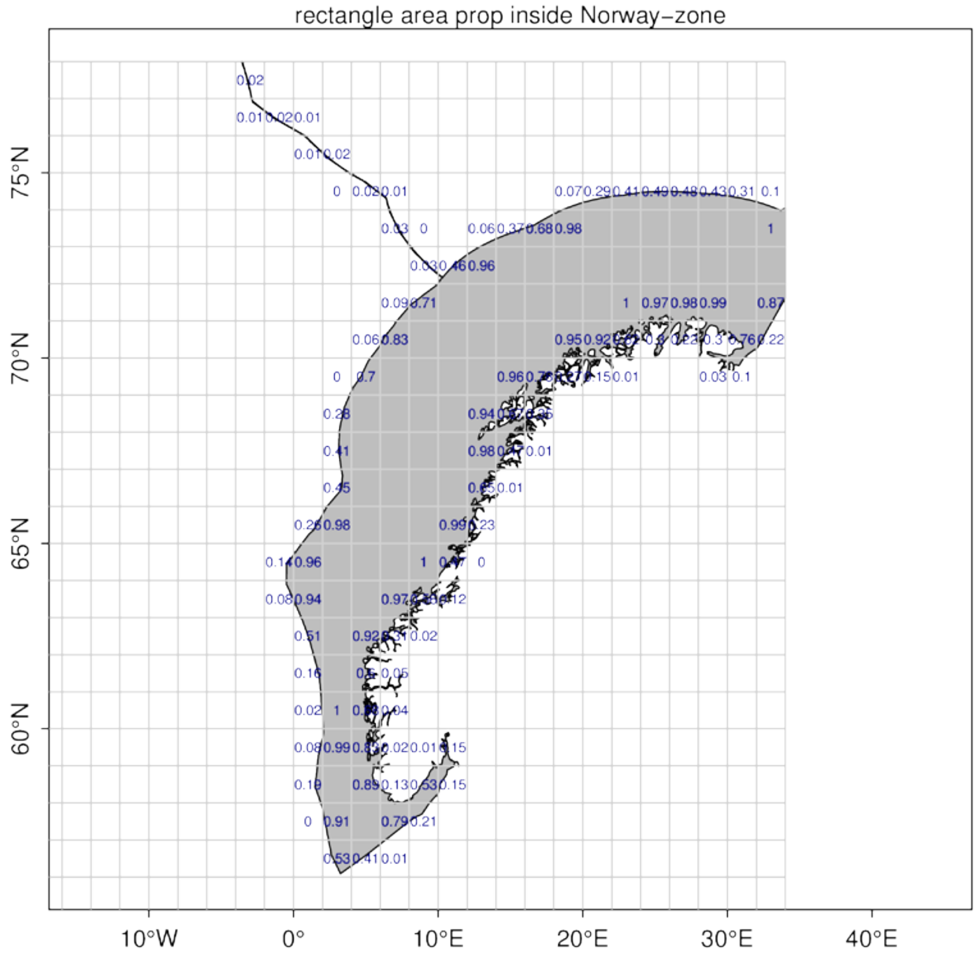

Figure A2. Sea area rectangle (1° latitude by 2° longitude) proportions within the Norway EEZ. The 'outgrowth' is due to discrepancy between the text file used for the Spitsbergen EEZ (pers. comm. Þ. Sigurðsson, MRI, from NEAFC work) and the Norway EEZ according to low-resolution shapefile on htpp://marineregions.org.

Annex 6: Individual survey cruise reports

Annex 6a: Western Baltic acoustic survey

Survey report for FRV “Solea”

German Acoustic Autumn Survey (GERAS)

30 September 2014 – 20 October 2014

Matthias Schaber [1] and Tomas Gröhsler [2]

Thünen Institute of

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1 INTRODUCTION

Background: The joint German/Danish GERAS survey is part of the Baltic International Acoustic Survey (BIAS), which is coordinated by the Baltic International Fish Survey Working Group (WGBIFS) and is conducted within the scope of the ICES Working Group for International Pelagic Surveys (WGIPS). Further WGBIFS contributors to the Baltic survey are national fisheries research institutes of Sweden, Poland, Finland, Latvia, Estonia, Lithuania and Russia. FRV “Solea” participated for the 27th time. The survey area covered the western Baltic Sea including Kattegat, Belt Sea, Sound and Arkona Sea (ICES Subdivisions 21, 22, 23 and 24). The survey effort was comparable to former years.

Objectives: The survey has the main objective to annually assess the clupeoid resources of herring and sprat in the Baltic Sea in autumn. The reported acoustic survey is conducted every year to supply the ICES:

- Herring Assessment Working Group for the Area South of 62°N (HAWG) and
- Baltic Fisheries Assessment Working Group (WGBFAS)

with an index value for the stock size of herring and sprat in the Western Baltic area (Kattegat/Subdivisions 21 and Subdivisions 22, 23 and 24).

2 SURVEY DESCRIPTION and METHODS

2.1 Personnel

Calibration of acoustic equipment (30.09.-02.10.2014)

Matthias Schaber	Scientist in charge	TI-SF
Svend-Erik Levinsky	Acoustics	DTU Aqua

Acoustic survey (02.10.-20.10.2014)

Tomas Gröhsler	Scientist in charge (02.10.-11.10.2014)	TI-OF
Matthias Schaber	Scientist in charge	TI-SF
France Collard	Biology	University Liege/Belgium
Tim Kirchner	Acoustics (11.10.-20.10.2014)	TI-SF
Mario Koth	Biology	TI-OF
Svend-Erik Levinsky	Biology	DTU Aqua/Denmark
Inken Rottgardt	Biology (02.10.-11.10.2014)	TI-SF
Dagmar Stephan	Biology (11.10.-20.10.2014)	TI-OF
Britta Stepputtis	Biology (02.10.-11.10.2014)	TI-OF

2.2 Narrative

The 694th cruise of FRV "SOLEA" represents the 27th subsequent GERAS survey. FRV "SOLEA" left the port of Rostock/Marienehe on 30 September 2014. The acoustic survey covered the whole area of Subdivisions (SD) 21, 22, 23 and 24. Both on the northernmost transect in SD 24 as well as on some sections of the transect in SD 23, the course had to be changed and measurements interrupted due to area closures of the Swedish armed forces. Several days were lost due to medical emergencies. Accordingly, survey operations had to be shifted to daytime in order to cover the northern survey area of SD 21 in the remaining survey time. The survey ended on 20 October 2014 in Rostock/Marienehe.

2.3 Survey design

ICES statistical rectangles were used as strata for all Subdivisions (ICES, 2014). The area was limited by the 10 m depth line. The survey area in the Western Baltic Sea is characterized by a number of islands and sounds. Consequently, parallel transects would lead to an unsuitable coverage of the survey area. Therefore a zig-zag track was adopted to cover all depth strata regularly and sufficiently. Overall regular cruise track length was 1 217 nm covering a survey area of 13 206 nm^2 (Figure 1).

2.4 Calibration

The 38 kHz hull mounted transducer was calibrated twice, the 120 hull-mounted transducer once during daytime on 30 September and 1 October 2014 off Kühlungsborn (54°12.74 N, 011°43.373 E). The calibration site off Kühlungsborn was chosen according to prevailing weather conditions providing acceptable conditions for calibration. The calibration procedure was carried out as described in the "Manual for the Baltic International Acoustic Surveys (BIAS)" (ICES, 2014). Resulting calibration parameters were regarded as very good (38 kHz) and acceptable (120 kHz). Calibration results for the 38 kHz transducer are given in Table 1.

2.5 Acoustic data collection

All acoustic investigations were performed during night-time, except for areas in SD 21 covered towards the end of survey. There, a shift to daytime recording had to be accomplished due to overall loss of survey time in order to allow coverage of this survey area in the remaining survey time.

The main pelagic species of interest were herring and sprat. The acoustic equipment used was a Simrad scientific echosounder EK60 operated at 38 kHz (120 kHz). Specific settings of the hydroacoustic equipment were used as described in the "Manual for the Baltic International Acoustic Survey (BIAS)" (ICES, 2014). Corresponding settings are listed in Table 1. Echo-integration, i.e. the integration and allocation of NASC values to species abundance and biomass was accomplished using Myriax Echoview 6.0 post-processing software. Mean volume backscattering values (sv) were integrated over 1 nm intervals from ca. 8 m below the surface (depending on surface turbulence) to ca. 0.5 m over the seabed. Interferences from surface turbulence, bottom structures and scattering layers were removed from the echogram.

2.6 Biological data – fishing trawls

Trawl hauls were conducted with a pelagic gear "PSN388" in midwater layers as well as near the seabed. Mesh size in the codend was 10 mm. It was planned to carry out at least two hauls per ICES statistical rectangle. Both trawling depth and net opening were continuously controlled by a netsonde during fishing operations. Trawl depth was chosen in accordance with echo distributions on the echogram. Normally, a vertical net opening of about 8–10 m was achieved. The trawling time usually lasted 30 minutes but was shortened when echograms and netsounder indicated large catches. From each haul subsamples were taken to determine length and weight of fish. Samples of herring and sprat were frozen for additional investigations (e.g. determining sex, maturity, age).

2.7 Hydrographic data

Hydrographic conditions were measured after each trawl haul and in regular distances on the survey transect. On each corresponding station, vertical profiles of temperature, salinity and oxygen concentration were measured using a "Seabird SBE 19 plus" CTD. Water samples for calibration purposes (salinity) were taken on every station, while water samples for Winkler titration and calibration of oxygen measurements were taken and processed at least once per day. Altogether, 80 CTD-profiles were measured (Figure 5).

2.8 Data analysis

The pelagic target species sprat and herring are often distributed in mixed layers together with other species. Thus, echo recordings cannot be allocated to a single species. Therefore the species composition allocated to echo recordings was based on corresponding trawl catch results. For each rectangle species composition and length distributions were determined as the unweighted mean of all trawl results in this rectangle. From these distributions the mean acoustic cross section σ was calculated according to the following target strength-length (TS) relation:

	TS	References
Clupeoids	= 20 log L (cm) - 71.2	ICES, 1983
Gadoids	= 20 log L (cm) - 67.5	Foote *et al.* 1986

The total number of fish (total N) in one rectangle was estimated as the product of the mean area scattering cross section (sA) and the rectangle area, divided by the corresponding mean cross section. The total number was separated into herring and sprat according to the mean catch composition.

In accordance with the guidelines in the "Manual for the Baltic International Acoustic Surveys (BIAS)" (ICES, 2014) further calculations were performed as follows:

Fish species considered:

Clupea harengus

Crystallogobius linearis

Gadus morhua

Gasterosteus aculeatus

Merlangius merlangus

Pollachius virens

Pomatoschistus minutus

Sprattus sprattus

Trachurus trachurus

Exclusion of trawl hauls with low catch level:

Haul No.	Rectangle	Subdivision (SD)
24	40G0	22
25	40G0	22
28	38G0	22
29	38G0	22
48	41G1	21
52	42G1	21

Despite low catch levels of both herring and sprat, hauls 1 (37G2/SD 24) and 22 (40G1/SD 22) were not excluded from the analysis as they were the only trawl hauls conducted in the corresponding rectangles and thus provided the only available information on species composition in these rectangles. One measured herring of 28.75 cm

TL caught in Subdivision 24, which was not sampled for age determination, was assumed to be 5 years old (5 Wrs, mean of 15 herring of 28.75 cm TL aged in 2012).

Usage of neighbouring trawl information for rectangles which contain only acoustic investigations:

Rectangle/SD to be filled	with Haul No.	of Rectangle/SD
43G2/21	56	43G1/21
	57	42G2/21
40F9/22	20, 21	40G0/22
39G2/23	16, 40	39G2/24
37G4/24	5, 8, 9	38G4/24

3 RESULTS

3.1 Acoustic data

Statistics on survey area, mean SA (NASC), mean scattering cross section σ, estimated total number of fish, as well as proportion of herring and sprat per SD/rectangle are shown in Table 6.

Figure 4 depicts the spatial distribution of mean NASC values (5 nm intervals) along the transects measured in 2014. In the majority of rectangles surveyed, mean NASC values per nautical mile were above the long-time survey average. However, on an ICES subdivision scale, differences compared to both previous years and long-time average were evident: While in SD 21 three out of five statistical rectangles, in SD 22 eight out of 11 and in SD 23 one out of two rectangles showed higher NASC values than both in 2013 and compared to the long-time mean resulting in overall higher NASC values in these rectangles, the situation was different in SD 24. There, the average NASC measured was distinctly lower than in 2013 and also lower than the long-time mean. This was reflected in only one (compared to 2013) and two (compared to the long-time average) rectangles showing higher NASC values as opposed to 8 (7) rectangles with partially significantly lower NASC values.

In SD 21, NASC values were slightly higher than in the previous year in the southern part of the Kattegat. In the northern part of rectangle 42G1 as well as in rectangle 43G1 NASC values were distinctly higher than in the other areas of that subdivision. In SD 22, NASC values were higher than in previous years especially in the Kiel Bight (38G0) but also north and south of the little Belt (e.g. 40G0, 39F9). In SD 23, the usual large aggregations of big herring in the Öre Sound near Ven Island were also present in autumn 2014, with mean NASC values in this area significantly exceeding previous years and the long-time average. From comparisons with distribution patterns in 2013 and additional daytime transects covered in 2014 it was evident that distribution patterns of this dense aggregations seem to shift rather fast according to prevailing currents. No southward expansion of these aggregations out of the Sound was detected in 2014. In SD 24, highest fish densities were recorded north and east of Rügen Island and to a lesser extent in the central to eastern parts of the Arkona Sea, however at partially much lower NASC values than in previous years. The differences were most pronounced in rectangles 37G3 and 38G3, i.e. around Rügen Island, where dense aggregations of herring had been observed in 2013. A similar decline was observed in rectangle 39G4 (Bornholmsgatt). This however could be an artefact as in that rectangle only a fraction of the planned cruise track could be covered due to area closures.

3.2 Biological data

In total 59 trawl hauls were conducted:

Subdivision	No. of Hauls
21	15
22	20
23	4
24	20

Altogether, 1 739 individual herring, 884 sprat, 513 European anchovies and 32 sardines were frozen for further investigations (e.g. determining sex, maturity, age). Results of catch compositions by Subdivision are presented in Tables 2–5. Altogether, 41 different species were recorded. Herring were caught in 58, sprat in 56 hauls. As in the previous year, mean catch rates per station (kg 0.5 h-1) were lowest in SD 22 and highest in SD 23. In contrast to the last two years where no sardines (*Sardina pilchardus*) were caught, this species reappeared in SD 21 in 2014. A distinct increase in comparison to previous years was evident for anchovy (*Engraulis encrasicolus*) catches. Anchovies were present throughout the survey area (exception SD 23) in 43 out of 59 hauls, including the majority of hauls in SD 24. In some hauls in SD 22, anchovies contributed the bulk of clupeid catches.

Figures 2 and 3 show relative length–frequency distributions of herring and sprat in ICES SD 21, 22, 23 and 24 for the years 2013 and 2014. Compared to results from the previous survey in 2013, the following conclusions for herring can be drawn (Figure 2):

- Catch numbers in SD 21 were dominated by the incoming year class (<15 cm). In contrast to 2013, when a bimodal distribution indicated presence of both incoming year class and older herring (ca. >17 cm), the latter were mostly absent in 2014.
- SD 22 shows the incoming year class with two modes at 12.75 cm and 15.25 cm in 2014 and at 11.75 cm and 14.25 cm in 2013. A further mode of older herring at 17.75 cm was absent in 2013. In contrast to previous years, which only contained herring smaller than ca. 20 cm, this year's results show few larger herring.
- In SD 23, very large herring (> 25 cm) dominated catches. The contribution of very large herring was less pronounced in 2013. Herring of the incoming year class show two modes at ca. 7.25 cm and at 11.75 cm, the latter only present in 2013.
- In SD24, the herring length–frequency distribution was similar compared to 2013. Both years were dominated by the incoming year class, which show a similar mode at 10.75 cm in 2014 and at 11.25 cm in 2013.
- Altogether, the present contribution of the incoming year class (ca. <15 cm) seemed to be similar to the one in the previous year.

Relative length–frequency distributions of **sprat** in the years 2013 and 2014 (Figure 3) can be characterized as follows:

- In SD 21, 22 and 23 catch numbers were dominated by the incoming year class (≤ 10 cm). In contrast to 2013, the contribution of larger sprat (>10 cm) was less pronounced in 2014.

- In SD 24, the sprat length–frequency distribution was similar compared to 2013 with a bimodal distribution of both incoming year class (≤ 10 cm) and older sprat. The contribution of largest sprat (>12 cm) was less pronounced in 2014.
- Altogether, the present contribution of the incoming year class (≤10 cm) seemed to be far stronger than the one in the previous year.

3.3 Biomass and abundance estimates

In the western Baltic, the distribution areas of two stocks, the Western Baltic Spring-spawning herring (WBSSH) and the Central Baltic herring (CBH) overlap. Survey results indicated in the recent years that in SD 24, which is part of the WBSSH management area, a considerable fraction of CBH is present and correspondingly erroneously allocated to WBSSH stock indices (ICES, 2013). Accordingly, a stock separation function (SF) based on growth parameters in 2005 to 2010 has been developed to quantify the proportion of CBH and WBSSH in the area (Gröhsler *et al.*, 2013). The estimates of the growth parameters based on baseline samples of WBSSH and CBH in 2011–2013 and in 2014 support the applicability of SF (Oeberst *et al.*, 2013, WD Oeberst *et al.*, 2014; WD Oeberst *et al.,* 2015). Thus, SF was applied to correct the GERAS index for WBSS from 2005–2014.

3.3.1 Estimates incl. Central Baltic herring

The total abundance of herring and sprat is presented in Table 6. Estimated numbers of herring and sprat by age group and SD/rectangle are given in Table 7 and Table 10. Corresponding mean weights by age group and SD/rectangle are shown in Table 8 and Table 11. Estimates of herring and sprat biomass by age group and SD/rectangle are summarized in Table 9 and Table 12.

The **herring** stock in Subdivisions 21–24 was estimated to be 12.3 x 10^9 fish (Table 7) or about 397.6 x 10^3 tonnes (Table 9). For the included area of Subdivisions 22–24 the number of herring was calculated to be 4.5 x 10^9 fish or about 312.1 x 10^3 tonnes. The overall abundance estimate was dominated by young herring as in former years (Figure 2 and Table 7).

The estimated **sprat** stock in Subdivisions 21–24 was 18.8 x 10^9 fish (Table 10) or 118.9 x 10^3 tonnes (Table 12). For the included area of Subdivisions 22–24 the number of sprat was calculated to be 18.7 x 10^9 fish or 118.5 x 10^3 tonnes. The overall abundance estimate was dominated by the incoming year class (Figure 3 and Table 10).

3.3.2 Estimates excl. Central Baltic herring

Estimated numbers of **herring excluding CBH** by age group and SD/rectangle for 2014 are given in Table 13 (SF was also applied to ICES rectangle 39G2 of SD 23 since biological samples of 39G2 of SD 24 were used to raise the corresponding recorded Sa values). Corresponding herring mean weights by age group and SD/rectangle are shown in Table 14. Estimates of herring biomass excluding CBH by age group and SD/rectangle are summarized in Table 15. Removal of the CBH fraction from herring GERAS survey indices in 2014 resulted in biomass reductions of ca. 0.8% with corresponding reductions in numbers of 0.6% (9.8 and 3.4%, respectively in 2013; Figure 5).

The ICES Herring Assessment Working Group for the area south of 62° N (HAWG)) is yearly supplied with an index for this survey (GERAS), which now excludes CBH in 2005–2014 and in general covers the total standard survey area, excluding ICES rectangles 43G1 and 43G2 in SD 21 and 37G3 and 37G4 in SD 24, which were not covered in 1994–2004.

3.4 Hydrographic data

In addition to the trawl hauls, vertical profiles of temperature, salinity and oxygen concentration were measured on a station grid covering the whole survey area. Altogether, hydrography profiles were measured on 80 stations. CTD stations as well as horizontal gradients of temperature, salinity and oxygen concentration both at the surface and at the seabed are displayed in Figure 5. Compared with previous years it was evident that temperatures in the survey area were distinctly higher than in 2013 with surface temperatures ranging from 13 °C in the Kattegat to more than 16°C in the Arkona Sea. Bottom temperatures in the largest part of the survey area were only slightly lower or –in the Arkona Sea- partially in the same range as surface temperatures. Surface salinities ranged from ca. 21 psu in the central Kattegat to ca. 8 psu in the eastern Arkona Sea. Bottom salinities showed a similar gradient but were generally higher in the range of > 31 psu (SD 21) to ca. 8 psu (SD 24). Surface layers were well oxygenated throughout the survey area. Signs of oxygen depletion were as in previous years evident in bottom layers of some areas in SD 22. In SD 22, oxygen depletion in the inner Mecklenburg Bight and the southern part of the little Belt had proceeded to almost anoxic conditions near the seabed.

4 DISCUSSION

Compared to previous results (incl. CBH), the present estimates of **herring (incl. CBH)** show a significant increase in stock biomass to record levels, while abundance decreased moderately to significantly in some subdivisions:

Herring	Difference compared to 2013	
Area	Numbers (%)	Biomass (%)
Subdivisions 22–24	-62	+22
Subdivisions 21–24	-6	+36

The high biomass estimates are mainly driven by unprecedentedly high NASC values measured in SD 23 (Sound) where WBSSH congregate in the autumn months for overwintering. According biomass and abundance estimates for the SD showed an increase of 317% and 38% respectively. From trawl catch data, a significant increase in large and older fish (≥4 wr) was evident. The origin of these fish however remains unclear as no correspondence with the abundance of younger fish in 2013 was detected. A further reason for the increase in biomass and the significant decrease in abundance was detected in SD 22 where unlike in previous years, when almost exclusively small herring were detected, also older and bigger herring (albeit in comparatively small numbers) were detected.

In previous years, older and bigger herring were detected in the northern and northwestern parts of SD 24. These were herring that already had started to migrate out of the Sound (SD 23). It is assumed that this migrations are triggered by hydrographic conditions in a way that barotropic inflow events in late summer and early autumn prevent deoxygenation in the Sound. This leads to prolonged aggregations of herring in the Sound (Miethe *et al.*, 2014). In 2014, no such migration of big herring was detected during the survey period, indicating that these herring still remained in SD 23. Accordingly, this might explain the small numbers of bigger herring in SD 24.

Small numbers of CBH result in only minor decreases in both biomass and abundance when removed from the combined estimates. Possibly the low CBH estimates in SD 21–24 can be explained by comparatively high water temperatures resulting in a more easterly distribution.

The presence of distinct numbers of anchovies (*Engraulis encrasicolus*) in large parts of the survey area and also the catches of sardines (*Sardina pilchardus*) most likely can be related to warm summer temperatures both in North and Baltic Sea and the prevailing high temperatures in October with both surface and bottom temperatures in SD 24 around 16°C (e.g. Alheit *et al.*, 2012)

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6 FIGURES AND TABLES

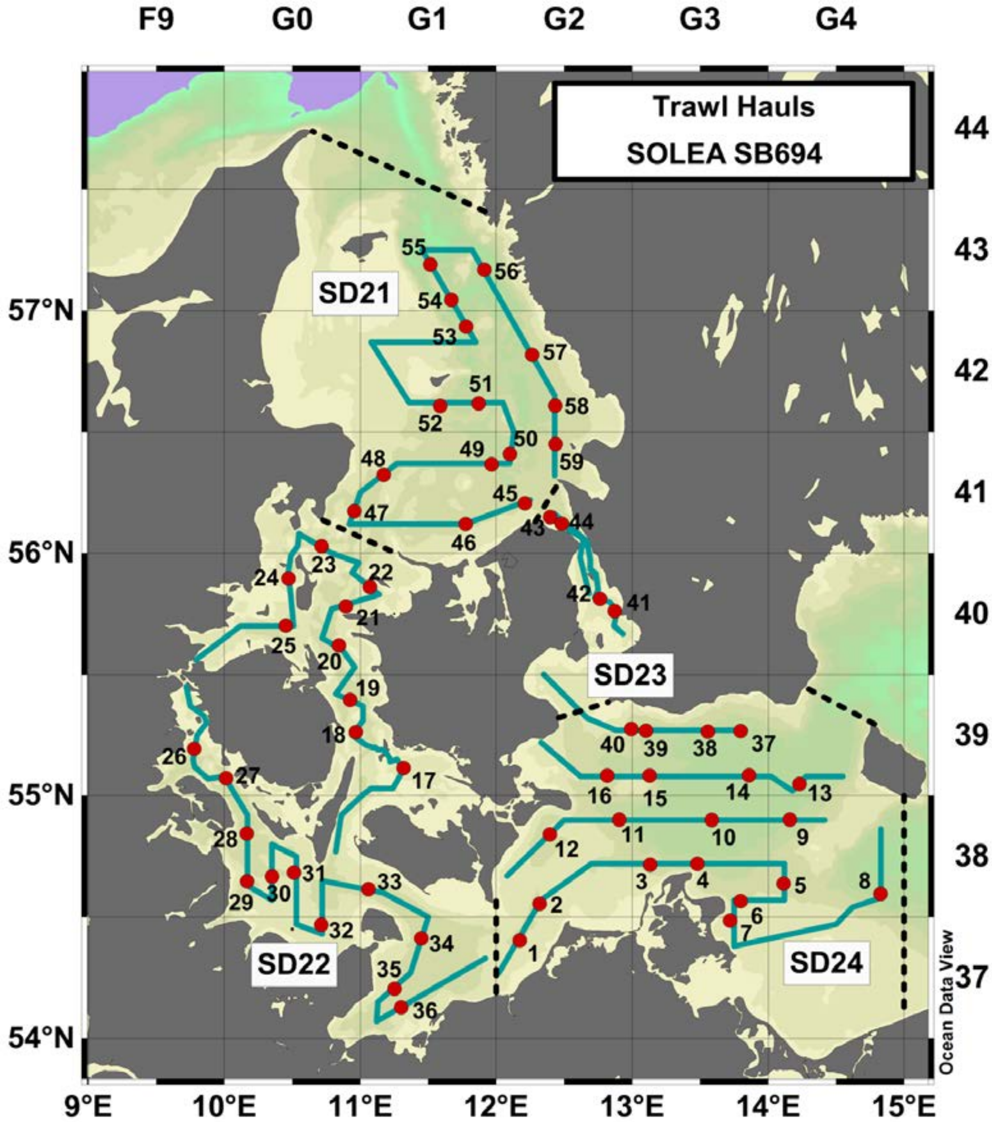

Figure 1. FRV "Solea", cruise 694/2014. Cruise track (lines) and fishery hauls (dots). ICES statistical rectangles are indicated in the top and right axis. Thick dashed lines separate ICES subdivisions (SD).

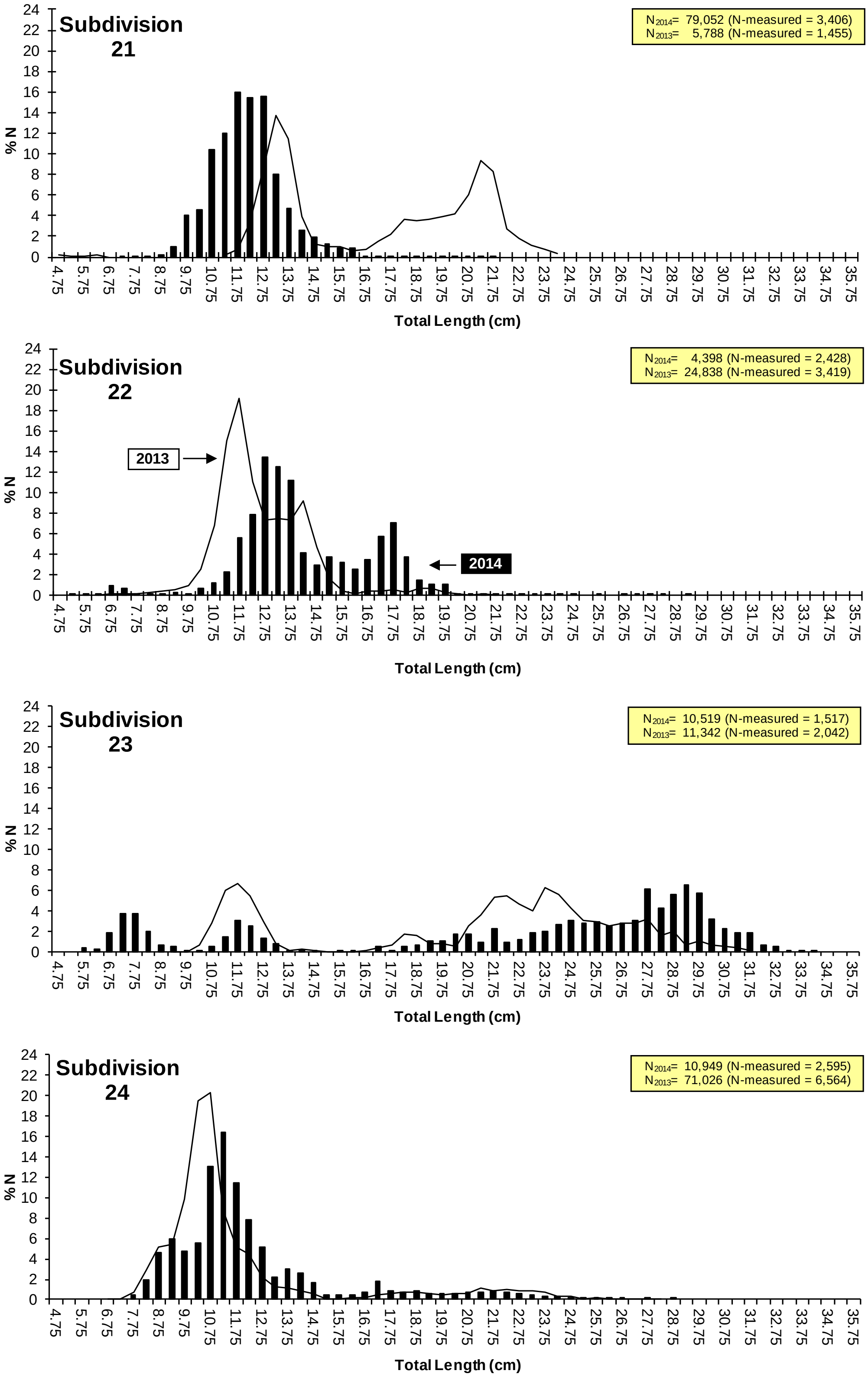

Figure 2. FRV "Solea," cruise 694/2014: Herring (*Clupea harengus*) length–frequency distribution compared to previous year (cruise 679/2013).

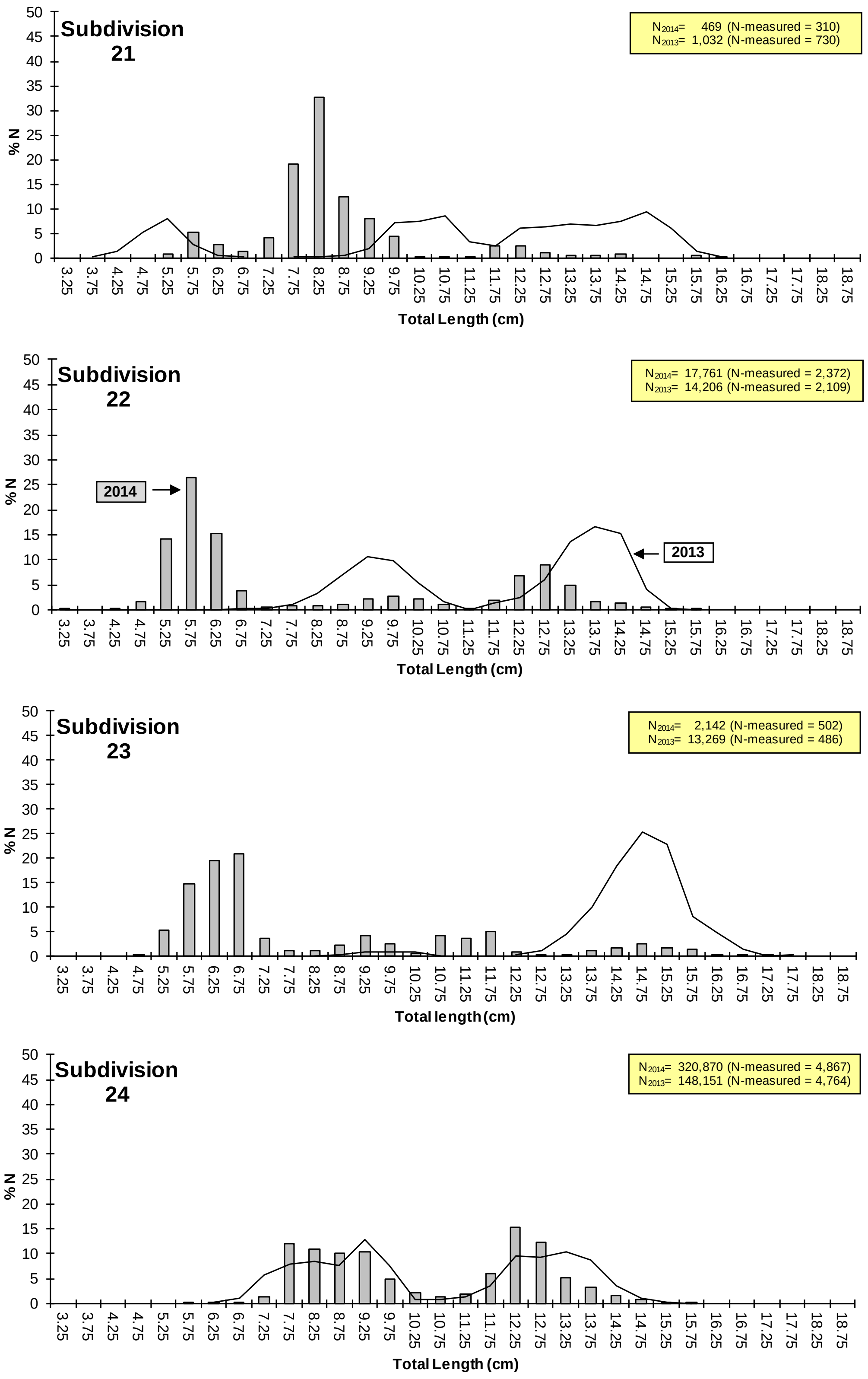

Figure 3. FRV "Solea", cruise 694/2014: Sprat (*Sprattus sprattus*) length–frequency distribution compared to previous year (cruise 679/2013).

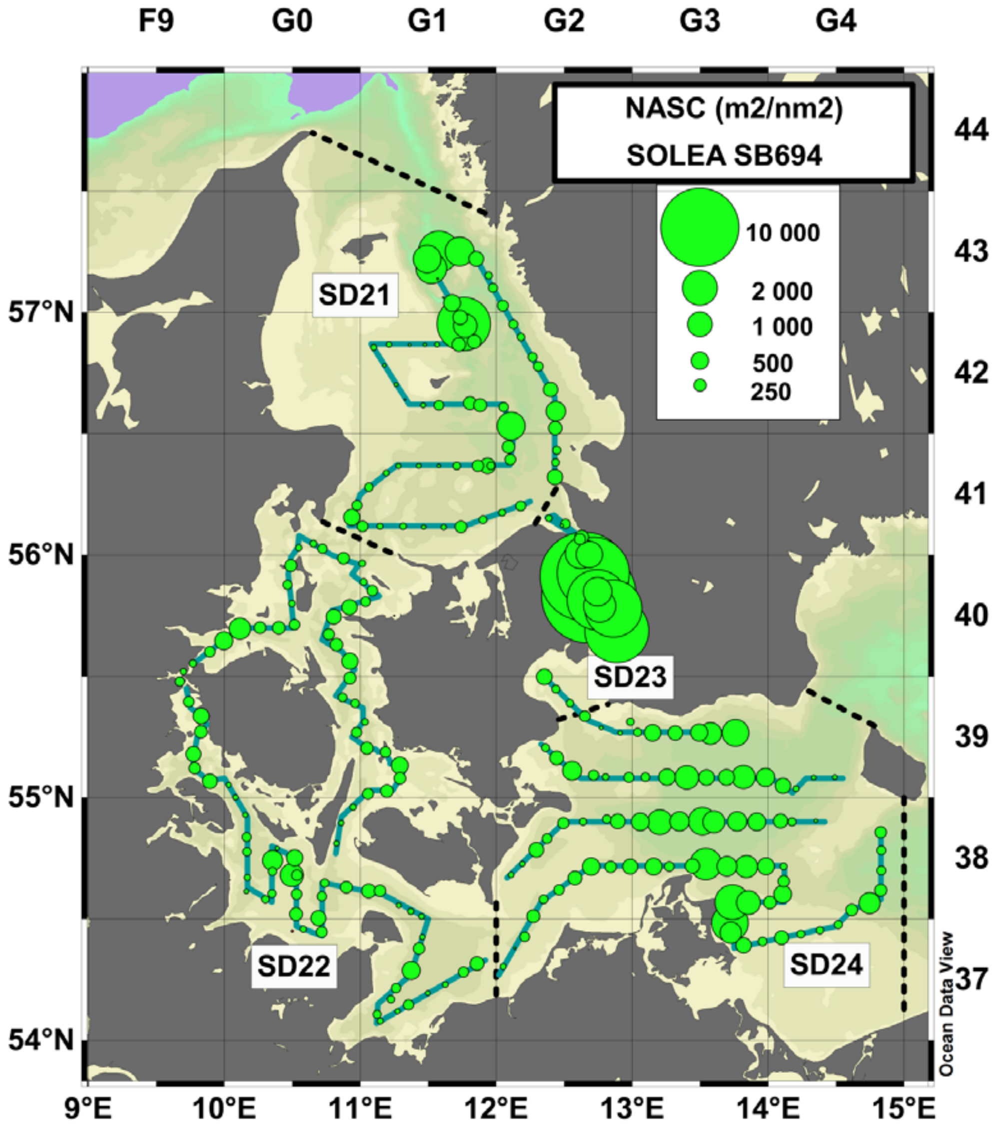

Figure 4. FRV "Solea", cruise 694/2014. Cruise track (lines) and mean NASC (5 nm intervals). ICES statistical rectangles are indicated in the top and right axis. Thick dashed lines separate ICES sub-divisions (SD). Deviations of cruisetrack in SE SD 24 due to temporal/navigational constraints.

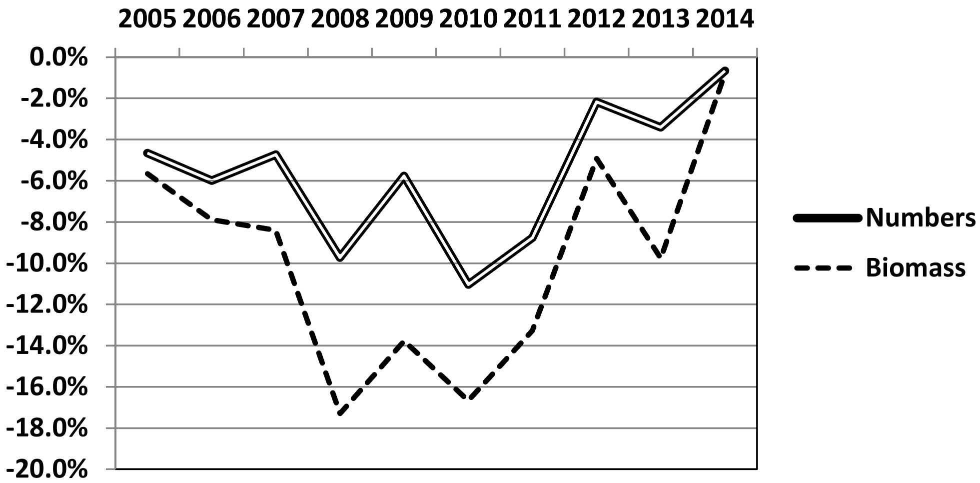

Figure 5. Relative changes in abundance and biomass of Western Baltic Spring-spawning herring in ICES Subdivisions 21–24 (2005–2014) after application of the stock separation function (SF, Gröhsler *et al.*, 2013) to the abundance and biomass index generated from German acoustic survey data (GERAS).

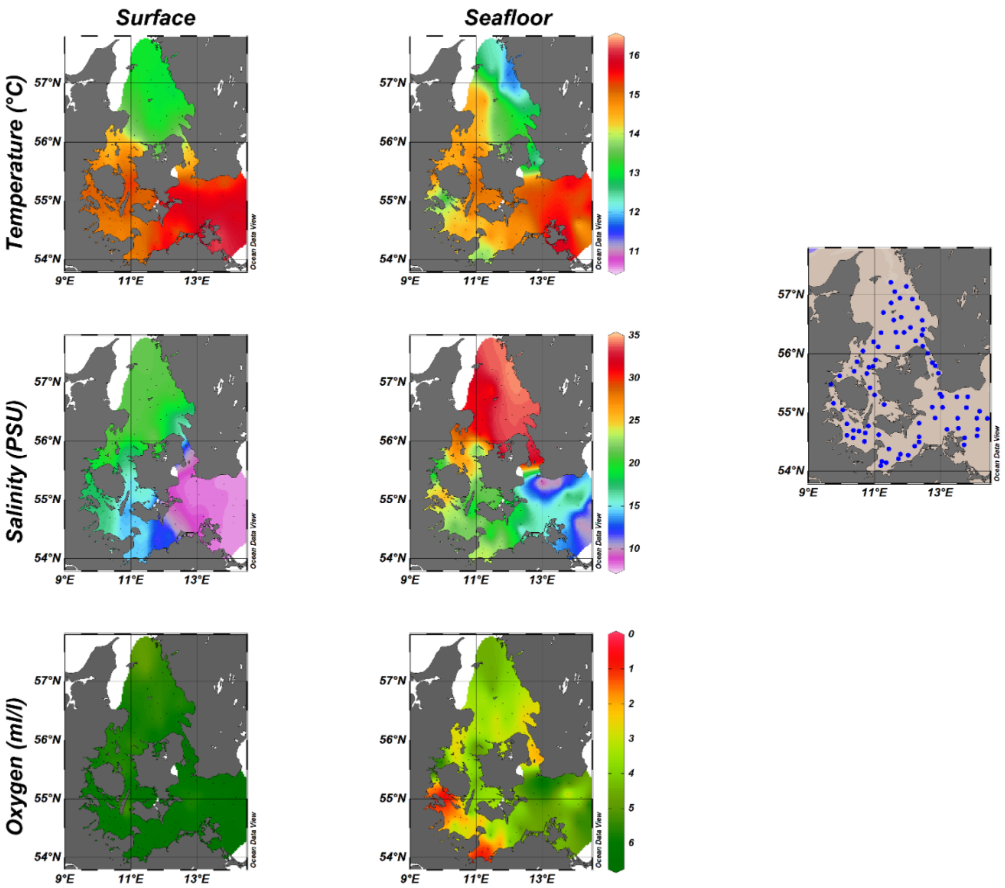

Figure 6. FRV "Solea" cruise 694/2014: Hydrography. CTD stations are depicted as blue dots in the area map (far right). Temperature (°C, top panels), salinity (PSU, middle panels and oxygen concentration (ml/l, lower panels) at the surface (left) and near the seabed (right).

Table 1. FRV "Solea", cruise 694/2014. Simrad EK60 calibration report.

```
#  Calibration  Version   2.1.0.12
#  Date:  01.10.2014
#  Comments: Kalibrierung querab Kühlungsborn. 54° 12.574 N,
#                       11° 43.373 E. Treibendes Schiff
#
#  Reference Target:
#    TS                    -42.40 dB         Min. Distance       15.00 m
#    TS Deviation          2.0 dB            Max. Distance       19.00 m
#
#  Transducer:  ES38B  Serial No.   30545
#    Frequency             38000 Hz          Beamtype                Split
#    Gain                  26.03 dB          Two Way Beam Angle      -20.6 dB
#    Athw. Angle Sens.     21.70             Along. Angle Sens.      21.70
#    Athw. Beam Angle      7.14 deg          Along. Beam Angle       7.14 deg
#    Athw. Offset Angle    -0.03 deg         Along. Offset Angle     0.01 deg
#    SaCorrection          -0.51 dB          Depth                   4.20  m
#
#  Transceiver:  GPT  38 kHz 009072056b06 2–1 ES38B
#    Pulse Duration        1.024 ms          Sample Interval         0.191   m
#    Power                 2000  W           Receiver Bandwidth      2.43 kHz
#
#  Sounder Type:
#    EK60 Version  2.2.0
#
#  TS Detection:
#    Min. Value            -50.0 dB          Min. Spacing            100%
#    Max. Beam Comp.       6.0 dB            Min. Echolength         80%
#    Max. Phase Dev.       8.0               Max. Echolength         180%
#
#  Environment:
#    Absorption Coeff.     3.7 dB/km         Sound Velocity          1488.8 m/s
#
#  Beam Model results:
#    Transducer Gain       = 25.95 dB        SaCorrection            = -0.49 dB
#    Athw. Beam Angle      = 7.17 deg        Along. Beam Angle       = 7.27 deg
#    Athw. Offset Angle    =-0.06 deg        Along. Offset Angle     =-0.01 deg
#
#  Data deviation from beam model:
#    RMS =    0.19 dB
#    Max =    0.57 dB      No. =    31       Athw. = -2.0 deg        Along =  4.4 deg
#    Min =   -0.76 dB      No. =   257       Athw. = -0.0 deg        Along = -1.8 deg
#
#  Data deviation from polynomial model:
#    RMS =    0.15 dB
#    Max =    0.51 dB      No. =    31       Athw. = -2.0 deg        Along =  4.4 deg
#    Min =   -0.64 dB      No. =   257       Athw. = -0.0 deg        Along = -1.8 deg
```

Table 2. FRV "Solea", cruise 694/2014. Catch composition (kg 0.5h[-1]) by trawl haul in SD 21.

Haul No.	45	46	47	48	49	50	51	52	53	54	55
Species / ICES Rectangle	41G2	41G1	41G0	41G1	41G1	41G2	42G1	42G1	42G1	43G1	43G1
CLUPEA HARENGUS	17.94	8.86	2.97	0.25	9.30	2.09	7.08	0.06	20.25	6.75	689.44
CRYSTALLOGOBIUS LINEARIS	0.02	+	+	+						+	
CYCLOPTERUS LUMPUS	0.92			0.28			0.21	0.14	1.17		
ENGRAULIS ENCRASICOLUS	0.46	12.04	46.02	4.60	21.70	3.16	13.40		0.06	0.02	
EUTRIGLA GURNARDUS	0.01										
GADUS MORHUA	0.95			4.45					3.43		
GASTEROSTEUS ACULEATUS		+									
LIMANDA LIMANDA	0.06	0.03	0.04								
LOLIGO FORBESI	1.90	0.58	0.03	0.01	0.02	+	0.01		0.42	0.28	1.420
MAUROLICUS MUELLERI									0.05	+	
MERLANGIUS MERLANGUS	0.38	0.04	0.01						0.2		
MERLUCCIUS MERLUCCIUS	+										
MULLUS SURMULETUS		0.01	0.01								
MYSIDACEA									1.37	0.02	
POLLACHIUS VIRENS									5.78		
POMATOSCHISTUS MINUTUS	+										
SARDINA PILCHARDUS	0.03	0.01	0.02		0.02	0.01	0.01				
SCOMBER SCOMBRUS			0.05						0.06		
SEPIOLA	0.03										
SPRATTUS SPRATTUS	0.06	+	0.02	0.02	0.01		0.1	0.4	0.03	0.07	
SQUALUS ACANTHIAS									1.57		
TRACHINUS DRACO	0.32	0.06	0.04	0.04	0.19	0.12	0.13		0.18	0.62	0.33
TRACHURUS TRACHURUS	0.04	0.06	0.04	0.01					0.01		
TRISOPTERUS ESMARKI									0.04		
Total	**23.12**	**21.69**	**49.25**	**9.66**	**31.24**	**5.38**	**20.94**	**0.60**	**34.62**	**7.76**	**691.19**
Medusae	0.25	1.47	0.08	1.75	3.40	0.12	0.05	0.63	2.00	0.17	0.00

Haul No.	56	57	58	59	Total
Species / ICES Rectangle	43G1	42G2	42G2	41G2	
CLUPEA HARENGUS	8.87	6.37	74.65	7.66	**862.54**
CRYSTALLOGOBIUS LINEARIS					**0.02**
CYCLOPTERUS LUMPUS					**2.72**
ENGRAULIS ENCRASICOLUS	0.31	6.40	8.40	0.36	**116.93**
EUTRIGLA GURNARDUS					**0.01**
GADUS MORHUA			9.31		**18.14**
GASTEROSTEUS ACULEATUS					**+**
LIMANDA LIMANDA					**0.13**
LOLIGO FORBESI	0.44	0.03		0.01	**5.15**
MAUROLICUS MUELLERI					**0.05**
MERLANGIUS MERLANGUS		0.17			**0.80**
MERLUCCIUS MERLUCCIUS					**+**
MULLUS SURMULETUS					**0.02**
MYSIDACEA					**1.39**
POLLACHIUS VIRENS					**5.78**
POMATOSCHISTUS MINUTUS					**+**
SARDINA PILCHARDUS		0.04	0.12		**0.26**
SCOMBER SCOMBRUS				0.06	**0.17**
SEPIOLA					**0.03**
SPRATTUS SPRATTUS	+		1.59	0.02	**2.32**
SQUALUS ACANTHIAS					**1.57**
TRACHINUS DRACO					**2.03**
TRACHURUS TRACHURUS					**0.16**
TRISOPTERUS ESMARKI					**0.04**
Total	**9.62**	**13.01**	**94.07**	**8.11**	**1020.26**
Medusae	0.22	1.56	0.12	0.02	**11.84**

+ = < 0.01 kg

Table 3. FRV "Solea", cruise 694/2014. Catch composition (kg 0.5h-1) by trawl haul in SD 22.

Haul No.	17	18	19	20	21	22	23	24	25	26	27
Species / ICES Rectangle	39G1	39G0	39G0	40G0	40G0	40G1	41G0	40G0	40G0	39F9	39G0
AGONUS CATAPHRACTUS						0.01		0.01	0.01		
BELONE BELONE										0.03	
CLUPEA HARENGUS	0.31	22.73	5.78	2.86	1.64	1.75	3.00	0.49	0.25	0.32	
CRANGON CRANGON				+							
CRYSTALLOGOBIUS LINEARIS	3.04	0.04	+	0.03	0.01	0.06	0.03	0.03	0.32	0.01	+
CTENOLABRUS RUPESTRIS	0.02		0.01					0.03			
CYCLOPTERUS LUMPUS	0.36							0.19			
ENGRAULIS ENCRASICOLUS		9.16	6.03	3.81	6.46	0.05	6.95	1.39	0.51	0.08	+
GADUS MORHUA	0.02	6.16	5.14					0.10	0.12		
GASTEROSTEUS ACULEATUS	1.38	0.03	+	0.03		0.01	+	0.24	7.20	5.82	0.09
GOBIUS NIGER										0.01	
LIMANDA LIMANDA	0.68	0.21	0.07	0.27			0.21	0.52	0.18		0.14
LOLIGO FORBESI			+	+		0.06	0.28	0.21	0.01		
MERLANGIUS MERLANGUS		0.01		0.08			0.25	0.02	0.03		0.01
MULLUS SURMULETUS		0.02		0.02		0.05	0.04				
MYOXOCEPHALUS SCORPIUS	0.32							0.11			
OSMERUS EPERLANUS											
PLATICHTHYS FLESUS								0.06	0.07		
PLEURONECTES PLATESSA						0.05					
POMATOSCHISTUS MINUTUS				+		+	+	+	+	0.01	+
PSETTA MAXIMA							0.30				
PUNGITIUS PUNGITIUS											
SCOMBER SCOMBRUS									0.04		
SPRATTUS SPRATTUS	1.76	14.80	0.48	0.11	0.40	0.19	0.65	0.21	0.11	11.38	4.23
SYMPHODUS MELOPS							0.06				
SYNGNATHUS ROSTELLATUS	0.01									0.01	
TRACHINUS DRACO		0.04		0.17		0.16	0.52	0.02			
TRACHURUS TRACHURUS	0.14	0.24	0.05	0.17	0.14	0.13	0.1	0.01	0.06		
Total	**8.04**	**53.44**	**17.56**	**7.55**	**8.65**	**2.52**	**12.39**	**3.64**	**8.91**	**17.67**	**4.47**
Medusae	32.0	3.8	8.5	2.2	9.9	12.8	4.9	5.4	7.8	0.0	4.5

Haul No.	28	29	30	31	32	33	34	35	36	Total
Species / ICES Rectangle	38G0	38G0	38G0	38G0	37G0	38G1	37G1	37G1	37G1	
AGONUS CATAPHRACTUS										**0.03**
BELONE BELONE										**0.03**
CLUPEA HARENGUS	0.15	0.17	14.97	0.29	6.40	10.34	3.90	11.37	5.76	**92.48**
CRANGON CRANGON										**+**
CRYSTALLOGOBIUS LINEARIS	+			+	0.14	+	0.05	+		**3.76**
CTENOLABRUS RUPESTRIS										**0.06**
CYCLOPTERUS LUMPUS										**0.55**
ENGRAULIS ENCRASICOLUS	0.05	0.03			0.66	0.03	0.03	0.08	4.76	**40.08**
GADUS MORHUA		+		8.90	+	12.39		3.17		**36.00**
GASTEROSTEUS ACULEATUS	0.09	0.08		+		0.03			0.06	**15.06**
GOBIUS NIGER										**0.01**
LIMANDA LIMANDA	0.13	0.10	0.24	0.27		0.97	0.03			**4.02**
LOLIGO FORBESI	+									**0.56**
MERLANGIUS MERLANGUS	+	0.02	0.87	+	0.06		0.13	2.11		**3.59**
MULLUS SURMULETUS										**0.13**
MYOXOCEPHALUS SCORPIUS										**0.43**
OSMERUS EPERLANUS			+							**+**
PLATICHTHYS FLESUS						0.40		0.46		**0.99**
PLEURONECTES PLATESSA										**0.05**
POMATOSCHISTUS MINUTUS	+	+		0.01	+	+			+	**0.02**
PSETTA MAXIMA										**0.30**
PUNGITIUS PUNGITIUS						+				**+**
SCOMBER SCOMBRUS										**0.04**
SPRATTUS SPRATTUS	0.06	0.07	1.50	0.10	2.08	0.03	59.24	6.09	0.16	**103.65**
SYMPHODUS MELOPS										**0.06**
SYNGNATHUS ROSTELLATUS										**0.02**
TRACHINUS DRACO	0.02									**0.93**
TRACHURUS TRACHURUS		0.09	0.42	0.01	0.07	0.02	0.12	0.06	0.27	**2.10**
Total	**0.50**	**0.56**	**18.00**	**9.58**	**9.41**	**24.21**	**63.50**	**23.34**	**11.01**	**304.95**
Medusae	1.5	2.8	6.2	1.8	5.6	10.9	1.6	2.5	6.8	**131.4**

+ = < 0.01 kg

Table 4. FRV "Solea", cruise 694/2014. Catch composition (kg 0.5h-1) by trawl haul in SD 23.

Haul No.	41	42	43	44	Total
Species / ICES Rectangle	40G2	40G2	41G2	41G2	
ANGUILLA ANGUILLA		0.42			**0.42**
CLUPEA HARENGUS	220.33	1016.93	14.08	5.02	**1256.36**
CRYSTALLOGOBIUS LINEARIS			+	+	**+**
CTENOLABRUS RUPESTRIS	+				**+**
EUTRIGLA GURNARDUS			+		**+**
GADUS MORHUA	29.88	57.97			**87.85**
LIMANDA LIMANDA			0.55	0.36	**0.91**
LIPARIS LIPARIS					**0.00**
LOLIGO FORBESI	+	+	0.47	0.33	**0.80**
MERLANGIUS MERLANGUS	0.54	0.56	0.13	+	**1.23**
MERLUCCIUS MERLUCCIUS			0.08	0.03	**0.11**
MULLUS SURMULETUS			0.07	0.01	**0.08**
PLEURONECTES PLATESSA		0.17			**0.17**
SPRATTUS SPRATTUS	4.87	0.13	6.33	0.37	**11.70**
TRACHINUS DRACO			0.14		**0.14**
TRACHURUS TRACHURUS			0.21	0.04	**0.25**
Total	**255.62**	**1076.18**	**22.06**	**6.16**	**1360.02**
Medusae	0.1	0.1	0.5	0.1	**0.7**

+ = < 0.01 kg

Table 5. FRV "Solea", cruise 694/2014. Catch composition (kg 0.5h^{-1}) by trawl haul in SD 24.

Haul No.	1	2	3	4	5	6	7	8	9	10	11
Species / ICES Rectangle	37G2	38G2	38G3	38G3	38G4	38G3	37G3	38G4	38G4	38G3	38G2
CLUPEA HARENGUS	0.85	23.15	4.05	11.26	0.97	8.48	9.70	8.97	0.56	1.79	1.68
CRANGON CRANGON		0.01	1.30	0.02				+			+
CRYSTALLOGOBIUS LINEARIS	+	0.01	+	+							
CTENOLABRUS RUPESTRIS			+								
CYCLOPTERUS LUMPUS								0.37	0.18		
ENGRAULIS ENCRASICOLUS	0.61		0.01	0.03	0.01	0.16			0.04	0.02	0.02
GADUS MORHUA		0.50	1.46	4.76		4.70	14.10	0.77		0.49	
GASTEROSTEUS ACULEATUS	+	0.28	0.28	0.02			0.01			0.07	0.93
LIMANDA LIMANDA		9.93	0.46								
LIPARIS LIPARIS			+								
LOLIGO FORBESI	+	0.01									
MERLANGIUS MERLANGUS		0.28	0.59	0.15		4.53	6.47		0.01	1.75	
MYOXOCEPHALUS SCORPIUS		0.14									
OSMERUS EPERLANUS	0.01		0.01	0.09		0.81	2.32	0.01			
PLATICHTHYS FLESUS		2.28	27.02	3.53		0.15	0.01	0.52			
PLEURONECTES PLATESSA		0.19	9.38								
POMATOSCHISTUS MINUTUS		0.05	0.71	0.09		0.04	0.02	+		0.03	0.03
PSETTA MAXIMA				0.49							
SALMO TRUTTA						1.09					
SCOMBER SCOMBRUS		0.05								0.03	
SPRATTUS SPRATTUS	0.01	1306.30	13.57	121.75	29.73	47.13	114.98	21.80	4.69	246.94	0.33
STIZOSTEDION LUCIOPERCA							1.97				
TRACHINUS DRACO		0.03									
TRACHURUS TRACHURUS	0.01	0.49	0.29	0.11		0.03	0.01		0.01	+	
Total	**1.49**	**1343.70**	**59.13**	**142.30**	**30.71**	**67.12**	**149.59**	**32.44**	**5.49**	**251.12**	**2.99**
Medusae	4.27	7.84	7.12	31.18	15.67	9.88	29.23	2.47	50.30	21.72	6.50

Haul No.	12	13	14	15	16	37	38	39	40	Total
Species / ICES Rectangle	38G2	39G4	39G3	39G3	39G2	39G3	39G3	39G3	39G2	
CLUPEA HARENGUS	25.04	3.94	8.90	1.43	16.50	21.87	6.21	1.57	4.94	**161.86**
CRANGON CRANGON		0.00		+	+					**1.33**
CRYSTALLOGOBIUS LINEARIS			+					+	0.01	**0.02**
CTENOLABRUS RUPESTRIS										**+**
CYCLOPTERUS LUMPUS										**0.55**
ENGRAULIS ENCRASICOLUS				0.05	0.22		0.01	0.03	0.01	**1.22**
GADUS MORHUA		3.14	1.25				4.94	2.81	1.57	**40.49**
GASTEROSTEUS ACULEATUS	0.17	+		0.01	0.16				+	**1.93**
LIMANDA LIMANDA										**10.39**
LIPARIS LIPARIS										**+**
LOLIGO FORBESI										**0.01**
MERLANGIUS MERLANGUS		2.85	0.14	0.02	0.02	0.23				**17.04**
MYOXOCEPHALUS SCORPIUS										**0.14**
OSMERUS EPERLANUS		0.02								**3.27**
PLATICHTHYS FLESUS				0.19			0.30			**34.00**
PLEURONECTES PLATESSA										**9.57**
POMATOSCHISTUS MINUTUS		0.16	0.01	0.04	0.04		+	0.04	+	**1.26**
PSETTA MAXIMA										**0.49**
SALMO TRUTTA										**1.09**
SCOMBER SCOMBRUS										**0.08**
SPRATTUS SPRATTUS	330.53	2.08	71.78	11.51	17.93	486.62	66.90	0.95	0.36	**2895.89**
STIZOSTEDION LUCIOPERCA										**1.97**
TRACHINUS DRACO										**0.03**
TRACHURUS TRACHURUS		0.01		0.02	0.02					**1.00**
Total	**355.74**	**12.20**	**82.08**	**13.27**	**34.89**	**508.72**	**78.36**	**5.40**	**6.89**	**3183.63**
Medusae	17.18	10.42	29.28	10.00	5.78	7.59	1.95	9.50	5.35	**283.2**

+ = < 0.01 kg

Table 6. FRV “Solea”, cruise 694/2014. Survey statistics by area.

ICES Rectangle	Area (nm²)	Sa (m²/NM²)	Sigma (cm²)	N total (million)	Herring (%)	Sprat (%)	NHerring (million)	NSprat (million)
41G0	108.1	269.5	2.021	144.15	92.21	0.65	132.92	0.94
41G1	946.8	88.3	1.714	487.76	97.77	0.32	476.91	1.56
41G2	432.3	207.1	1.541	580.98	95.81	1.3	556.64	7.57
42G1	884.2	99.8	2.026	435.55	98.32	0.81	428.25	3.52
42G2	606.8	370.0	1.2	1870.97	97.87	2.05	1831.15	38.27
43G1	699	825.7	1.385	4167.25	99.7	0.24	4154.67	10.07
43G2	107	194.4	1.207	172.33	99.84	0.09	172.06	0.16
Total	**3,784.2**			**7,858.99**			**7,752.60**	**62.09**
37G0	209.9	169.7	1.090	326.79	39.55	14.61	129.25	47.73
37G1	723.3	157.0	1.729	656.78	43.67	47.08	286.83	309.22
38G0	735.3	175.1	2.447	526.16	49.27	39.37	259.22	207.16
38G1	173.2	113.5	2.273	86.49	94.44	0.45	81.68	0.39
39F9	159.3	284.4	0.343	1320.84	0.26	71.99	3.38	950.91
39G0	201.7	134.5	1.736	156.27	42.42	52.97	66.29	82.78
39G1	250.0	219.6	0.17	3229.41	0.09	2.32	2.91	74.78
40F9	51.3	123.8	1.343	47.29	42.58	9.89	20.14	4.68
40G0	538.1	294.9	1.343	1181.58	42.58	9.89	503.11	116.84
40G1	174.5	101.5	0.619	286.13	12.3	3.47	35.2	9.93
41G0	173.1	92.2	1.42	112.39	34.98	14.8	39.31	16.63
Total	**3,389.7**			**7,930.13**			**1,427.32**	**1,821.05**
39G2	130.9	135.1	1.378	128.34	49.62	40.97	63.68	52.58
40G2	164	7283.2	7.44	1605.44	90.93	7.69	1459.81	123.52
41G2	72.3	290.4	0.982	213.81	64.82	34.05	138.59	72.8
Total	**367.2**			**1,947.59**			**1,662.08**	**248.90**
37G2	192.4	96.6	1.41	131.81	84.72	2.78	111.67	3.66
37G3	167.7	489.0	0.898	913.2	3.76	95.82	34.3	875.06
37G4	875.1	157.7	0.887	1555.84	5.71	94.12	88.91	1464.42
38G2	832.9	235.7	0.957	2051.35	9.49	66.11	194.74	1356.12
38G3	865.7	755.8	0.81	8077.73	4.2	89.63	339.62	7240.07
38G4	1034.8	246.9	0.887	2880.41	5.71	94.12	164.6	2711.16
39G2	406.1	191.4	1.378	564.06	49.62	40.97	279.87	231.08
39G3	765.0	566.0	1.478	2929.57	5.6	89.24	164.19	2614.22
39G4	524.8	191.9	2.332	431.86	15.82	39.9	68.3	172.32
Total	**5,664.5**			**19,535.83**			**1,446.20**	**16,668.11**
Total	**9,421.4**			**29,413.55**			**4,535.60**	**18,738.06**
Total	**13,205.6**			**37,272.54**			**12,288.20**	**18,800.15**

Table 7. FRV "Solea", cruise 694/2014. Numbers (millions) of herring incl. CBH by age/W-rings and area.

Sub-division	Rectangle/ W-rings	0	1	2	3	4	5	6	7	8+	Total
21	41G0	106.92	25.92	0.08	0.00	0.00	0.00	0.00	0.00	0.00	132.92
21	41G1	466.21	10.15	0.55	0.00	0.00	0.00	0.00	0.00	0.00	476.91
21	41G2	547.61	8.96	0.07	0.00	0.00	0.00	0.00	0.00	0.00	556.64
21	42G1	381.81	45.26	1.18	0.00	0.00	0.00	0.00	0.00	0.00	428.25
21	42G2	1,830.50	0.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,831.15
21	43G1	4,138.94	15.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4,154.67
21	43G2	172.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	172.06
21	Total	7,643.99	106.73	1.88	0.00	0.00	0.00	0.00	0.00	0.00	7,752.60
22	37G0	104.63	23.34	0.85	0.37	0.07	0.00	0.00	0.00	0.00	129.26
22	37G1	228.96	48.75	5.07	2.93	0.94	0.18	0.00	0.00	0.00	286.83
22	38G0	176.65	82.17	0.40	0.00	0.00	0.00	0.00	0.00	0.00	259.22
22	38G1	70.60	10.64	0.26	0.15	0.03	0.00	0.00	0.00	0.00	81.68
22	39F9	3.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.38
22	39G0	37.42	28.72	0.15	0.00	0.00	0.00	0.00	0.00	0.00	66.29
22	39G1	1.63	1.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.91
22	40F9	11.20	8.00	0.31	0.29	0.17	0.17	0.00	0.00	0.00	20.14
22	40G0	279.79	199.81	7.86	7.27	4.19	4.19	0.00	0.00	0.00	503.11
22	40G1	12.85	15.61	2.05	4.06	0.63	0.00	0.00	0.00	0.00	35.20
22	41G0	17.99	19.31	0.42	1.13	0.34	0.13	0.00	0.00	0.00	39.32
22	Total	945.10	437.63	17.37	16.20	6.37	4.67	0.00	0.00	0.00	1,427.34
23	39G2	54.52	6.23	1.36	0.71	0.25	0.26	0.09	0.20	0.06	63.68
23	40G2	3.38	124.35	159.92	213.33	301.61	307.84	211.38	82.73	55.28	1,459.82
23	41G2	135.91	0.90	0.25	0.36	0.51	0.4	0.22	0.04	0.01	138.60
23	Total	193.81	131.48	161.53	214.40	302.37	308.50	211.69	82.97	55.35	1,662.10
24	37G2	98.86	11.65	0.31	0.61	0.00	0.24	0.00	0.00	0.00	111.67
24	37G3	31.05	1.26	0.64	0.61	0.34	0.04	0.06	0.23	0.06	34.29
24	37G4	64.74	6.99	5.98	5.41	2.75	0.63	0.84	1.02	0.55	88.91
24	38G2	182.16	12.07	0.37	0.04	0.00	0.10	0.00	0.00	0.00	194.74
24	38G3	294.45	19.40	10.58	7.82	2.09	0.67	1.79	1.94	0.88	339.62
24	38G4	119.86	12.94	11.06	10.01	5.09	1.16	1.55	1.90	1.03	164.60
24	39G2	239.59	27.39	5.99	3.12	1.08	1.15	0.41	0.87	0.25	279.85
24	39G3	80.16	23.59	17.45	18.32	11.62	3.93	2.67	4.29	2.16	164.19
24	39G4	5.17	7.57	19.41	18.02	8.06	2.58	2.77	3.05	1.69	68.32
24	Total	1,116.04	122.86	71.79	63.96	31.03	10.50	10.09	13.30	6.62	1,446.19
22-24	Total	2,254.95	691.97	250.69	294.56	339.77	323.67	221.78	96.27	61.97	4,535.63
21-24	Total	9,898.94	798.70	252.57	294.56	339.77	323.67	221.78	96.27	61.97	12,288.23

Table 8. FRV "Solea", cruise 694/2014. Mean weight (g) of herring incl. CBH by age/W-rings and area.

Sub-division	Rectangle/ W-rings	0	1	2	3	4	5	6	7	8+	Total
21	41G0	16.77	38.18	50.00							20.97
21	41G1	14.37	38.09	62.43							14.93
21	41G2	12.35	39.95	50.00							12.80
21	42G1	14.68	45.07	60.71							18.02
21	42G2	8.33	26.59								8.34
21	43G1	10.53	31.26								10.61
21	43G2	8.38	26.59								8.39
21	Total	10.61	40.14	60.36							11.03
22	37G0	14.50	33.69	54.42	62.63	62.63					18.39
22	37G1	14.49	36.18	61.05	91.98	73.73	75.25				20.02
22	38G0	15.40	33.94	47.52							21.33
22	38G1	13.56	36.13	50.49	62.63	62.63					16.73
22	39F9	10.67									10.67
22	39G0	15.32	35.04	47.25							23.94
22	39G1	19.22	32.36								25.00
22	40F9	15.21	35.44	66.56	79.17	154.93	172.65				27.47
22	40G0	15.21	35.44	66.56	79.17	154.93	172.65				27.45
22	40G1	22.03	42.33	64.56	109.06	70.34					44.41
22	41G0	22.16	34.60	89.82	114.34	123.00	75.25				32.69
22	Total	15.09	35.34	63.84	90.90	131.43	166.18				23.77
23	39G2	11.95	35.72	57.60	68.36	87.05	46.29	58.82	78.77	84.85	16.66
23	40G2	12.04	54.85	100.96	127.24	184.87	202.71	216.03	222.36	241.47	168.32
23	41G2	7.99	39.28	88.93	131.91	168.96	184.21	182.56	177.17	206.19	10.10
23	Total	9.17	53.84	100.58	127.05	184.76	202.55	215.93	221.99	241.29	149.32
24	37G2	11.07	36.26	35.64	44.33		37.58				14.00
24	37G3	5.83	36.98	67.92	79.26	105.49	84.53	65.56	95.49	79.97	11.36
24	37G4	9.03	38.82	65.06	72.22	85.13	54.64	57.28	85.84	89.25	23.50
24	38G2	9.45	30.66	34.12	40.67		36.89				10.83
24	38G3	6.75	35.98	63.66	68.56	87.44	64.64	62.71	77.17	67.53	13.08
24	38G4	9.03	38.82	65.06	72.22	85.13	54.64	57.28	85.84	89.25	23.50
24	39G2	11.95	35.72	57.60	68.36	87.05	46.29	58.82	78.77	84.85	16.65
24	39G3	11.76	37.82	65.23	75.42	87.86	101.58	64.89	89.31	91.60	39.77
24	39G4	15.02	44.29	64.17	73.15	78.80	82.76	65.12	74.84	73.62	63.79
24	Total	9.44	36.76	63.77	72.54	84.95	78.40	62.52	82.88	82.89	20.75
22-24	Total	11.78	39.11	87.49	113.23	174.65	198.00	208.95	202.77	224.37	68.81
21-24	Total	10.88	39.24	87.29	113.23	174.65	198.00	208.95	202.77	224.37	32.36

Table 9. RV "Solea", cruise 694/2014. Total biomass (t) of herring incl. CBH by age/W-rings and area.

Sub-division	Rectangle/ W-rings	0	1	2	3	4	5	6	7	8+	Total
21	41G0	1,793.1	989.6	4.0	0.0	0.0	0.0	0.0	0.0	0.0	2,786.7
21	41G1	6,699.4	386.6	34.3	0.0	0.0	0.0	0.0	0.0	0.0	7,120.4
21	41G2	6,763.0	358.0	3.5	0.0	0.0	0.0	0.0	0.0	0.0	7,124.4
21	42G1	5,605.0	2,039.9	71.6	0.0	0.0	0.0	0.0	0.0	0.0	7,716.5
21	42G2	15,248.1	17.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15,265.4
21	43G1	43,583.0	491.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	44,074.8
21	43G2	1,441.4	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,443.0
21	Total	81,132.9	4,284.7	113.5	0.0	0.0	0.0	0.0	0.0	0.0	85,531.1
22	37G0	1,517.1	786.3	46.3	23.2	4.4	0.0	0.0	0.0	0.0	2,377.3
22	37G1	3,317.6	1,763.8	309.5	269.5	69.3	13.6	0.0	0.0	0.0	5,743.3
22	38G0	2,720.4	2,788.9	19.0	0.0	0.0	0.0	0.0	0.0	0.0	5,528.3
22	38G1	957.3	384.4	13.1	9.4	1.9	0.0	0.0	0.0	0.0	1,366.2
22	39F9	36.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.1
22	39G0	573.3	1,006.4	7.1	0.0	0.0	0.0	0.0	0.0	0.0	1,586.7
22	39G1	31.3	41.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	72.8
22	40F9	170.4	283.5	20.6	23.0	26.3	29.4	0.0	0.0	0.0	553.2
22	40G0	4,255.6	7,081.3	523.2	575.6	649.2	723.4	0.0	0.0	0.0	13,808.2
22	40G1	283.1	660.8	132.4	442.8	44.3	0.0	0.0	0.0	0.0	1,563.3
22	41G0	398.7	668.1	37.7	129.2	41.8	9.8	0.0	0.0	0.0	1,285.3
22	Total	14,260.9	15,464.8	1,108.9	1,472.57	837.2	776.1	0.00	0.00	0.0	33,920.4
23	39G2	651.5	222.5	78.3	48.54	21.8	12.0	5.29	15.75	5.1	1,060.9
23	40G2	40.7	6,820.6	16,145.5	27,144.1	55,758.6	62,402.3	45,664.4	18,395.8	13,348.5	245,720.5
23	41G2	1,085.9	35.4	22.2	47.5	86.2	73.7	40.2	7.1	2.1	1,400.2
23	Total	1,778.1	7,078.5	16,246.1	27,240.1	55,866.6	62,488.0	45,709.9	18,418.7	13,355.6	248,181.6
24	37G2	1,094.4	422.4	11.1	27.0	0.0	9.0	0.0	0.0	0.0	1,563.9
24	37G3	181.0	46.6	43.5	48.4	35.9	3.4	3.9	22.0	4.8	389.4
24	37G4	584.6	271.4	389.1	390.7	234.1	34.4	48.1	87.6	49.1	2,089.0
24	38G2	1,721.4	370.1	12.6	1.6	0.0	3.7	0.0	0.0	0.0	2,109.4
24	38G3	1,987.5	698.0	673.5	536.1	182.8	43.3	112.3	149.7	59.4	4,442.7
24	38G4	1,082.3	502.3	719.6	722.9	433.3	63.4	88.8	163.1	91.9	3,867.7
24	39G2	2,863.1	978.4	345.0	213.3	94.0	53.2	24.1	68.5	21.2	4,660.9
24	39G3	942.7	892.2	1,138.3	1,381.7	1,020.9	399.2	173.3	383.1	197.9	6,529.2
24	39G4	77.7	335.3	1,245.5	1,318.2	635.1	213.5	180.4	228.3	124.4	4,358.3
24	Total	10,534.7	4,516.6	4,578.1	4,639.9	2,636.1	823.2	630.8	1,102.3	548.7	30,010.5
22-24	Total	26,573.7	27,059.9	21,933.1	33,352.6	59,339.9	64,087.2	46,340.7	19,520.9	13,904.4	312,112.4
21-24	Total	107,706.7	31,344.6	22,046.5	33,352.6	59,339.9	64,087.2	46,340.7	19,520.9	13,904.4	397,643.5

Table 10. FRV "Solea", cruise 694/2014. Numbers (millions) of sprat by age and area.

Sub-division	Rectangle/ Age group	0	1	2	3	4	5	6	7	8+	Total
21	41G0	0.00	0.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.94
21	41G1	1.17	0.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.56
21	41G2	7.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.57
21	42G1	1.11	0.65	0.00	0.98	0.59	0.20	0.00	0.00	0.00	3.53
21	42G2	37.53	0.57	0.00	0.12	0.06	0.00	0.00	0.00	0.00	38.28
21	43G1	5.04	1.68	0.00	0.56	0.56	0.56	1.68	0.00	0.00	10.08
21	43G2	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16
21	Total	52.58	4.23	0.00	1.66	1.21	0.76	1.68	0.00	0.00	62.12
22	37G0	8.08	14.90	8.45	7.75	8.27	0.29	0.00	0.00	0.00	47.74
22	37G1	87.53	131.48	28.21	25.97	33.50	2.53	0.00	0.00	0.00	309.22
22	38G0	105.00	24.96	22.25	24.62	28.83	1.50	0.00	0.00	0.00	207.16
22	38G1	0.26	0.11	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.39
22	39F9	947.91	1.87	0.91	0.11	0.11	0.00	0.00	0.00	0.00	950.91
22	39G0	53.22	17.42	6.47	2.82	2.62	0.24	0.00	0.00	0.00	82.79
22	39G1	74.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	74.78
22	40F9	0.98	0.52	0.54	1.03	1.60	0.01	0.00	0.00	0.00	4.68
22	40G0	24.50	12.89	13.50	25.74	39.98	0.23	0.00	0.00	0.00	116.84
22	40G1	0.90	1.70	1.18	2.79	3.36	0.00	0.00	0.00	0.00	9.93
22	41G0	0.00	11.86	2.25	1.27	1.21	0.04	0.00	0.00	0.00	16.63
22	Total	1,303.16	217.71	83.78	92.10	119.48	4.84	0.00	0.00	0.00	1,821.07
23	39G2	42.94	6.24	1.05	1.33	0.33	0.45	0.23	0.02	0.00	52.59
23	40G2	15.72	17.72	4.91	24.31	30.13	20.92	5.46	2.36	1.99	123.52
23	41G2	62.74	8.58	1.47	0.00	0.00	0.00	0.00	0.00	0.00	72.79
23	Total	121.40	32.54	7.43	25.64	30.46	21.37	5.69	2.38	1.99	248.90
24	37G2	3.29	0.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.66
24	37G3	585.83	261.87	18.63	4.78	0.87	2.72	0.37	0.00	0.00	875.07
24	37G4	1,313.79	123.52	9.21	9.03	3.43	3.98	1.35	0.11	0.00	1,464.42
24	38G2	668.34	527.90	45.20	63.86	17.70	25.73	6.86	0.53	0.00	1,356.12
24	38G3	6,328.66	782.79	50.44	41.63	14.48	17.49	3.88	0.70	0.00	7,240.07
24	38G4	2,432.30	228.68	17.04	16.72	6.36	7.37	2.50	0.20	0.00	2,711.17
24	39G2	188.72	27.42	4.61	5.84	1.43	1.96	1.02	0.08	0.00	231.08
24	39G3	974.55	1,189.67	134.61	186.61	37.33	68.27	22.31	0.88	0.00	2,614.23
24	39G4	11.87	109.14	14.31	23.59	4.48	6.86	1.87	0.20	0.00	172.32
24	Total	12,507.35	3,251.36	294.05	352.06	86.08	134.38	40.16	2.70	0.00	16,668.14
22-24	Total	13,931.91	3,501.61	385.26	469.80	236.02	160.59	45.85	5.08	1.99	18,738.11
21-24	Total	13,984.49	3,505.84	385.26	471.46	237.23	161.35	47.53	5.08	1.99	18,800.23

Table 11. FRV “Solea”, cruise 694/2014. Mean weight (g) of sprat by age and area.

Sub-division	Rectangle/ Age group	0	1	2	3	4	5	6	7	8+	Total
21	41G0		17.33								17.33
21	41G1	1.62	13.00								4.47
21	41G2	2.04									2.04
21	42G1	4.42	12.55		21.93	22.33	24.33				14.90
21	42G2	4.13	6.60		21.33	21.33					4.25
21	43G1	2.00	20.00		24.33	24.33	24.33	27.00			12.89
21	43G2	2.00									2.00
21	Total	3.57	15.81		22.70	23.21	24.33	27.00			6.19
22	37G0	4.96	16.43	18.75	20.24	20.78	18.65				16.28
22	37G1	6.91	15.48	18.34	21.04	21.87	23.25				14.54
22	38G0	1.30	17.10	19.02	20.89	21.49	21.65				10.39
22	38G1	7.35	16.16	16.16							10.29
22	39F9	1.35	17.70	17.70	17.70	17.70					1.40
22	39G0	3.94	16.47	18.12	19.95	20.20	18.65				8.79
22	39G1	5.57									5.57
22	40F9	2.31	16.35	19.49	20.96	21.95	18.65				16.71
22	40G0	2.31	16.35	19.49	20.96	21.95	18.65				16.71
22	40G1	2.63	15.35	20.15	21.03	21.49					18.44
22	41G0	0.00	15.28	18.13	20.09	20.22	18.65				16.40
22	Total	2.11	15.87	18.75	20.86	21.66	21.98				6.80
23	39G2	4.11	12.98	15.74	16.18	17.28	14.83	15.58	19.5		5.93
23	40G2	4.97	16.94	17.07	21.49	22.52	23.38	23.86	28.63	30.64	19.52
23	41G2	2.14	11.37	12.21							3.43
23	Total	3.20	14.71	15.92	21.21	22.46	23.20	23.53	28.55	30.64	11.94
24	37G2	5.61	7.10								5.76
24	37G3	3.58	9.82	10.49	14.49	14.49	13.67	15.85			5.70
24	37G4	4.56	11.57	13.49	15.60	18.10	14.06	16.78	19.50		5.35
24	38G2	4.87	12.61	15.27	15.70	16.96	14.39	16.32	19.50		9.14
24	38G3	3.56	11.27	12.15	15.97	18.25	14.22	16.99	19.50		4.59
24	38G4	4.56	11.57	13.49	15.60	18.10	14.06	16.78	19.50		5.35
24	39G2	4.11	12.98	15.74	16.18	17.28	14.83	15.58	19.50		5.93
24	39G3	4.58	12.72	15.26	15.89	16.28	14.71	16.42	19.50		10.18
24	39G4	4.54	12.22	14.94	16.68	17.77	15.45	16.36	19.50		12.85
24	Total	4.02	11.98	14.26	15.88	17.03	14.55	16.46	19.50		6.19
22-24	Total	3.83	12.25	15.27	17.15	20.08	15.92	17.34	23.74	30.64	6.32
21-24	Total	3.83	12.25	15.27	17.17	20.09	15.96	17.68	23.74	30.64	6.32

Table 12. FRV "Solea", cruise 694/2014. Total biomass (t) of sprat by age and area.

Sub-division	Rectangle/ Age group	0	1	2	3	4	5	6	7	8+	Total
21	41G0	0.0	16.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.3
21	41G1	1.9	5.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.0
21	41G2	15.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.4
21	42G1	4.9	8.2	0.0	21.5	13.2	4.9	0.0	0.0	0.0	52.6
21	42G2	155.0	3.8	0.0	2.6	1.3	0.0	0.0	0.0	0.0	162.6
21	43G1	10.1	33.6	0.0	13.6	13.6	13.6	45.4	0.0	0.0	129.9
21	43G2	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
21	Total	187.7	66.9	0.0	37.7	28.1	18.5	45.4	0.0	0.0	384.1
22	37G0	40.1	244.8	158.4	156.9	171.9	5.4	0.0	0.0	0.0	777.5
22	37G1	604.8	2,035.3	517.4	546.4	732.7	58.8	0.0	0.0	0.0	4,495.4
22	38G0	136.5	426.8	423.2	514.3	619.6	32.5	0.0	0.0	0.0	2,152.9
22	38G1	1.9	1.8	0.3	0.0	0.0	0.0	0.0	0.0	0.0	4.0
22	39F9	1,279.7	33.1	16.1	2.0	2.0	0.0	0.0	0.0	0.0	1,332.8
22	39G0	209.7	286.9	117.2	56.3	52.9	4.5	0.0	0.0	0.0	727.5
22	39G1	416.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	416.5
22	40F9	2.3	8.5	10.5	21.6	35.1	0.2	0.0	0.0	0.0	78.2
22	40G0	56.6	210.8	263.1	539.5	877.6	4.3	0.0	0.0	0.0	1,951.8
22	40G1	2.4	26.1	23.8	58.7	72.2	0.0	0.0	0.0	0.0	183.1
22	41G0	0.0	181.2	40.8	25.5	24.5	0.8	0.0	0.0	0.0	272.7
22	Total	2,750.4	3,455.3	1,570.9	1,921.1	2,588.3	106.4	0.0	0.0	0.0	12,392.4
23	39G2	176.5	81.0	16.5	21.5	5.7	6.7	3.6	0.4	0.0	311.9
23	40G2	78.1	300.2	83.8	522.4	678.5	489.1	130.3	67.6	61.0	2,411.0
23	41G2	134.3	97.6	18.0	0.0	0.0	0.0	0.0	0.0	0.0	249.8
23	Total	388.9	478.7	118.3	543.9	684.2	495.8	133.9	68.0	61.0	2,972.6
24	37G2	18.5	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.1
24	37G3	2,097.3	2,571.6	195.4	69.3	12.6	37.2	5.9	0.0	0.0	4,989.2
24	37G4	5,990.9	1,429.1	124.2	140.9	62.1	56.0	22.7	2.2	0.0	7,828.0
24	38G2	3,254.8	6,656.8	690.2	1,002.6	300.2	370.3	112.0	10.3	0.0	12,397.2
24	38G3	22,530.0	8,822.0	612.9	664.8	264.3	248.7	65.9	13.7	0.0	33,222.3
24	38G4	11,091.3	2,645.8	229.9	260.8	115.1	103.6	42.0	3.9	0.0	14,492.4
24	39G2	775.6	355.9	72.6	94.5	24.7	29.1	15.9	1.6	0.0	1,369.8
24	39G3	4,463.4	15,132.6	2,054.2	2,965.2	607.7	1,004.3	366.3	17.2	0.0	26,610.9
24	39G4	53.9	1,333.7	213.8	393.5	79.6	106.0	30.6	3.9	0.0	2,214.9
24	Total	50,275.7	38,950.2	4,193.1	5,591.6	1,466.3	1,955.0	661.2	52.7	0.0	103,145.8
22-24	Total	53,415.0	42,884.2	5,882.3	8,056.6	4,738.8	2,557.2	795.0	120.6	61.0	118,510.8
21-24	Total	53,602.7	42,951.1	5,882.3	8,094.3	4,766.9	2,575.7	840.4	120.6	61.0	118,894.9

Table 13. FRV "Solea", cruise 694/2014. Numbers (m) of herring excl. CBH by age/W-rings and area.

Sub-division	Rectangle/ W-rings	0	1	2	3	4	5	6	7	8+	Total	
21	41G0	106.92	25.92	0.08	0.00	0.00	0.00	0.00	0.00	0.00	132.92	
21	41G1	466.21	10.15	0.55	0.00	0.00	0.00	0.00	0.00	0.00	476.91	
21	41G2	547.61	8.96	0.07	0.00	0.00	0.00	0.00	0.00	0.00	556.64	
21	42G1	381.81	45.26	1.18	0.00	0.00	0.00	0.00	0.00	0.00	428.25	
21	42G2	1,830.50	0.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,831.15	
21	43G1	4,138.94	15.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4,154.67	
21	43G2	172.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	172.06	
21	Total	7,643.99	106.73	1.88	0.00	0.00	0.00	0.00	0.00	0.00	7,752.60	
22	37G0	104.63	23.34	0.85	0.37	0.07	0.00	0.00	0.00	0.00	129.26	
22	37G1	228.96	48.75	5.07	2.93	0.94	0.18	0.00	0.00	0.00	286.83	
22	38G0	176.65	82.17	0.40	0.00	0.00	0.00	0.00	0.00	0.00	259.22	
22	38G1	70.60	10.64	0.26	0.15	0.03	0.00	0.00	0.00	0.00	81.68	
22	39F9	3.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.38	
22	39G0	37.42	28.72	0.15	0.00	0.00	0.00	0.00	0.00	0.00	66.29	
22	39G1	1.63	1.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.91	
22	40F9	11.20	8.00	0.31	0.29	0.17	0.17	0.00	0.00	0.00	20.14	
22	40G0	279.79	199.81	7.86	7.27	4.19	4.19	0.00	0.00	0.00	503.11	
22	40G1	12.85	15.61	2.05	4.06	0.63	0.00	0.00	0.00	0.00	35.20	
22	41G0	17.99	19.31	0.42	1.13	0.34	0.13	0.00	0.00	0.00	39.32	
22	Total	945.10	437.63	17.37	16.20	6.37	4.67	0.00	0.00	0.00	1,427.34	
23	39G2	54.52	6.01	1.18	0.50	0.18	0.02	0.00	0.06	0.02	62.49	
23	40G2	3.38	124.35	159.92	213.33	301.61	307.84	211.38	82.73	55.28	1,459.82	
23	41G2	135.91	0.90	0.25	0.36	0.51	0.4	0.22	0.04	0.01	138.60	
23	Total	193.81	131.26	161.35	214.19	302.30	308.26	211.60	82.83	55.31	1,660.91	
24	37G2	98.86	11.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	110.51	
24	37G3	31.05	1.26	0.57	0.57	0.32	0.03	0.00	0.10	0.00	33.90	
24	37G4	64.74	6.95	5.85	4.47	2.30	0.15	0.00	0.35	0.35	85.16	
24	38G2	182.16	11.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	193.86	excl. CBH
24	38G3	294.45	18.63	10.05	6.70	1.53	0.25	0.00	0.36	0.00	331.97	
24	38G4	119.86	12.87	10.84	8.27	4.26	0.28	0.00	0.64	0.64	157.66	
24	39G2	239.59	26.43	5.17	2.21	0.80	0.09	0.00	0.28	0.09	274.66	
24	39G3	80.16	22.96	16.79	15.39	10.53	2.29	0.00	1.52	0.55	150.19	
24	39G4	5.17	7.48	19.20	16.69	6.87	1.40	0.00	0.00	0.00	56.81	
24	Total	1,116.04	119.93	68.47	54.30	26.61	4.49	0.00	3.25	1.63	1,394.72	
22-24	Total	2,254.95	688.82	247.19	284.69	335.28	317.42	211.60	86.08	56.94	4,482.97	
21-24	Total	9,898.94	795.55	249.07	284.69	335.28	317.42	211.60	86.08	56.94	12,235.57	

Table 14. FRV "Solea", cruise 694/2014. Mean weight (g) of herring excl. CBH by age/W-rings and area.

Sub-division	Rectangle/ W-rings	0	1	2	3	4	5	6	7	8+	Total	
21	41G0	16.77	38.18	50.00							20.97	
21	41G1	14.37	38.09	62.43							14.93	
21	41G2	12.35	39.95	50.00							12.80	
21	42G1	14.68	45.07	60.71							18.02	
21	42G2	8.33	26.59								8.34	
21	43G1	10.53	31.26								10.61	
21	43G2	8.38	26.59								8.39	
21	Total	10.61	40.14	60.36							11.03	
22	37G0	14.50	33.69	54.42	62.63	62.63					18.39	
22	37G1	14.49	36.18	61.05	91.98	73.73	75.25				20.02	
22	38G0	15.40	33.94	47.52							21.33	
22	38G1	13.56	36.13	50.49	62.63	62.63					16.73	
22	39F9	10.67									10.67	
22	39G0	15.32	35.04	47.25							23.94	
22	39G1	19.22	32.36								25.00	
22	40F9	15.21	35.44	66.56	79.17	154.93	172.65				27.47	
22	40G0	15.21	35.44	66.56	79.17	154.93	172.65				27.45	
22	40G1	22.03	42.33	64.56	109.06	70.34					44.41	
22	41G0	22.16	34.60	89.82	114.34	123.00	75.25				32.69	
22	Total	15.09	35.34	63.84	90.90	131.43	166.18				23.77	
23	39G2	11.95	36.29	60.84	76.10	96.09	105.00		103.50	100.50	16.12	
23	40G2	12.04	54.85	100.96	127.24	184.87	202.71	216.03	222.36	241.47	168.32	
23	41G2	7.99	39.28	88.93	131.91	168.96	184.21	182.56	177.17	206.19	10.10	
23	Total	9.17	53.89	100.65	127.13	184.79	202.68	216.00	222.25	241.41	149.39	
24	37G2	11.07	36.26								13.73	
24	37G3	5.83	36.98	71.44	81.86	108.69	105.00		113.73		10.75	
24	37G4	9.03	38.92	65.64	75.96	89.76	84.89		100.50	100.50	21.94	
24	38G2	9.45	30.99								10.75	
24	38G3	6.75	36.58	65.19	71.44	95.87	95.29		111.17		12.09	excl. CBH
24	38G4	9.03	38.92	65.64	75.96	89.76	84.89		100.50	100.50	21.93	
24	39G2	11.95	36.29	60.84	76.10	96.09	105.00		103.50	100.50	16.13	
24	39G3	11.76	38.31	66.31	79.58	90.57	132.69		109.40	130.71	37.66	
24	39G4	15.02	44.58	64.43	74.66	81.51	99.97				63.27	
24	Total	9.44	37.16	65.08	76.10	88.72	115.09		106.51	110.69	19.35	
22-24	Total	11.78	39.19	88.21	115.33	176.15	200.90	216.00	217.88	237.67	68.93	
21-24	Total	10.88	39.32	88.00	115.33	176.15	200.90	216.00	217.88	237.67	32.25	

Table 15. FRV "Solea", cruise 694/2014. Total biomass (t) of herring excl. CBH by age/W-rings and area.

Sub-division	Rectangle/ W-rings	0	1	2	3	4	5	6	7	8+	Total	
21	41G0	1,793.1	989.6	4.0	0.0	0.0	0.0	0.0	0.0	0.0	2,786.7	
21	41G1	6,699.4	386.6	34.3	0.0	0.0	0.0	0.0	0.0	0.0	7,120.4	
21	41G2	6,763.0	358.0	3.5	0.0	0.0	0.0	0.0	0.0	0.0	7,124.4	
21	42G1	5,605.0	2,039.9	71.6	0.0	0.0	0.0	0.0	0.0	0.0	7,716.5	
21	42G2	15,248.1	17.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15,265.4	
21	43G1	43,583.0	491.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	44,074.8	
21	43G2	1,441.4	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,443.0	
21	Total	81,132.9	4,284.7	113.5	0.0	0.0	0.0	0.0	0.0	0.0	85,531.1	
22	37G0	1,517.1	786.3	46.3	23.2	4.4	0.0	0.0	0.0	0.0	2,377.3	
22	37G1	3,317.6	1,763.8	309.5	269.5	69.3	13.6	0.0	0.0	0.0	5,743.3	
22	38G0	2,720.4	2,788.9	19.0	0.0	0.0	0.0	0.0	0.0	0.0	5,528.3	
22	38G1	957.3	384.4	13.1	9.4	1.9	0.0	0.0	0.0	0.0	1,366.2	
22	39F9	36.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.1	
22	39G0	573.3	1,006.4	7.1	0.0	0.0	0.0	0.0	0.0	0.0	1,586.7	
22	39G1	31.3	41.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	72.8	
22	40F9	170.4	283.5	20.6	23.0	26.3	29.4	0.0	0.0	0.0	553.2	
22	40G0	4,255.6	7,081.3	523.2	575.6	649.2	723.4	0.0	0.0	0.0	13,808.2	
22	40G1	283.1	660.8	132.4	442.8	44.3	0.0	0.0	0.0	0.0	1,563.3	
22	41G0	398.7	668.1	37.7	129.2	41.8	9.8	0.0	0.0	0.0	1,285.3	
22	Total	14,260.9	15,464.8	1,108.9	1,472.57	837.2	776.1	0.00	0.00	0.0	33,920.4	
23	39G2	651.5	218.1	71.8	38.1	17.3	2.1	0.0	6.2	2.0	1,007.1	
23	40G2	40.7	6,820.6	16,145.5	27,144.1	55,758.6	62,402.3	45,664.4	18,395.8	13,348.5	245,720.5	
23	41G2	1,085.9	35.4	22.2	47.5	86.2	73.7	40.2	7.1	2.1	1,400.2	
23	Total	1,778.1	7,074.1	16,239.5	27,229.7	55,862.1	62,478.0	45,704.6	18,409.1	13,352.5	248,127.8	
24	37G2	1,094.4	422.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,516.8	
24	37G3	181.0	46.6	40.7	46.7	34.8	3.2	0.0	11.4	0.0	364.3	
24	37G4	584.6	270.5	384.0	339.5	206.5	12.7	0.0	35.2	35.2	1,868.1	
24	38G2	1,721.4	362.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2,084.0	
24	38G3	1,987.5	681.5	655.2	478.7	146.7	23.8	0.0	40.0	0.0	4,013.4	excl. CBH
24	38G4	1,082.3	500.9	711.5	628.2	382.4	23.8	0.0	64.3	64.3	3,457.8	
24	39G2	2,863.1	959.1	314.5	168.2	76.9	9.5	0.0	29.0	9.1	4,429.3	
24	39G3	942.7	879.6	1,113.3	1,224.7	953.7	303.9	0.0	166.3	71.9	5,656.1	
24	39G4	77.7	333.5	1,237.1	1,246.1	560.0	140.0	0.0	0.0	0.0	3,594.2	
24	Total	10,534.7	4,456.7	4,456.4	4,132.0	2,360.8	516.7	0.0	346.2	180.4	26,983.9	
22-24	Total	26,573.7	26,995.6	21,804.8	32,834.3	59,060.1	63,770.9	45,704.6	18,755.3	13,533.0	309,032.1	
21-24	Total	107,706.7	31,280.2	21,918.2	32,834.3	59,060.1	63,770.9	45,704.6	18,755.3	13,533.0	394,563.2	

Annex 6b: Northern Ireland (Irish Sea and Northern Channel)

Annex 6B: Irish Sea acoustic survey (Northern lreland)

Survey report for RV Corystes

28 August-14 September 2013

Pieter-Jan Schön,
Agri-Food and Biosciences Institute (AFBI), Belfast,
Northern Ireland

INTRODUCTION

Acoustic surveys of the northern Irish Sea (ICES Area VIIaN) have been carried by the Agri-Food and Biosciences Institute (AFBI), formerly the Department of Agriculture and Rural Development for Northern Ireland (DARD), since 1991. This report covers the routine Irish Sea survey in autumn.

SURVEY DESCRIPTION and METHODS

Personnel

Pieter-Jan Schön (SIC)
Bill Clarke
Peter McCorriston
Ian McCausland
Clara Alvarez Alonso
Vanessa Brown
Enda O'Callaghan
Philip Stewart
Mathieu Lundy

Narrative

The vessel departed Belfast at 2200 on the 28th August and proceeded to the east coast of the Isle of Man for acoustic calibration off Laxey on the 28th August. An additional survey was conducted from 27–28 August. The survey started off the northwest coast of the Isle of Man at 1445 on the 29th August and was completed at 1915 on the 13th September. A repeat of the grid to the east of the Isle of Man was conducted 13–14 September. Sea conditions were reasonably good during the survey, with a few poor weather days in the middle of the survey that mostly coincided with a mid-cruise break.

Survey design

The survey design of systematic, parallel transects covers approximately 620 nm (Figure 6B.1). The position of the set of widely-spaced (8–10 nm) transects around the periphery of the Irish Sea is randomized within +/- 4 nm of a baseline position each year. Transect spacing is reduced to 2 nm in strata around the Isle of Man to improve precision of estimates of adult herring biomass. Relatively lower effort is deployed around the periphery of the Irish Sea where the acoustic targets comprise mainly extended school groups of sprats and 0-group herring. Although this survey design yields high-precision estimates for these small clupeoids due to their extended distribution, the probability of encountering highly aggregated and patchy schools of larger herring remains low around the periphery of the Irish Sea compared with around the Isle of Man. Survey design and methodology adheres to the methods laid out in the WGIPS acoustic survey manual.

Calibration

The hull-mounted transducer ES38B was calibrated on 28 August off Laxey on the east coast of the Isle of Man. Conditions were good and the calibration results satisfactory. All procedures were according to those defined in the survey manual. Summary of calibration results are presented in Table 6B.1.

Acoustic data collection

Acoustic data were only collected during 24hrs a day, except in coastal areas on the English and Irish coasts were data collection was restricted to daylight hours (06:00–21:00). Acoustic data at 38 kHz are collected in 15-minute elementary distance sampling units (EDSU's) with the vessel steaming at 10 knots. A Simrad EK-60 echosounder with hull-mounted split-beam transducer is employed, and data are logged and analysed using SonarData Echoview software. The system settings are given in Table 6B.1.

Biological data – fishing stations

Targets are identified where possible by aimed midwater trawling fitted with a sprat brailer. The net was fished with a vertical mouth opening of approximately 15m, which was observed using a SCANMAR "Trawleye" netsounder. To facilitate determining the position of the net in the water column, a SCANMAR depth sensor is also fitted to the headline.

Trawl catches are sorted to species level and then weighted. Depending on the number of fish, the sorted catch is normally subsampled for length measurements. Length frequencies are recorded in 0.5 cm length classes. Individual length-weight data are collected for all fish species contributing to the catches. Random samples of 50 herring (1+ gp) are taken from each catch for recording of biological parameters (length, weight, sex and maturity) and removal of otoliths for age determination. Random samples of 25 sprats and 25 0-gp herring per haul are collected and frozen for extraction of otoliths on shore.

Hydrographic data

Surface temperature and salinity were recorded using the through-flow thermosalinograph, and logged together with DGPS position at 1-minute intervals.

Data analysis

EDSUs were defined by 15 minute intervals which represented 2.5 nm per EDSU, assuming a survey speed of 10 knots. The surface-area backscattering (NASC) estimates are calculated for schools, school groups and scattering layers using a threshold of -60 dB. Targets in each 15-minute interval were allocated to species or species mixes by scrutinizing the echo charts together with acoustic records during trawling and maps of NASC values indicating location of trawls relative to school groups. In some cases, trawls with similar species and size composition are combined to give a more robust estimate of population length composition. Data were analysed using quarter rectangles of 15′ by 30′.

The single-species or mixed-species mean target strength (*TS*) is calculated from trawl data for each interval as 10 log $\{(\Sigma_{s,l}\ N_{s,l}.10^{0.1.TS_{s,l}}) \ / \ \Sigma_{s,l}\ N_{s,l}\}$ where $N_{s,l}$ is the number of fish of species *s* in length class *l*. The values recommended by ICES for the parameters *a* and *b* of the length -*TS* relationship $TS = a \log(l) + b$ are used: $a = 20$ (all species); $b = -71.2$ (herring, sprat, horse mackerel), -84.9 (mackerel) and -67.5 (gadoids). The weighted mean *TS* is applied to the NASC value to give numbers per square nautical mile. For herring, this is further decomposed into densities by age class according to the length frequencies in the relevant target-identification trawls and the survey age–length key. Mean weights-at-age, calculated from length-weight parameters for the survey, is used to calculate biomass of herring from the estimated numbers-at-age. The weighted mean fish density is estimated for each survey stratum (Figure 6B.1) using distance covered in each 15-minute EDSU as weighting factors, and raised by stratum surface area. Approximate standard errors are computed for the biomass estimates based on the variation between EDSUs within strata.

RESULTS

Biological data

Sampling intensity was high during the 2013 survey with 41 successful trawls completed. Table 6B.2 gives the positions, catch composition and mean length by species for these trawl hauls. Forty hauls contained herring to be used in the analysis, but only 20 hauls contained large numbers/proportions of herring. The length frequency distributions of these hauls are illustrated in Figure 6B.2. Length frequency distributions reflect the general juvenile/adult herring distributions within the sampling area.

The resulting weight-length relationship for herring was calculated from the sampling information as $W = 0.00273*L^{3.343}$ (length measured in cm). The age length key (Table 6B.3) used in the analysis indicate that the population is composed of juveniles and adults fish (age 0–11).

Acoustic data

The distribution of the NASC values assigned to herring and to clupeoid mixes (juvenile herring and sprat) are presented in Figure 6B.3 and for herring only in Figure 6B.4. The highest abundance of herring was towards the northeast Isle of Man and off the Mull of Galloway.

Biomass estimates

The estimated biomass and number of herring and sprat by strata are given in Table 6B.4. The total number estimate comprises of ~94% age 0, ~1% age 1, ~3% age 2, ~1% age 3, ~1% age 4 and <1% age 5+.

DISCUSSION

The herring stock estimate in the survey area (Irish Sea/North Channel) was estimated to be 123,407 t or 1.0×10^{10} individuals. The major contribution of ages to the total estimates is from ages 0 fish by number and weight.

The herring were fairly widely distributed within mixed schools at low abundance, with a few distinct high abundance areas. The largest herring aggregations were found northwest of the Isle of Man and off the Northern Ireland coast.

Sprat and 0-group herring were distributed around the periphery of the Irish Sea, with the most abundance of 0-group herring in the northeast. The bulk of 1+ herring targets in 2013 were observed north of the Isle of Man and off the Mull of Galloway (southwestern corner of stratum 5; Figure 6B.1&4), with a fairly scattered lesser abundance observed throughout the Irish Sea (Figure 6B.4). The length frequencies generated from these trawls highlight the spatial heterogeneous nature of herring age groups in the Irish Sea (Figure 6B.2).

The estimate of herring SSB of 55 350 t for 2013 is similar to the 2012 estimate. The biomass estimate of 65 649 t for 1+ ringers is, however, lower than the 2012 estimate and a significant reduction from the 2010 and 2011 estimates, which were the highest in the time-series. More than a third of the 1+biomass estimate was to the north of the Isle of Man. This is an area of mixed size fish and the survey was mismatched with the migration of the main spawning biomass, as indicated by the high abundance of herring observed by the fishery on the Douglas Bank post survey. Results of a successive acoustic survey conducted later in September confirmed this. The evidence of higher abundance of spawning herring suggests poor reflection of the current age structure and abundance of the herring population in the Irish Sea.

TABLES AND FIGURES

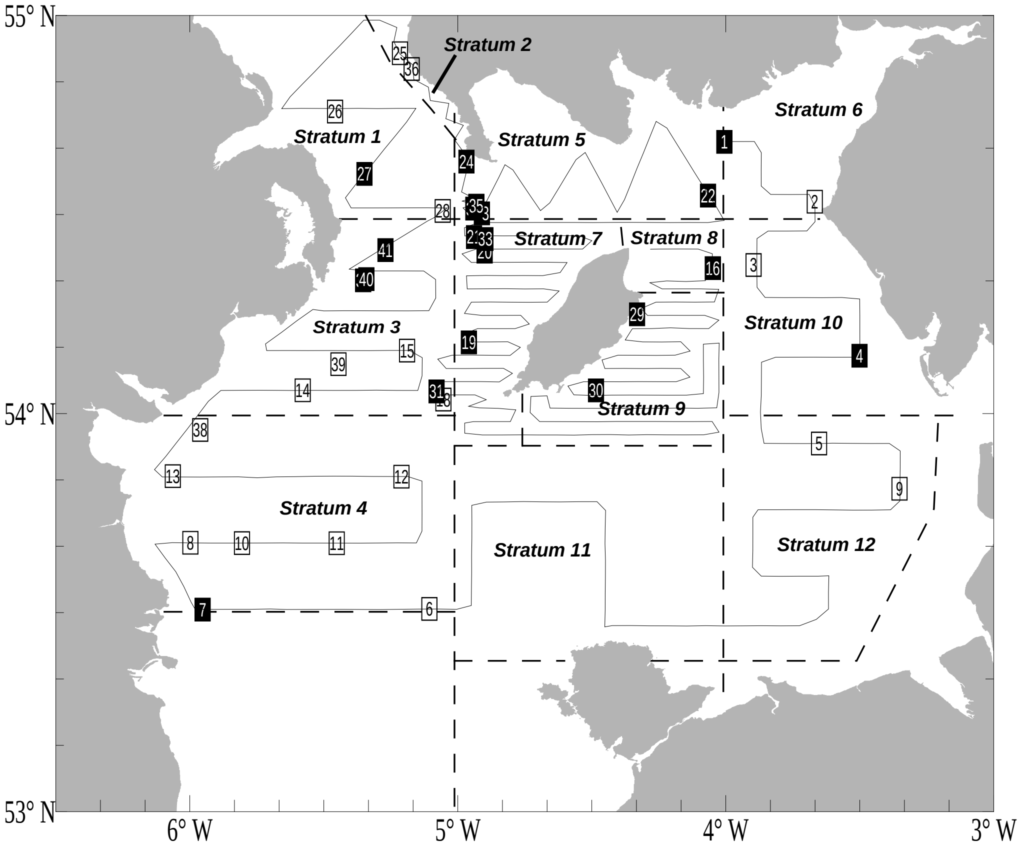

Figure 6B.1. Acoustic survey tracks with trawl positions of the 2013 Irish Sea and North Channel survey on RV "Corystes". Filled squares indicate trawls in which significant numbers of herring were caught or trawls with a large proportion of herring, while open squares indicate trawls with few or no herring.

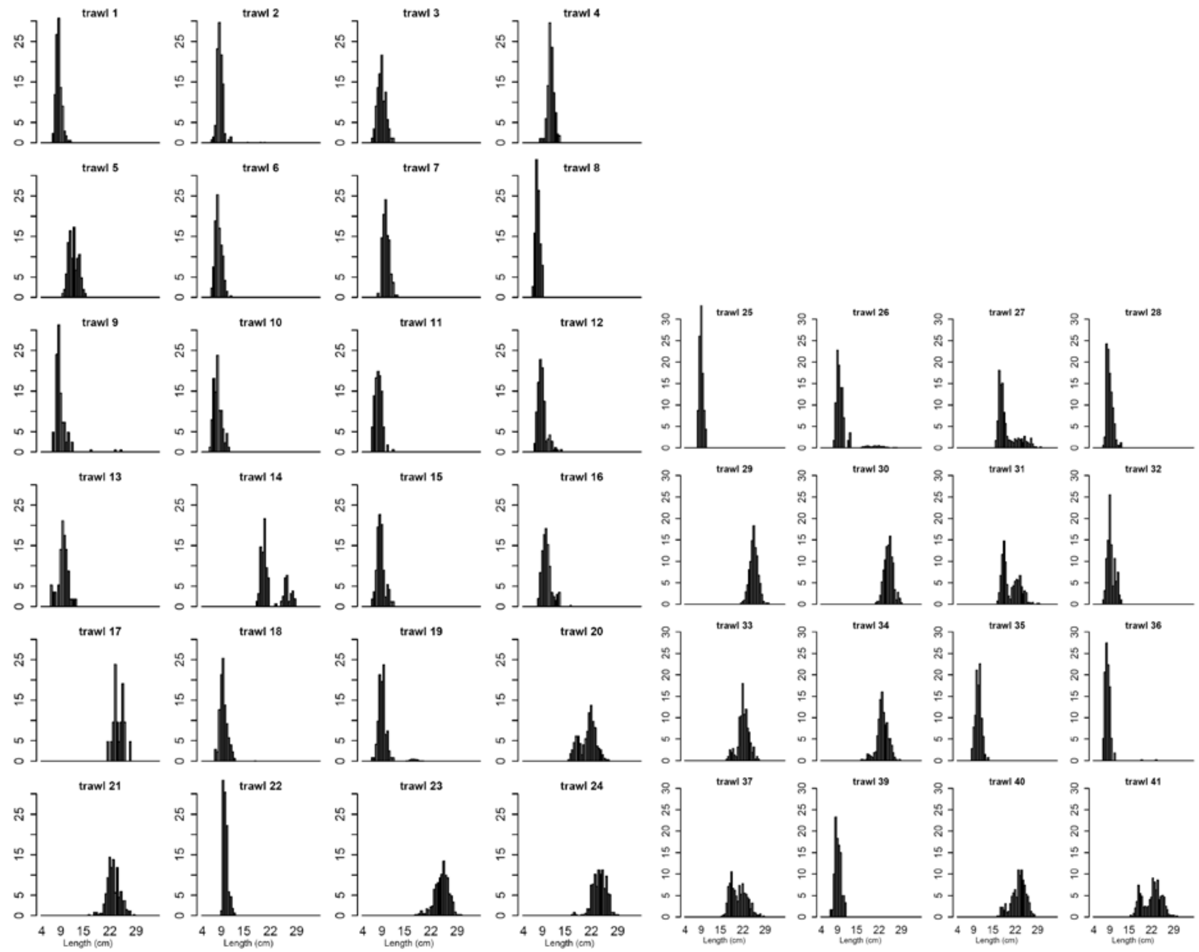

Figure 6B.2. Percentage length compositions of herring in each trawl sample in the September 2013 Irish Sea and North Channel acoustic survey on RV "Corystes".

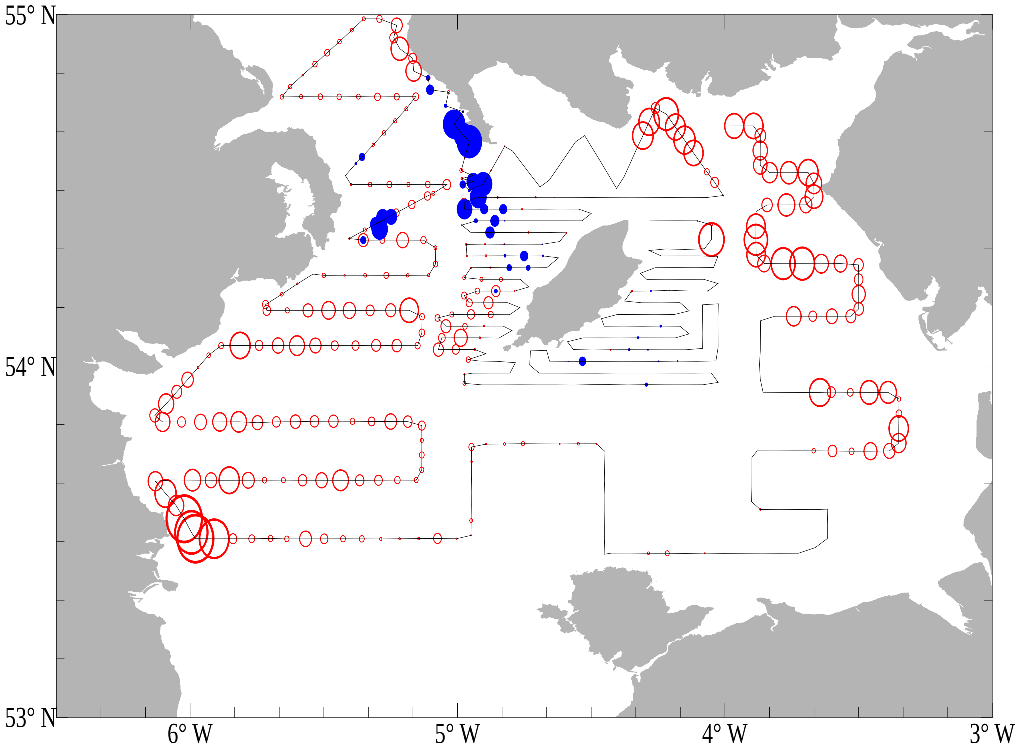

Figure 6B.3. Map of the Irish Sea and North Channel with a post plot showing the distribution of NASC values (size of ellipses is proportional to square root of the NASC value per 15-minute interval) obtained during the 2013 acoustic survey on RV "Corystes". (a) Solid circles are for herring NASC values (maximum value was 6500) and (b) open circles are for clupeoid mix NASC, which include juvenile herring and sprat (maximum value was 14600).

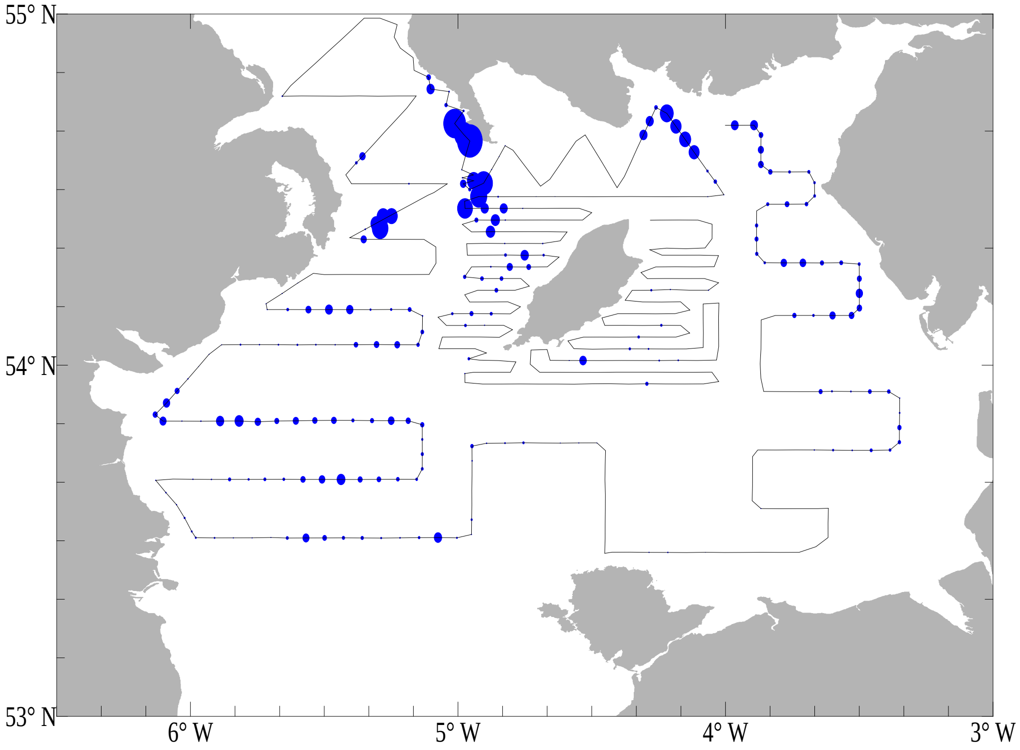

Figure 6B.4. Map of the Irish Sea and North Channel with a post plot showing the distribution of NASC values for assigned herring only (size of ellipses is proportional to square root of the NASC value per 15-minute interval) obtained during the 2013 acoustic survey on RV "Corystes" (maximum value was 6500).

Table 6B.1. Simrad EK60 and analysis settings used on the September 2013 Irish Sea and North Channel herring acoustic survey on RV "Corystes".

Transceiver Menu	
Frequency	38 kHz
Sound speed	1511 m.s^{-1}
Max. Power	2000 W
Equivalent two-way beam angle	-20.6 dB
Default Transducer Sv gain	24.74 dB
3 dB Beam width	6.89°
Calibration details	
TS of sphere	-33.6 dB
Range to sphere in calibration	12.1 m
Log Menu	
Integration performed in Echoview post-processing based on 15 minute EDSUs	
Operation Menu	
Ping interval	0.7 s 1 s at 250 m range
Analysis settings	
Bottom margin (backstep)	0.5 m
Integration start (absolute) depth	8 m
Sv gain threshold	-60 dB

Table 6B.2. Catch composition and position of hauls undertaken by the RV Corystes during the Irish Sea/North Channel survey, September 2013.

		Shooting details				Total fish	percentage composition of fish by weight							Mean length (cm)		Invertebrate catch (kg)
Tow	Date	Time	Lat	Long	depth (m)	catch (kg)	sprat	herring	mackerel	scad	anchovy	whiting	other fish	sprat	herring	
1	28/08	1650	54 41.0	4 0.3	40	218	81.43	18.54	0.00	0.00	0.00	0.02	0.00	7.3	8.7	
2	28/08	1946	54 31.9	3 40.1	25	255	95.45	2.68	1.84	0.00	0.00	0.01	0.01	6.6	8.9	
3	29/08	0730	54 22.4	3 53.8	45	498	94.73	3.95	1.28	0.00	0.00	0.03	0.00	7.1	9.2	
4	29/08	1053	54 8.7	3 30.1	26	120	48.17	46.29	5.14	0.00	0.00	0.00	0.40	7.6	11.5	
5	29/08	1530	53 55.5	3 39.1	35	117	96.16	2.80	1.03	0.00	0.00	0.00	0.01	11.8	12.6	
6	30/08	1755	53 48.7	3 21.1	25	247	92.62	6.83	0.52	0.00	0.00	0.03	0.00	6.3	8.5	
7	30/08	1835	53 30.6	5 6.4	98	50	9.06	88.62	0.00	0.00	0.00	0.78	1.54	8.8	10.4	
8	31/08	2241	53 30.5	5 57.1	37	425	90.94	0.39	0.00	0.00	0.00	8.42	0.26	5.3	8.0	
9	31/08	0758	53 40.5	5 59.9	35	221	95.86	0.55	1.84	0.00	0.00	0.54	1.21	6.5	9.2	
10	31/08	0956	53 40.5	5 48.3	65	281	95.27	4.46	0.27	0.00	0.00	0.01	0.00	5.6	8.3	
11	31/08	1230	53 40.5	5 27.1	118	66	24.47	21.86	2.49	0.00	0.00	38.35	12.83	5.9	8.3	
12	31/08	1545	53 50.5	5 12.6	65	45	73.00	26.34	0.00	0.00	0.00	0.40	0.25	7.4	9.2	
13	31/08	2017	53 50.6	6 3.8	35	32	50.29	1.14	48.56	0.00	0.00	0.00	0.00	6.9	9.9	
14	01/09	0900	54 3.5	5 34.7	67	28	78.69	7.10	13.61	0.00	0.00	0.60	0.00	6.5	9.2	
15	01/09	1220	54 9.5	5 11.4	117	166	91.71	7.70	0.59	0.00	0.00	0.00	0.00	6.4	9.0	
16	03/09	0735	54 21.9	4 2.9	42	898	90.05	9.90	0.05	0.00	0.00	0.00	0.00	9.6	10.4	
17	04/09	0200	54 0.8	4 32.3	43	65	0.00	4.25	95.75	0.00	0.00	0.00	0.00		24.6	
18	04/09	1331	54 2.1	5 3.2	70	227	68.70	30.70	0.57	0.00	0.00	0.00	0.02	7.2	9.8	
19	04/09	1900	54 10.7	4 57.5	83	245	22.87	70.63	1.73	0.00	0.00	0.63	4.14	7.1	9.5	
20	05/09	0510	54 24.4	4 54.0	72	179	0.00	94.84	2.83	0.00	0.00	0.94	1.39		21.3	
21	05/09	0920	54 26.6	4 56.4	79	2500	0.00	100.00	0.00	0.00	0.00	0.00	0.00		23.3	
22	05/09	1441	54 32.9	4 4.0	57	76	19.67	79.22	1.11	0.00	0.00	0.00	0.00	12.0	10.4	
23	05/09	2257	54 30.2	4 54.6	77	1067	0.00	93.72	2.30	0.00	0.00	0.26	3.72		25.2	
24	06/09	0157	54 38.0	4 58.1	66	52	0.00	100.00	0.00	0.00	0.00	0.00	0.00		24.5	
25	06/09	0534	54 54.3	5 12.9	47	58	97.73	0.19	0.25	0.00	0.00	1.42	0.41	5.4	9.3	
26	06/09	0942	54 45.5	5 27.5	103	63	45.94	45.85	4.65	0.00	0.00	2.88	0.68	7.8	10.6	
27	06/09	1330	54 36.1	5 20.9	93	580	0.00	99.72	0.27	0.00	0.00	0.01	0.00		19.6	
28	08/09	1558	54 30.5	5 3.4	122	64	75.91	19.81	0.90	0.00	0.00	2.01	1.36	7.2	9.2	
29	09/09	1041	54 15.0	4 19.9	27	5000	0.00	100.00	0.00	0.00	0.00	0.00	0.00		25.7	
30	10/09	2155	54 3.5	4 29.1	36	198	0.00	100.00	0.00	0.00	0.00	0.00	0.00		25.3	
31	11/09	0805	54 3.3	5 4.8	74	369	0.00	91.63	0.73	0.00	0.00	7.24	0.40		20.9	
32	11/09	1614	54 16.8	4 58.5	114	70	2.22	9.32	0.00	0.00	0.00	19.68	68.78	6.1	9.7	
33	12/09	0323	54 26.3	4 53.8	68	235	0.00	84.38	0.22	0.00	0.00	8.94	6.45		22.45	
34	12/09	1009	54 30.9	4 56.52	90	532	0.00	100.00	0.00	0.00	0.00	0.00	0.00		23.41	
35	12/09	1200	54 31.34	4 55.85	99	61	13.13	57.03	27.60	0.00	0.00	1.85	0.39	8.31	10.71	
36	12/09	1833	54 51.93	5 10.32	27	166	85.73	1.09	10.39	0.00	0.00	1.02	1.78	5.30	8.56	
37	12/09	2227	54 20.08	5 21.17	68	340	0.17	38.53	1.08	0.00	0.00	56.24	3.98	11.06	20.94	
38	13/09	0343	53 57.53	5 57.66	36	136	97.75	0.00	1.06	0.00	0.00	1.19	0.00	9.23		
39	13/09	1320	54 7.45	5 26.71	72	1800	99.19	0.46	0.12	0.00	0.00	0.23	0.00	8.61	9.47	
40	14/09	0007	54 20.27	5 20.47	64	1300	0.00	100.00	0.00	0.00	0.00	0.00	0.00		23.31	
41	14/09	0405	54 24.64	5 16.19	60	1000	0.00	100.00	0.00	0.00	0.00	0.00	0.00		22.41	

Table 6B.3. Age-length key for herring from which otoliths were removed at sea during the Irish Sea/North Channel survey. Data are numbers of fish at age in each length class in samples collected from each trawl.

	AGE CLASS (rings, or ages assuming 1 January birthdate)												
Length (cm)	0	1	2	3	4	5	6	7	8	9	10	11	total
6	11												11
7	30												30
8	40												40
9	49												49
10	43												43
11	37												37
12	29												29
13	11												11
14	3												3
15	1	7											8
16		17											17
17		52											52
18		58	1										59
19		59	2										61
20		42	14										56
21		12	66										78
22		7	80	1									88
23			82	13	1								96
24			67	24	7	3							101
25			31	30	26	13	1						101
26			8	30	24	25	9	6	1	1	1		105
27				3	23	29	18	13	4	1	3		94
28				2	6	6	7	15	6	2	2	1	47
29				2	3	1	2	3	2		2		15
30					2					2			4
TOTAL	254	255	350	105	92	77	37	37	13	6	8	1	1235

Table 6B.4. Acoustic survey estimates of biomass (t) and numbers ('000) of herring and sprat by survey stratum from the AFBI acoustic surveys in 2013.

Stratum	No. sprat	Biomass sprat	No. Her	Biomass Her
1	1207780	2637	202029	2610
2	2880565	2534	143169	17020
3	9580260	17400	1135308	21579
4	56399709	62133	3215268	17310
5	502721	5754	3032332	42149
6	9033133	21102	706791	2813
7	366267	873	282106	8838
8	448853	2947	41148	299
9	2562	12	6350	679
10	21192293	49314	1280194	7954
11	480173	1679	129891	799
12	7824410	31125	254932	1357
Total	109918725	197510	10429518	123407

Annex 6c: Celtic Sea Herring Acoustic Survey

Please find enclosed a link to the Celtic Sea herring acoustic survey report 2014:

http://hdl.handle.net/10793/1049

Annex 6d: Boarfish survey

Please find enclosed a link to the Boarfish acoustic survey report 2014:

http://hdl.handle.net/10793/981

Annex 6e: Pelagic ecosystem survey in the Western Channel and eastern Celtic Sea (PELTIC)

Cruise report CEND20_14

PELTIC14: small pelagic fish in the coastal waters of the western Channel and Celtic Sea

Preliminary version V1.0

Prepared by:

Jeroen van der Kooij, Elisa Capuzzo, Joana Silva, Nigel Symes

1 Outline of the survey

1.1 Staff

Part 1 (30th Sept-11th of October)	Part 2 (11– 19th of Oct)
Jeroen van der Kooij (SIC)	Jeroen van der Kooij
Elisa Capuzzo (2IC)	Elisa Capuzzo
Joana Silva (2IC)	Joana Silva
Dave Brown*	Richard Ayers*
Ken May	Chris Lynam*
Mark Etherton*	Ken May
Richard Humphreys	Richard Humphreys
Samuel Roslyn*	Matt Eade*
James Pettigrew	James Pettigrew
Scott Davis	Scott Davis
Kate Collingridge*	Conor Mulholland
Conor Mulholland (Irish Observer)	Nigel Symes
Nigel Symes (Marinelife observer)	Ruth Molloy
Ruth Molloy (Marinelife observer)	

**staff involved in part of the survey*

1.2 Duration

30 September to 19 October

1.3 Location

Western Channel and Celtic Sea coastal-zone (embarking in Portland and disembarking in Swansea)

1.4 Objectives

1. To carry out the third in a series of five annual multidisciplinary pelagic survey of the Western Channel and Celtic Seawaters to estimate the biomass of-, and gain insight into the population of the small pelagic fish community (sprat, sardine, mackerel, anchovy, horse mackerel, herring).
    a. To carry out a fisheries acoustic survey during daylight only using four operating frequencies (38, 120, 200 and 333 kHz) to investigate:
        - distribution of small pelagic species
        - abundance of small pelagic species
        - distribution of the pelagic species in relation to their environment
    b. To trawl for small pelagic species using a 20x40m herring (midwater) trawl (taking the Cosmos Fotø and Engels 800 as back up) in order to obtain information on:
        - Species- and size composition of acoustic marks
        - Age-composition and distribution, from all small pelagic species
        - Length weight and maturity information on pelagic species
        - Stomach contents (stomach will be extracted frozen for future work)
2. To collect plankton samples using 2 different mesh ringnets (80 µm, and 270 µm mesh) at fixed stations along the acoustic transects at night and at a subset of trawl stations during the day. Samples will be processed aboard:
    a. Ichtyoplankton (eggs and larvae, 270 µm) of pelagic species will be identified and counted onboard and combined with information from maturity to identify spawning areas.
    b. Zooplankton will be stored for further analysis back in the lab.
3. To undertake a comprehensive survey of the vertical profile of the water column in the study area using a rosette, ESM2 and Ferrybox methods. At ~30 fixed stations along the acoustic transect, a Rosette and ESM2 will be deployed to obtain a vertical profile of the water column. Water column profile and surface water samples will provide information on chlorophyll, oxygen, salinity temperature, nutrients and the relevant QAQC samples for calibration of the equipment. Water samples will be collected and fixed on board for analysis post hoc.
4. To record the locations, species, numbers and activities of seabirds and marine mammals in the survey area during daylight hours.
5. To further test the ability of a new (continuous) passive zooplankton sampler (CALPS) to supplement ringnet-plankton nets with high resolution data on the surface. Focus includes sardine spawning, and key zooplankton prey.
6. To conduct continuous online measurement of Phytoplankton Functional types by flow cytometry as part of the internal Cefas seedcorn project DP366
7. To collect acoustic data with the new high (333 kHz) frequency echosounder and map the acoustically derived zooplankton densities. These will be compared with data collected under 2 (and where possible 6) as part of a new Defra funded project HAZARD, supplemented by Seedcorn project DP366.

8. To collect water samples for nutrient and TA/DIC analysis in support of a programme on ocean acidification (Naomi Greenwood) to continue autumn time-series in area.
9. To collect, where possible, and freeze 2 kg samples each of mackerel, herring, sardine, sprat, blue whiting and dogfish for dioxin analysis as part of MSFD monitoring (Robin Law)
10. To collect where possible 40 specimens each of adult and juvenile mackerel from the English Channel for Paula Alvarez (AZTI).

1.5 Narrative

Cefas staff joined the RV Cefas Endeavour in the afternoon of Monday the 29th of September. The vessel left Portland the following morning at 6:30 of the 30th of September and steamed straight to the calibration site off Portland Head (50° 36.180 N, 002° 35.762 W), to calibrate the echosounders. During the first calibration attempt tide was still too strong and the time was used to collect a relevant local sound velocity profile for the echosounder calibration, conduct a muster drill and safety walks with all scientific staff. At 14:00 BST the tide started to drop below 0.5 knots and by 16:30 the three frequencies were successfully calibrated. Whereas for anchor the Rosette plus ESM2 logger were deployed and tested and finally, after coming off anchor, the plankton ringnets were tested on the drift.

Wednesday morning the 1st of October the RV Cefas Endeavour sailed to deeper waters of the eastern English Channel. Two shake-down tows were undertaken with the pelagic trawl between 10:00 and 16:00, to get the crew used to the gear, fine-tune her geometry and make some small alterations to the rig.

On Thursday morning the 2nd of October, the survey started proper. Whereas during the previous two years transects were ran for 24 hours, this year fisheries acoustic transects, trawling and bird and mammal observations were conducted during daylight hours only, and CTD and plankton stations were covered during the night. When appropriate, the pelagic trawl was deployed to ascertain the species- and length composition of acoustic targets, or 'marks'. In total 16 valid tows were made. On Wednesday the 8th of October at 19:00 the survey work was suspended due to bad weather associated with a series of westerly depressions, and the Endeavour was forced to seek shelter Northwest of the Isles of Scilly until 13:30 BST the next day when survey work could be resumed. Trawl operations were however not possible due to the remaining swell and wind conditions.

On the morning of 11th October, after completing all but two transects in the western Channel and most of the Isles of Scilly subarea, the Endeavour steamed to Falmouth for a planned staff changeover which commenced at 8:00. D. Brown, M. Etherton, S. Roslyn and K. Collingridge left the vessel, whereas R. Ayers, C. Lynam and M. Eade joined.

After changeover, at 10:00 BST the Endeavour sailed to the start of the last two transects left in the Channel subarea which were completed that day. After completion of the necessary CTD and plankton stations the Endeavour steamed overnight to complete the last of the Isles of Scilly subarea on the 12th of October and set an eastward course to begin the survey of the Bristol Channel subarea. Between the 13th and the 16th of October most of the southwest to northeast running transects were completed in the Bristol Channel subarea and on the night of the 16th saw the last of the primary CTD and zooplankton stations were completed. Whereas the western-most Bristol Channel transects showed very few fish, schools gradually started to appear in large numbers both offshore, parallel with the coast and inshore. Prior to completing the last three of the conventional Bristol Channel transects, the expected increase in southerly winds over the weekend lead to a decision to run the 100 nmi transect from the inner Bristol Channel to the Celtic Deep on the 17th of October. Two planned transects were completed on the 18th of October and deteriorating weather conditions meant that only one trawl could be performed in the morning.

On the morning of the 19th the Endeavour completed the final transect which ran from the north Devon coast into Swansea bay where the pilot was booked for 13:30. The RV Cefas Endeavour docked at 15:30 in Swansea port.

2. Material and Methods

2.1 Study area

The survey were conducted according to the PELTIC survey grid (Figure 1) established in 2012. Acoustic transects, plankton and water sampling were undertaken along the predefined transects, undertaken in a generally east to west direction for the first half of the survey, then a southwest to northeast direction for the second half of the survey. Trawls were undertaken opportunistically, depending on the presence and type of acoustic marks observed.

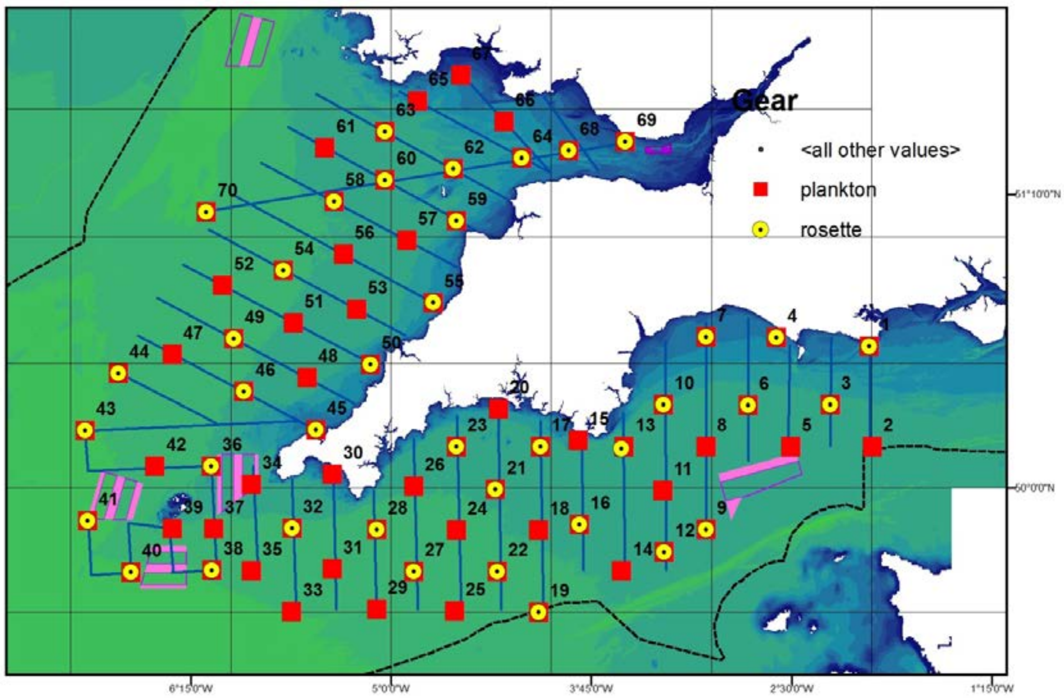

Figure 1. Overview of the survey area, with the acoustic transect (blue lines), plankton stations (red squares) and hydrographic stations (Yellow circles).

2.2 Fisheries acoustics

2.2.1. Acquisition

All three frequency echosounders present were successfully calibrated off Portland on the 14th of October. On the 11th of October a 333kHz GPT was brought onboard following some noise test tests by Simrad. Whereas data were recorded during the second half of the survey, no calibration of the 333 kHz could be conducted. There were still issues with noise rendering data deeper than ~50m useless. After some experiments with pulse duration these were changed to 1.024 ms which appeared to improve the range of good data to 70m.

Fisheries acoustics were recorded along the pre-designed transects (Figure 1) at three operating frequencies (38, 120 and 200 kHz). The transducers were mounted on a drop keel which was lowered to 3.0 m below the hull, 8.2 m below the sea surface, which reduced adverse effects of weather. Pulse duration was set to 0.512 ms for all three frequencies and the ping rate was set to 0.6 pings s-1. Acoustic data were generally of very high standard despite occasional strong windy conditions and Atlantic swell. Occasional spells of very bad weather adversely affected some of the surface data due to aeration but only on one occasion was it necessary to hold acoustic data collection. At all times on-transect live acoustic data were monitored and when unidentified acoustic marks appeared the trawl was shot where possible to identify these marks.

2.2.2. Processing

Acoustic data were cleaned, which included removal of data collected during plankton and oceanographic stations, fishing operations. Both the on-transect data and those collected during the steam between transects were retained. Only the former was used for further biomass estimates but the inter-transect data were retained and cleaned for future studies on spatial distribution of predators and prey. Surface aeration caused by bad weather was removed by setting a surface exclusion line and acoustic data below 1 m above the seabed were also removed, to exclude the strong signals from the seabed. Large amounts of plankton were present throughout the survey, often represented in layers on all three acoustic frequencies (although at different strengths depending on the organisms). Fish schools and plankton were often mixed and a simple extraction of fish echoes was not possible. Therefore to distinguish between organisms with different acoustic properties (echotypes) a multifrequency algorithm developed in 2012 was refined to separate echograms for each of the echotypes (Figure 2). The echogram with only the echoes from fish with swimbladders was then scrutinised and split into a number of categories:

1. Diffuse echoes in the bottom 10 m above the seabed consisting of loosely aggregated gadoids, and scattered mackerel and/or clupeids
2. Schools in midwater consisting predominantly of sprat, sardine, anchovy
3. Mackerel schools, either in midwater or near the seabed – extracted from 200kHz and occasionally pixels need to be removed from 38kHz.
4. Diffuse Unidentified Scattering Targets (DUST) in mid water, often containing fish.
5. Probable sardine schools: ground-truth trawl not successful or available, but acoustic features match those of sardine from adjacent areas and/or sardine eggs were recorded in nearby plankton stations
6. Residual plankton scatterings from very dense plankton layers that could not be removed by the filter

The acoustic density within each of these categories was then attributed to individual species based on the nearest relevant trawls, using imagery of sonar and netsonde collected during the trawling process to assess the sampling performance in relation to the acoustic marks.

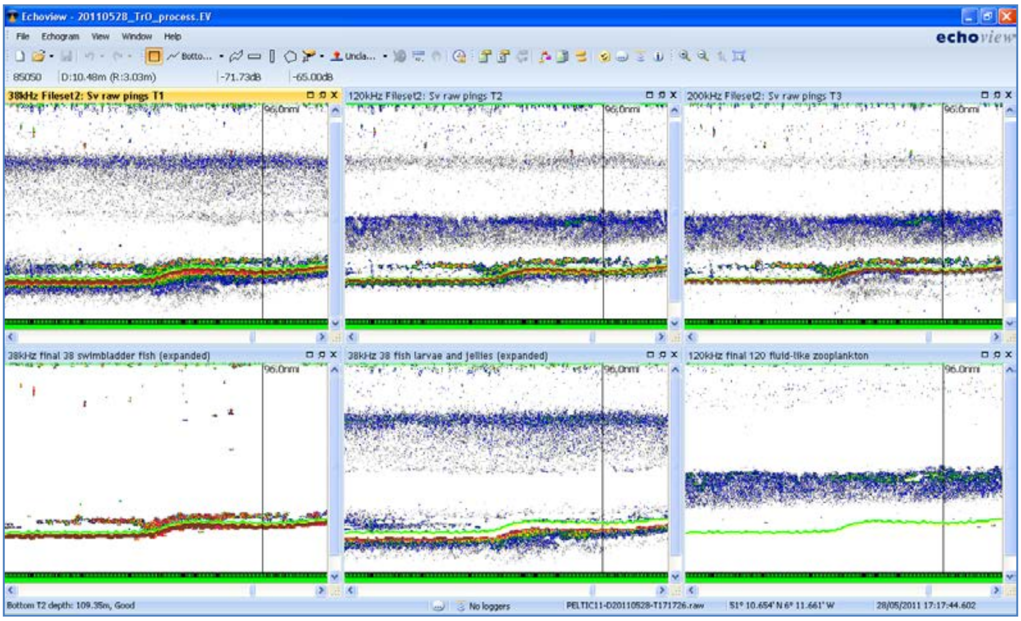

Figure 2. Dataflow of algorithm (top) used to divide the acoustic data by echotype. Screen-shot example (bottom) with raw echograms of 38, 120 and 200 kHz (top panels) and three examples of extracted echotypes (bottom panel from left to righ): fish with swimbladder (sardine schools at surface and myctophids layer near seabed), fish larvae/ jellyfish and zooplankton (dense krill layer).

In the case of mackerel a separate algorithm was used (following Korneliussen 2010). An additional bad weather filter was developed which removed "empty" pings as a result of adverse weather conditions.

2.3 Fishing and catch sampling

A new heavy-duty 'herring' trawl (20 x 40m v d K Herring trawl, KT nets) was used to sample the pelagic community for the purpose of validating acoustic marks and collecting biological samples. The trawl was tested and tuned during the morning of the 2nd of October by experimenting with different weights, speeds and warp. A wireless 50 kHz Marport netsonde was mounted on the headrope of the trawl at the mouth of the net, which allowed for live monitoring of the trawling performance. In general, the trawl performed well and caught a broad range of species and size classes. After preliminary tests during last years survey (2013) a GoPro (Hero silver edition) videocamera mounted in a 10,000 ft. waterproof housing, was mounted in front of the codend (facing forward) with underwater lighting to monitor fish behaviour in the trawl a posteriori.

Fish were sorted to species and size categories before the total catch was weighed and measured using the Cefas EDC system. In the case of very large catches, subsamples were taken before weighing and measuring. The sex and maturity of the pelagic species in each trawl was assessed (10 per length class of mackerel, sprat, sardine, anchovy, horse mackerel, garfish, herring), and their otoliths and stomachs were dissected out and removed for later analysis. For the stomachs a total of 25 stomachs were taken across the various length categories per species per catch.

2.4 Plankton

The various planktonic size components were sampled at 71 fixed plankton stations along the various transects using two ringnets of different mesh: 270 µm (ichtyoplankton and macro-zooplankton) and 80 µm (zooplankton). The two ringnets were fixed to a frame which enabled them to be deployed simultaneously. Both nets had flowmeters (General Oceanics mechanical flowmeters with standard rotor, model 2030R) mounted in the centre of the aperture of the net and a mini-CTD (SAIV) was attached to the bridle. Position, date, time, seabed depth, sampled depth (from CTD attached to net) and flowmeter reading were recorded. Nets were washed down on hauling and samples were transferred from the terminal mesh grid. When possible, samples from the 270 µm mesh were transferred into jars and immediately analysed under a binocular microscope before the full sample was preserved in 4% buffered formaldehyde. If immediate analysis was not possible, samples were transferred into 1 lb glass jars and preserved before analysis on a later day during the survey. Ichthyoplankton (eggs and larvae) and macrozooplankton from the 270 µm samples were counted and, in the case of clupeid larvae, measured and raised using flowmeter derived sample volumes. Samples from the 80 µm mesh were transferred into jars and preserved with 4% buffered formaldehyde for later analysis using a zooscan in the lab.

At a subset of 18 prime stations two water sample were taken and fixed on lugol, one for phytoplankton analysis back in the lab and one for microzooplankton analysis. In addition, this year at 40 stations surface samples of zooplankton were taken using the new CALPS (Cefas Autonomous Litter and Plankton Sampler). For an hour at each of these stations a sample was taken using an 80 µm mesh net to be compared with the vertical casts.

2.5 Oceanography

The main physical, chemical and biological environmental variables were investigated collecting discrete and continuous in situ measurements, and via remote sensing. Daily and weekly maps of chlorophyll concentration (OC5 algorithm), sea surface temperature and frontal systems were obtained from Neodaas (www.neodaas.ac.uk).

Discrete in situ measurements of temperature, salinity, fluorescence, optical backscatter, dissolved oxygen and Photosynthetically Available Radiation (PAR) were collected at 39 sampling stations using an ESM2 profiler. The Rosette water sampler (equipped with an FSI CTD) was used for collection of water samples at discrete depths at 10 sampling stations. At the other stations, where the Rosette could not be deployed due to rough sea conditions, surface samples were collected from the continuous water pump that supplies the Ferrybox.

Samples for determination of Total Alkalinity (TA), dissolved inorganic nutrients and dissolved organic matter (for PML, Shelf Sea Biogeochemistry project), salinity, dissolved inorganic nutrients (for this project), samples for flow cytometry and pigments analysis were collected only at the surface. At 18 stations, samples for analysis at the microscope of phytoplankton and microzooplankton composition and abundance were collected at the surface. Samples for dissolved oxygen analysis were collected at 8 sampling stations for calibration of the oxygen sensor of the ESM2 profiler. A summary of the samples collected and of the CTD casts carried out during the survey is given in Table 2.

Table 1. Samples collected during the survey and number of vertical casts carried out.

	Total
Salinity	18
Dissolved oxygen	8(x3)
TA/DIC	23
Dissolved inorganic nutrients (PML)	23
Dissolved organic nutrients (PML)	23
Dissolved inorganic nutrients (Cefas)	18
Chlorophyll/Pigments analysis (HPLC)	39(x2)
Flow Cytometry	39(x2)
Phytoplankton	18
Microzooplankton	18
CTD casts with ESM2	39

A Ferrybox provided continuous surface measurements of different environmental variables including temperature, salinity, fluorescence, dissolved oxygen. This year it was also connected to a flow cytometer, which performed hourly measurements (continuously) of the size and abundance of pico- and nanoplankton populations. The pCO2 analyser carried out continuous measurements of the dissolved carbon dioxide in water and air during the whole survey.

2.6 Top predators

Effort-related surveys were made for top predators daily during all daylight hours whenever the ship was moving on or between transects. For cetaceans, distance sampling methods were used, whereas seabirds were sampled by a strip transect containing two distance bands (300m and 1km), with sightings grouped into one minute intervals.

Special attention was given to gathering data on Balearic Shearwaters, as the waters off southwest England are considered an increasingly important habitat for this globally critically endangered seabird. For each Balearic Shearwater encountered, more detailed recording was made including precise location, initial and any subsequent behavioural activity. At ~20 minute intervals, or whenever the ships course moved, 'effort data' was recorded including ship's position, speed, direction of travel and environmental conditions (e.g. sea state and swell height). Finally, all seabirds were counted on each trawl, with a maximum count for each species logged over the trawl duration.

3. Preliminary Results

3.1. Pelagic Ichthyofauna

After removing the off-transect data a total of ~1400 nautical miles of acoustic sampling units were collected for further analysis (Figure 3). A total of 16 successful trawls were made (Figure 3). The trawls were evenly spread across the survey area, providing a suitable source of species and length data to adequately partition the acoustic data. However it fell below the originally planned number of trawls mainly due to the fact that at times trawling was not possible mainly due to weather and presence of static gear.

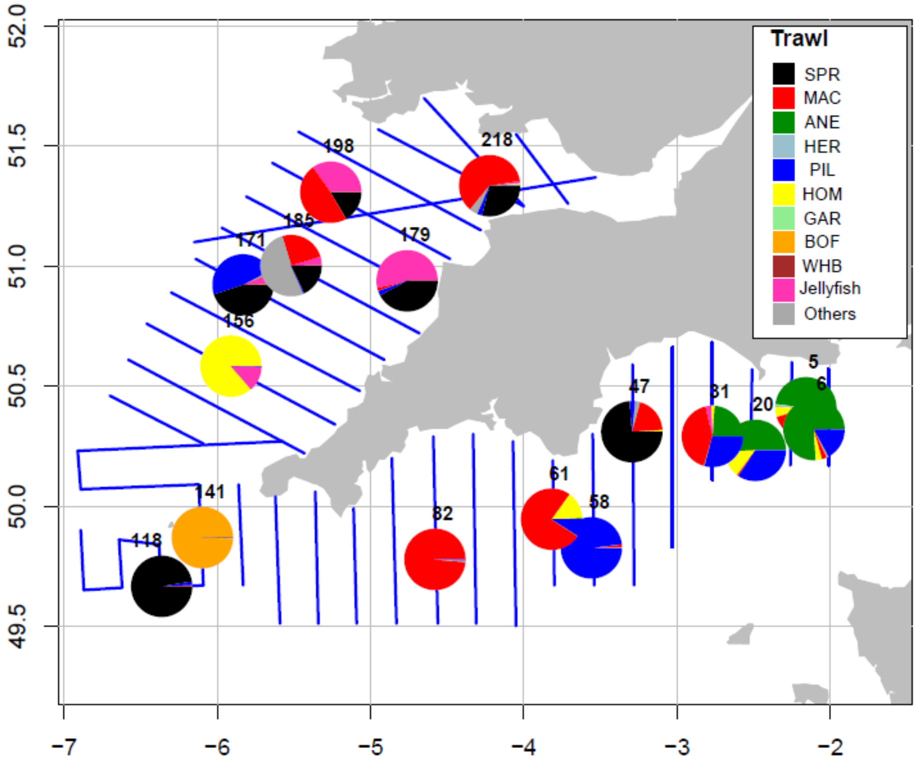

Figure 3. Overview map and detail of the survey area. Acoustic transects (blue lines) and trawl catches (pies) with relative catch composition by key species. Three letter codes: SPR=sprat, MAC=mackerel, ANE=anchovy, HER=herring, PIL=sardine, HOM= horse mackerel, GAR=garfish, BOF=Boarfish, WHB=Blue whiting.

Several trawls included jellyfish of at least three species. Sprat (*Sprattus sprattus*) dominated the inshore waters of England, both in the English Channel and in the Bristol Channel. However sprat in the Bristol Channel consisted nearly entirely of small specimens, whereas those from the Lyme Bay area were more mature (Figure 4). Some very high densities of sprat were encountered in Lyme Bay. For the first time sprat were found in deeper waters around the Isles of Scilly and large offshore aggregations mixed with sardine in the Bristol Channel.

Sardines (*Sardina pilchardus*) were much more widespread than in previous years according to the trawl stations (Figure 3), with predominantly juvenile specimens found in most hauls, including around the Isles of Scilly and offshore in the Bristol Channel (Figure 3 and 4). This year for the first time large spawning aggregations were observed in the acoustic data of the western channel (Figure 4).

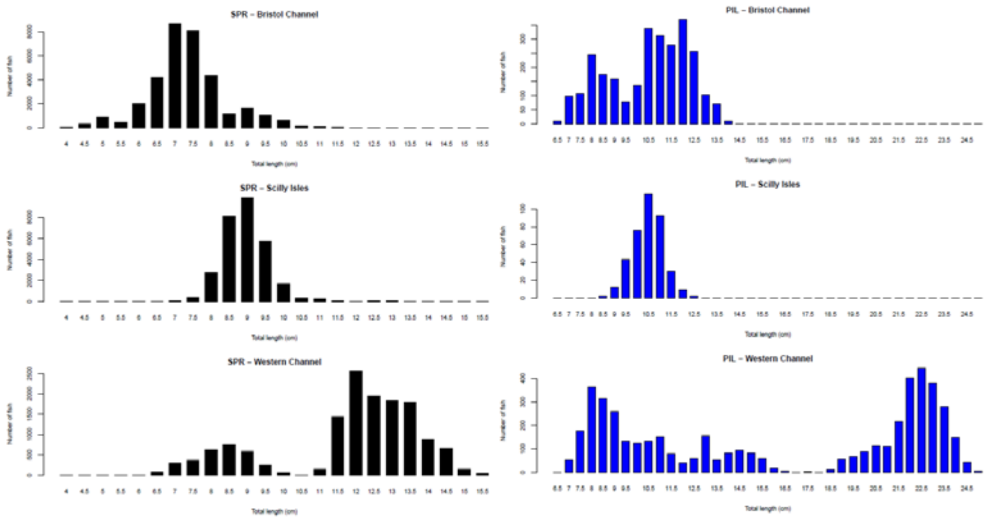

Figure 4. Trawl-caught numbers by length of sardine (*Sardina pilchardus*; left) and sprat (*Sprattus sprattus*) by subarea. Please note that these numbers were not yet raised by the acoustic data.

Mackerel (*Scomber scombrus*) observations appeared to be in line with those in 2012 when only small numbers of juvenile mackerel were found. None of the very large mackerel schools as seen in 2013 were observed in the western channel this year despite the large overlap in timing of the surveys.

This year, anchovy appeared in larger numbers than in previous years but again only in the Lyme Bay trawl stations (Figures 3, 5). However three length classes could be identified in the catches with good numbers of large fish. Horse mackerel (*Trachurus trachurus*) and herring (*Clupea harengus*) were found in the study area (Figure. 3) although generally not in dense schools, but mixed in with other small pelagic species. Herring typically displayed a more coastal distribution whereas horse mackerel were found pretty much across the entire study.

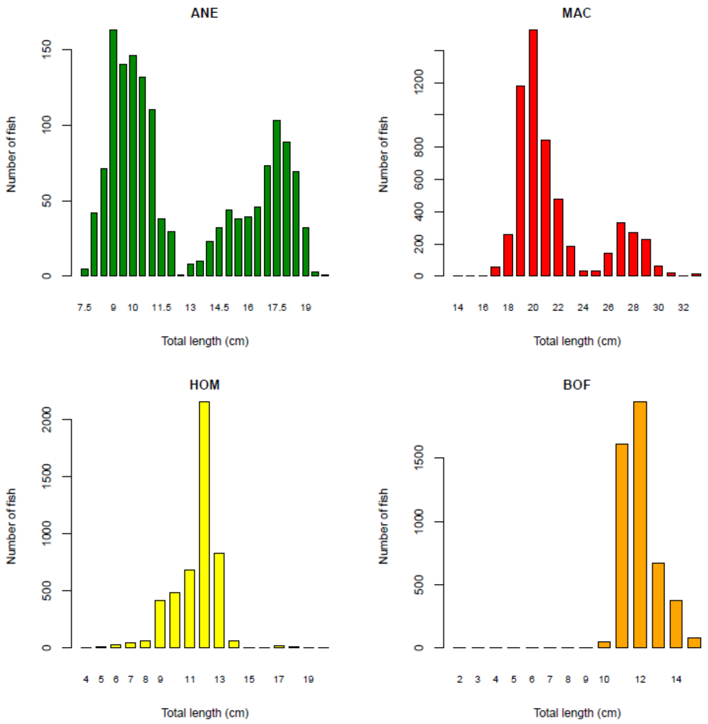

Figure 5. Trawl caught numbers by length of anchovy, mackerel, horse mackerel and boarfish for survey.

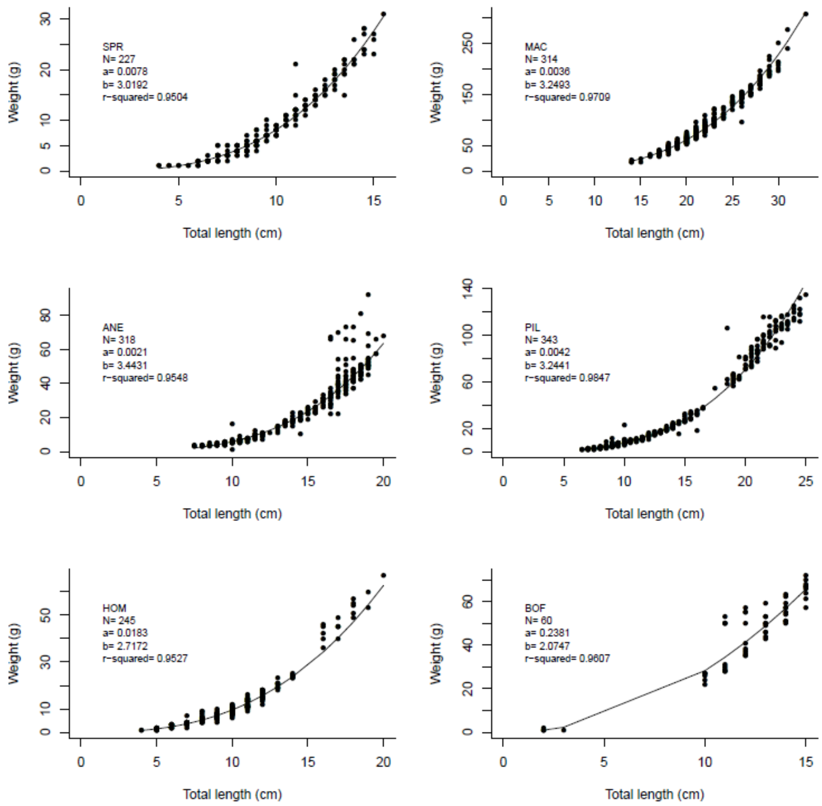

Figure 6. Length weight relationships of dominant pelagic species across the survey area.

3.2. Plankton data

Zooplankton samples were collected at 70 stations with the two ringnets. Whereas water samples were taken from 39 stations, only a subset of 18 "key" stations will be further analysed to extract microzooplankton. Onboard ichthyoplankton processing revealed that the bulk of eggs were sardine (Figure 7), with small numbers of sprat, lemon sole and sandsol making up the remaining categories. Most abundant were sardine eggs (Figure 7) and larvae (Figure 8) and "unidentified clupeid" larvae the vast majority of which were thought to comprise of sardine as few other clupeid species are spawning at this time of year. Sardine eggs were patchily distributed predominantly in the western part of the English Channel (Figure 7) with smaller numbers in the Isles of Scilly. No eggs were found in the Bristol Channel. Although the distribution of sardine eggs was comparable with last year numbers were much higher. Sardine larvae were prevalent throughout the study area, particularly in the western channel but also in Bristol Channel, although those in the latter area consisted of larger specimens and may have drifted there (Figure 8a, b). These results matched those of 2013. In 2012 the distribution was much more restricted to a handful of stations across a diagonal line running southeast from around the Isles of Scilly.

A detailed size based (zooscan) and taxonomic analysis of the zooplankton will be undertaken on return to the laboratory.

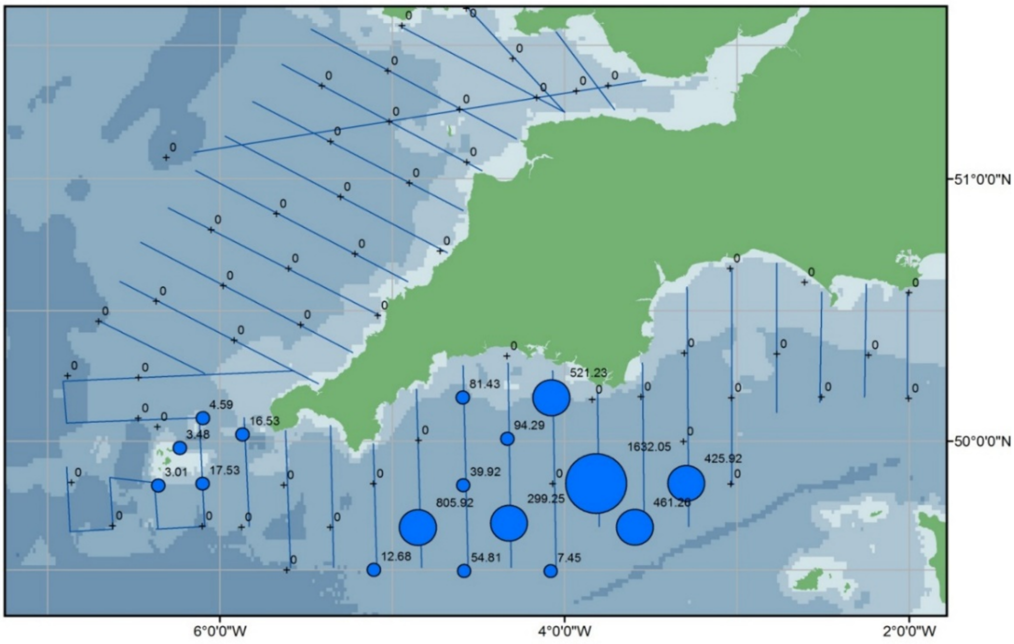

Figure 7. Ichtyo-plankton stations with sardine eggs. Bubble size relative to numbers caught.

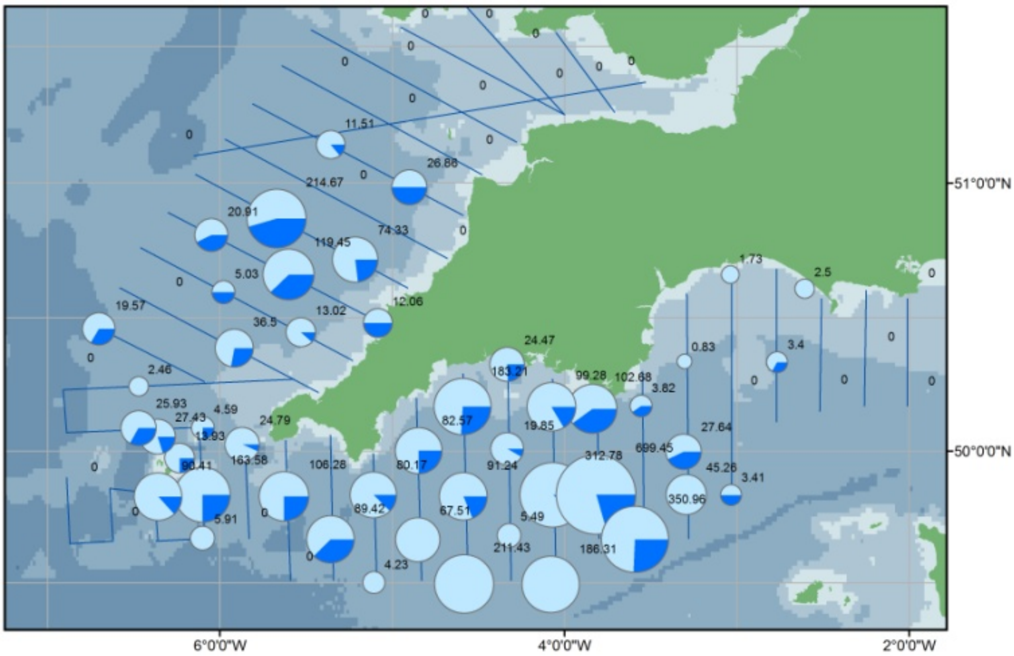

Figure 8a. Ichtyoplankton stations with unidentified clupeid (light blue) and sardine (dark blue) larva. Pie size relative to total larvae numbers caught; numbers of sardine larvae m^{-2} indicated in centre.

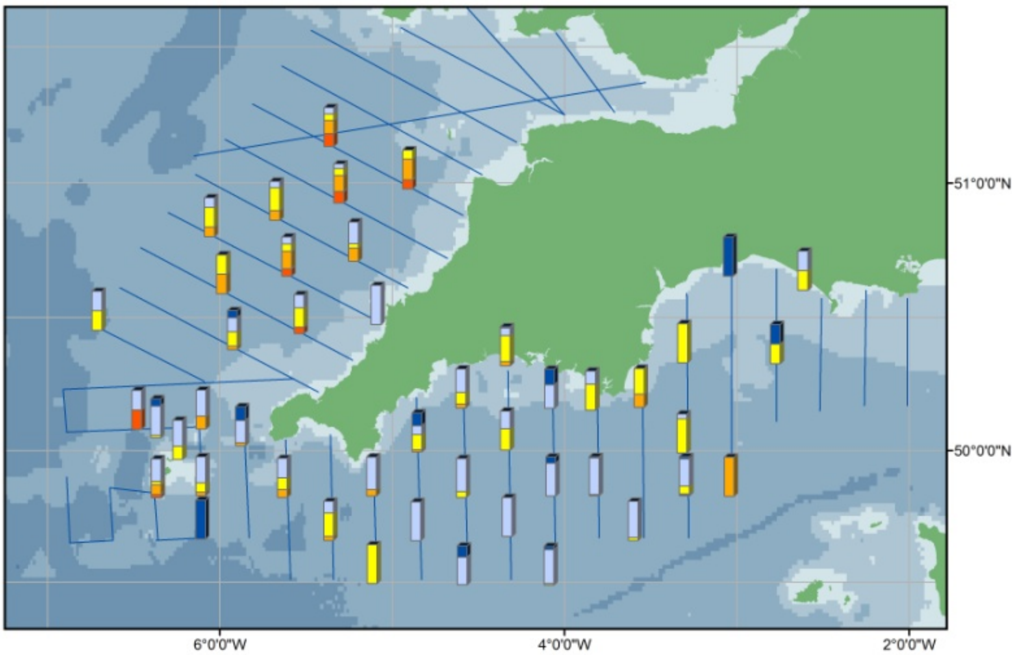

Figure 8b).distribution of positively identified sardine larvae by size class, dark blue (3mm)

3.3. Oceanographic data

Temperature and salinity

Surface waters of the Western English Channel and of the shelf edge were warmer than the rest of the Celtic Sea with temperature > 18°C (Figure 9a and Table 1). A patch of slightly cooler water (approximately between 14–15°C), was located south of Eddystone Bay down to the France coast (Figure 9a). During the course of the survey this patch of cooler water extended west towards the Celtic Sea including also the Scilly Isle (Figure 9c).

The boundary layer where the cooler waters south of Eddystone Bay meet the warmer waters of the English Channel and the Celtic Sea was marked by a series of frontal systems (Figure 9b and d).

Vertical profiles of temperature and salinity (carried out with a SAIV Mini CTD mounted on the zooplankton sampling nets) were plotted using the software Ocean Data View (ODW). Surface maps from CTD measurements (Figure 10, 11 and 12) showed a temperature distribution similar to the one observed from the satellite-derived maps. The surface maps of the Western English Channel (Figure 10) show the presence of a gradient from cooler and saltier waters towards the Scilly Isle to warmer and less salty waters in Lyme Bay. Stations in the Bristol Channel showed a similar gradient (warm and less salty waters in the inner Bristol Channel, cooler and saltier waters in the outer Channel; Figure 4), although waters in the Bristol Channel were not as warm as in Lyme Bay (16.33 and 18.08 °C respectively; Table 2).

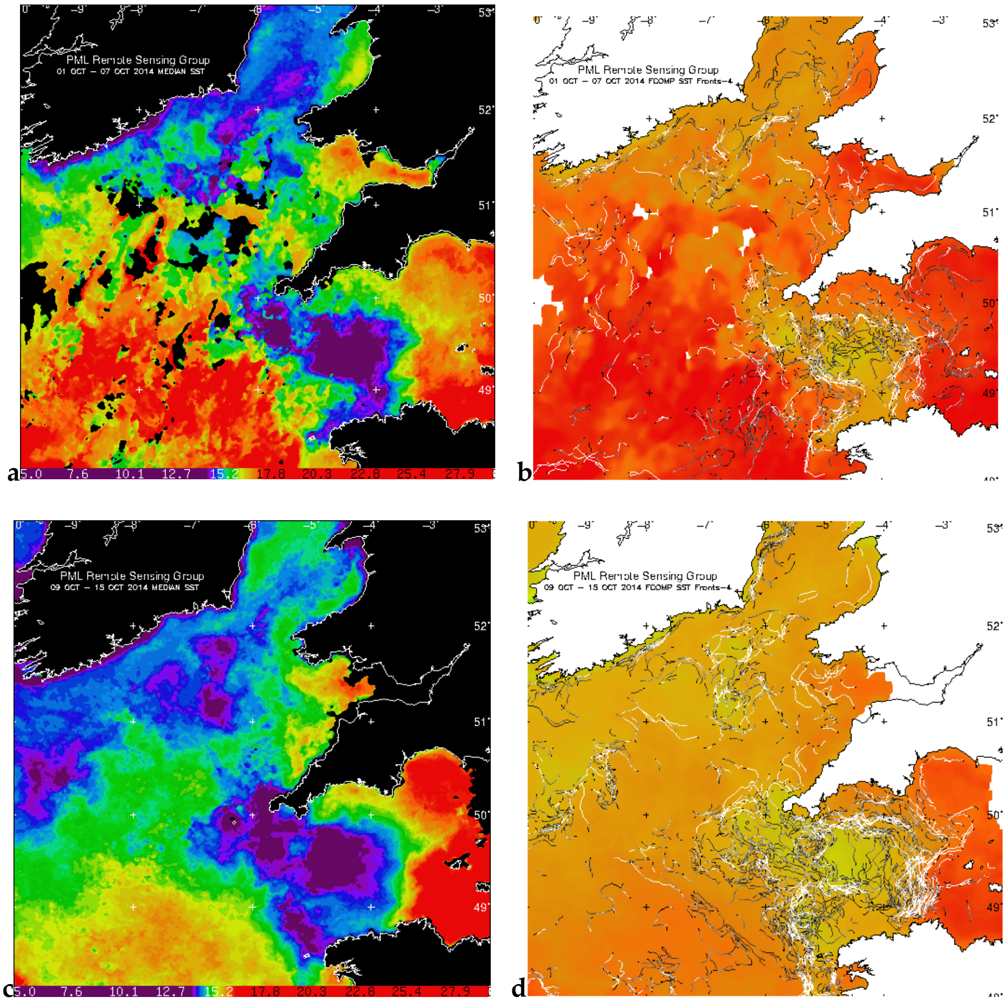

Figure 9. Composite surface maps for the periods 1–7 October and 9–15 October 2014 of temperature (a and c) and thermal frontal systems (b and d) from Neodaas.co.uk.

Table 2. Minimum and maximum values at the surface and bottom of temperature (°C) and salinity (measured by the SAIV Mini CTD on the zooplankton nets), ΔT (surface temperature – bottom temperature) and ΔS (surface salinity – bottom salinity) for the study area. The prime station numbers, sampling period and number of stratified stations (ΔT > 0.5 °C) are also indicated. WEC = Western English Channel; SI = Scilly Isles; BC = Bristol Channel.

	WEC	SI	BC
Prime	1–33	34–44	45–70
Sampling period	30/9 - 11/10	8 - 12/10	12 - 17/10
Surface Temp	14.48 / 18.07	14.49 / 15.88	14.63 / 16.33
Bottom Temp	12.53 / 18.08	10.88 / 15.00	10.15 / 16.34
ΔT	-0.02 / 2.27	-0.01 / 5	-0.07 / 4.85
Surface Salinity	35.07 / 35.52	35.33 / 35.44	33.39 / 35.84
Bottom Salinity	35.07 / 35.56	35.37 / 35.50	33.42 / 35.91
ΔS	-0.13 / 0.04	-0.13 / -0.01	-0.23 / 0.01
Stratified	15 (45%)	8 (80%)	5 (10%)

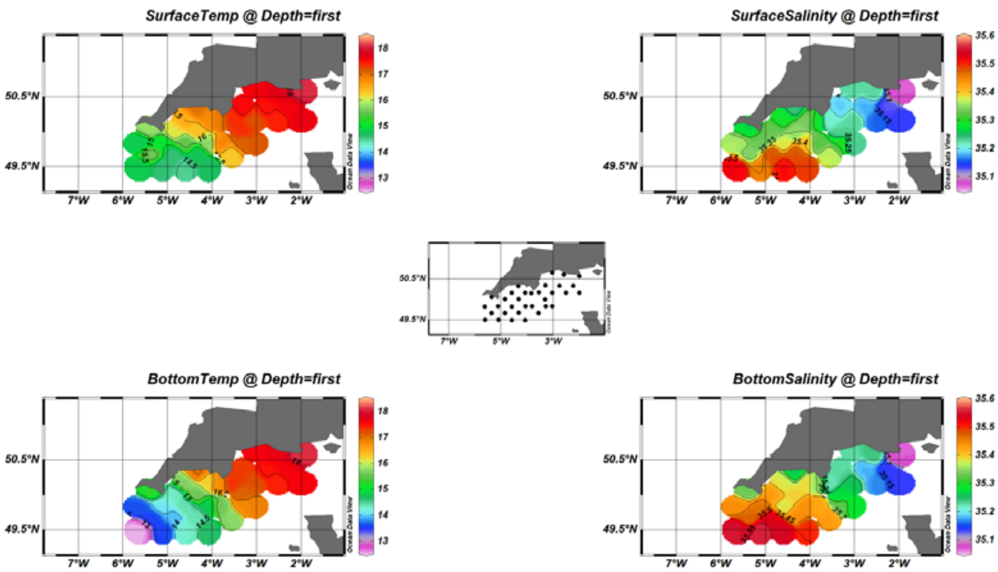

Figure 10. Values of temperature (°C) and salinity at the surface and bottom at the stations in the Western English Channel (WEC), as measured by the SAIV MiniCTD.

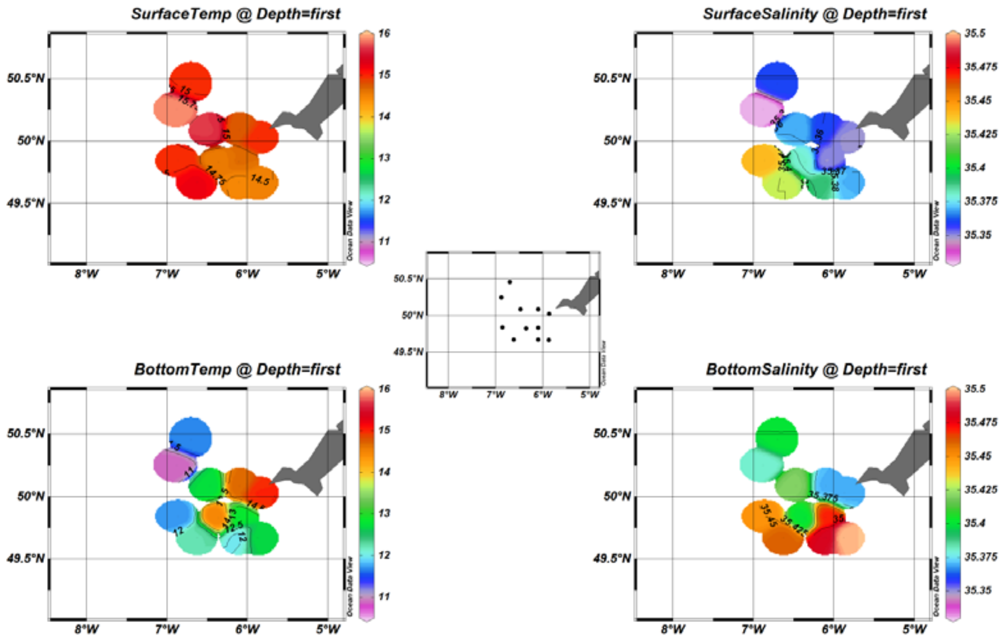

Figure 11. Values of temperature (°C) and salinity at the surface and bottom at the stations in the Isles of Scilly (SI), as measured by the SAIV MiniCTD.

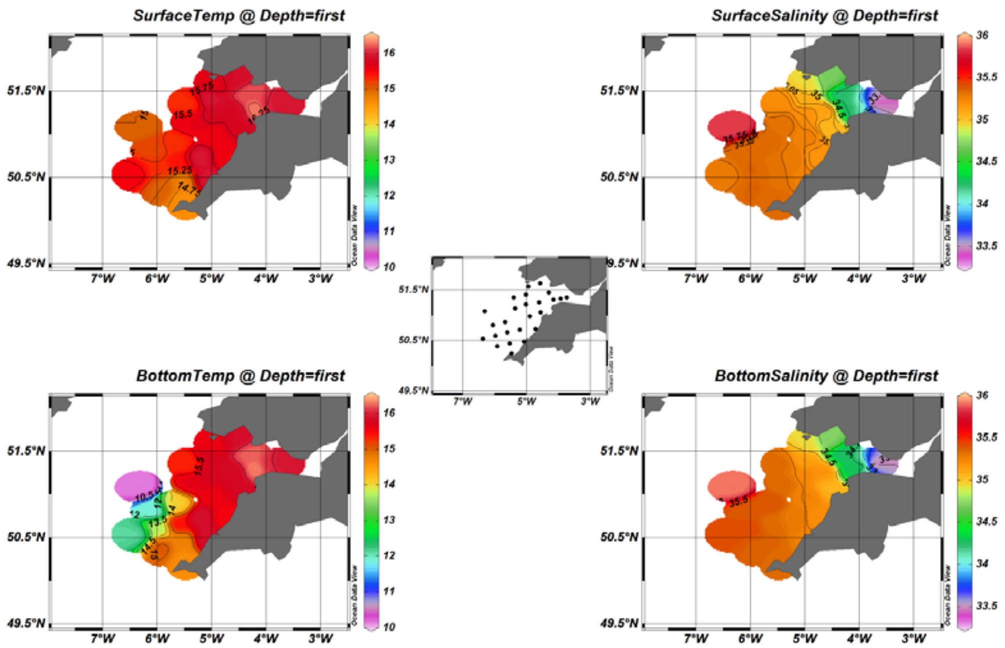

Figure 12. Values of temperature (°C) and salinity at the surface and bottom at the stations in the Bristol Channel (BC), as measured by the SAIV Mini CTD.

The main part of the stations at the Isles of Scilly and half of the stations in the Western English Channel were thermally stratified ($\Delta T > 0.5$ °C) with difference in temperature between surface and bottom of up to 5 °C (Table 2). This is particularly clear in Figure 13, where all stations in Lyme Bay, inshore of north Cornwall and Bristol Channel were vertically mixed (ΔT < 0.5 °C). Differences in salinity between surface and bottom were small (-0.23 / 0.04; Table 2 and Figure 13), suggesting that the vertical stratification of the water column was mainly driven by changes in temperature rather than salinity.

At the stratified stations, the depth and width of the thermocline were variable; examples of temperature profiles are presented in Figure 14.

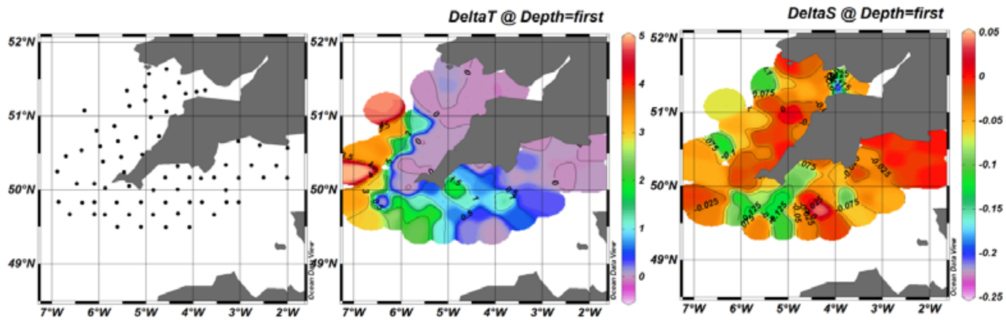

Figure 13. Values of ΔT (surface temperature – bottom temperature; °C) and ΔS (surface salinity – bottom salinity) at the 70 sampling stations, as measured by the SAIV MiniCTD. The water column is considered stratified when ΔT > 0.5 (°C).

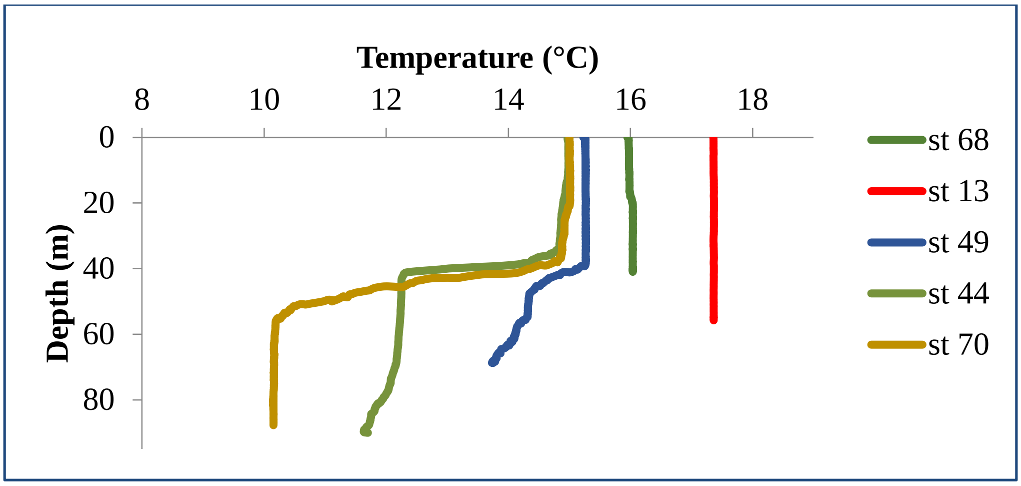

Figure 14. Examples of temperature vertical profiles, highlighting different level of stratification of the water column.

Chlorophyll and fluorescence

Higher levels of chlorophyll concentration were observed offshore (Figure 15) in correspondence of the Ushant front and the frontal systems around the cool patch of water in the Western English Channel (Figure 9). In these frontal systems, nutrient-rich waters are mixed with nutrient-depleted surface waters leading to a potential increase in phytoplankton biomass. These frontal systems act as 'physical barriers' for plankton organisms including also fish eggs and larvae.

Chlorophyll was higher in Lyme Bay compared to Eddystone Bay, as also shown by the Ferrybox raw fluorescence (Figure 16). Remote sensing images indicated high level of chlorophyll concentration in Bristol Channel. However this observation was not supported by the Ferrybox fluorescence measurements which were generally low (compare Figure 15 and 16). This is likely due to the higher level of suspended solids in the inner Bristol Channel affecting the reliability of the remote sensing algorithm for calculating chlorophyll concentration.

Due to poor weather conditions, it was not possible to follow the evolution of the phytoplankton autumn bloom, as occurred during the previous survey (Peltic 13). Therefore it is not clear when the bloom initiated.

Analysis of phytoplankton samples at the inverted microscope, and of samples for HPLC and flow cytometry in the laboratory will provide details of the pico-, nano- and phytoplankton community as well as their abundance and pigment composition.

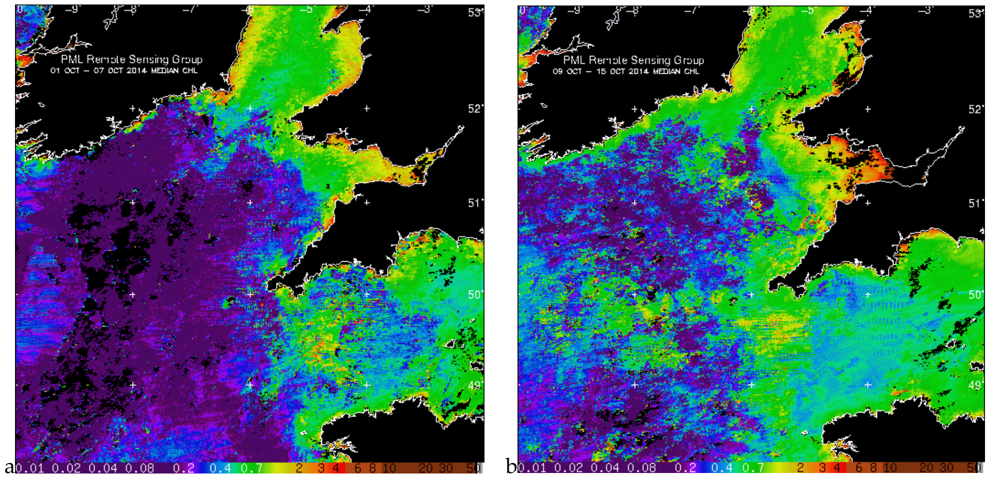

Figure 15. Chlorophyll concentration at the surface for the periods 1–7 October (a) and 9–15 October 2014 (b) from Neodaas.co.uk.

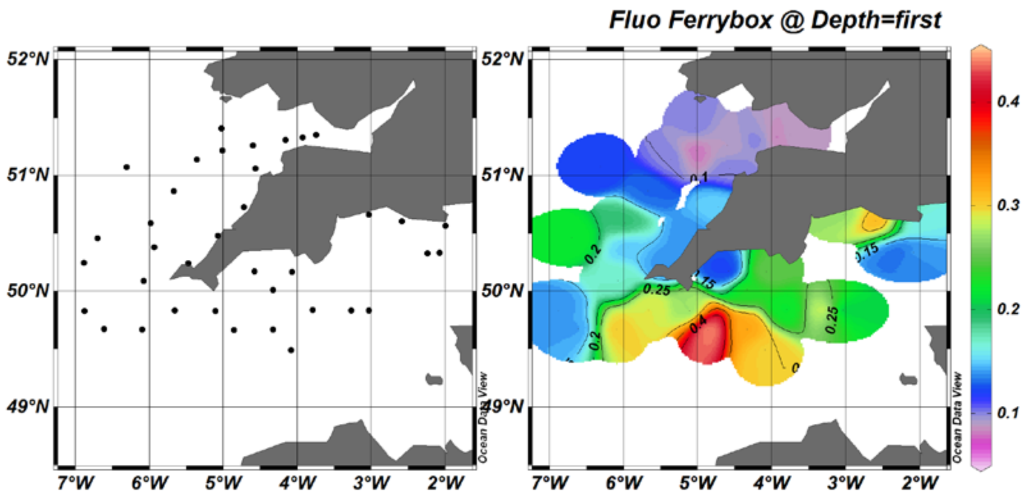

Figure 16. Fluorescence values at 4 m depth, at 18 sampling stations, as recorded by the Ferrybox.

3.4. Marine Mammals and birds

This year, because of changes made to the survey methodology, all transects were run in daylight, and with more sea time in the survey area and better weather, almost complete coverage was achieved in all sections of the survey. Poor weather, particularly high winds and sea state, is inevitable for surveys conducted late in the year, however conditions were significantly better than in 2013. Visibility during effort surveys was generally good to excellent, and rain was infrequent and fog absent.

In total, there were 96 sightings (99 in 2013) of seven cetacean species (4 in 2013), with significantly more individual animals counted. The chief highlight was of 7 Fin Whales feeding together 30 nmi north of Lands End. They were seen feeding together on dense concentrations of sprat and sardine in association with a Minke Whale, Common Dolphins and Harbour Porpoise. Bluefinned Tuna were seen foraging in the same area. Meanwhile, two single Minke Whales were found inshore off the South Devon coast.

Ten Risso's Dolphin were seen 10 nmi south of Portland, and White-beaked Dolphin were encountered within 1 nmi of where they were seen 2013, in Lyme Bay; this population is thought to be the only one in the English Channel. Meanwhile, the most abundant species encountered throughout was Common Dolphin with 76 (74 in 2013) sightings of 1,520 animals (120% of 2013), chiefly but not exclusively in deeper waters (>50m) in the west and northwest of the survey area. A single group of Bottlenose Dolphin were seen feeding offshore in the English Channel, whereas Harbour Porpoises were seen sparsely but widely mainly inshore in calmer smooth seas, however they were also noted feeding in the fin whale encounter.

There were ~2,200 sightings of 38 bird species with 17,000 individuals counted (slightly more than last year). Gannets were again by far the most numerous species recorded (~9,000, 94% of last year's total), but in many ways the demography was quite different; significantly more Manx Shearwaters and Storm Petrels, but fewer auks, Kittiwakes, and skuas.

The unexpectedly large numbers of Balearic Shearwaters (chiefly in the Bristol Channel) in 2013, provided an important focus for 2014. With only 2,000 pairs surviving in the world, all breeding on the Balearic Islands, and having declined by ~95% since 1970s, they are now classified by IUCN as Critically Endangered. UK waters are at the edge of their non-breeding range however, distinct northward shifts in range have been noted in recent years so it is likely that the UK will become increasingly important for them. 79 were logged in 2013, whereas 205 were seen this year, including 147 in the same general area of the Bristol Channel as last year, associated with concentrations of small sprat. This confirmation of an important feeding area is highly significant, and will be used to inform future conservation measures.

Terrestrial bird migration was noted particularly in the English Channel, where Meadow Pipit, was by the most abundant (>550). Swallows, Pied Wagtails and Robins were also noted. More unusually a Short-eared Owl rested on the ship in strong opposing winds in the Celtic Sea, presumably enroute from southern Ireland. Several Hummingbird Hawkmoths visited the ship over a number of days, and two or three unidentified butterflies flew past.

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